Choice Based Credit System (CBCS)

B. Sc Prog. with Industrial Chemistry
University of Delhi

UNDERGRADUATE PROGRAMME
(Courses effective from Academic Year 20xx-xx)

SYLLABUS OF COURSES TO BE OFFERED: Core Courses, Elective Courses & Ability Enhancement Courses

SYLLABUS REVISED DURING THE ACADEMIC YEAR 2019
Introduction:
The Choice based credit system (CBCS) offers flexibility of program structure while ensuring that students gets a strong foundation in the subject and gains in-depth knowledge of all aspects of the field. The learning outcome based curriculum framework is designed around the CBCS and is intended to suit the present day needs of the students in terms of securing their path towards higher studies or employment.

Duration of Program:
The B.Sc. Applied Physical Sciences with Industrial Chemistry program will be of three year duration. Each year will be called an academic year and will be divided into two semesters. Thus there will be a total of six semesters. Each semester will consist of sixteen weeks.

Design of Program:
The teaching learning process will involve theory classes (Periods) of one hour duration and practical classes of four hour duration. The curriculum will be delivered through various methods including chalk and talk, power point presentations, audio, video tools, E-learning/ E-content, virtual labs, simulations, field trips/ Industry visits, seminars (talks by experts), workshops, projects, models and class discussions. The assessment broadly will comprises of Internal Assessment (Continuous Evaluation) and End Semester Examination. Each theory paper will be 100 marks with 25% marks for Internal Assessment and 75% for End semester examination. The internal assessment will be through MCQ, test, assignment, oral presentation, worksheets and short projects. Each practical paper will be of 50 marks.

Structure of Program:
The program will consist of six credit courses and four credit courses. All six credit courses will be comprises of theory classes (four credits) and practical (two credits). Four credit courses will be comprises of theory classes (two credits) and practical (two credits). For theory classes one credit indicates an one hour lecture per week while for practical one credit indicates a two hour session per week. Each practical batch will be of fifteen students. A number exceeding fifteen (by at least 10) will be divided into two equal batches.
The program includes Core Courses (CC) and elective courses. The core courses are all
compulsory courses. There are two kinds of elective courses: Discipline-Specific Elective (DSE), and Skill Enhancement Course (SEC). In addition there are two compulsory Ability Enhancement Courses (AEC).

To acquire a degree in B.Sc. Applied Physical Sciences with Industrial Chemistry program a student must study twelve core courses, six Discipline Specific Elective, four Skill Enhancement courses. The Core Courses, Discipline-Specific Electives are six credit courses. The Skill Enhancement Course are four-credit courses while the Ability Enhancement courses are four credit courses. A student has to earn a minimum of 132 credits to get a degree in B.Sc. Applied Physical Sciences with Industrial Chemistry.

The program offers Discipline-Specific Elective (DSEs) Chemistry, Industrial Chemistry and Mathophysics, of which the students must choose one in each of the Semesters V and VI. The DSEs will be of six credits each (four credits theory and two credits practical). A particular option of DSE course will be offered in Semesters V and VI semesters only if the minimum number of students opting for that course is 10. The DSE course that is project work will also carry six credits. The number of students who will be allowed to opt for project work will vary from college to college depending upon the infrastructural facilities and may vary each year. The college shall announce the number of seat of projects work well in advance and may select the students for the same based of merits. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes. The final evaluation of the project will be through a committee involving internal and external examiners. In this regard guidelines provided by University of Delhi for executing and evaluation of project work will be final. Students will be asked their choice for Project work at the end of IV semester and all formalities of topics and mentor selection will be completed by this time.

The students will undertake four Skill Enhancement (SE) Course for four credits in Chemistry/Industrial Chemistry each in semester III and IV, which they can choose from the list of SE courses offered by their college. The SE course will be of four credits each (two credits theory and two credits practical).

The two compulsory Ability Enhancement Courses (AECs): AE1 (Environmental Sciences) and AE2 (English Communication) will be of four credits each (theory only). The student will take one each in Semester I and II.
COURSES OFFERED UNDER B.SC. APPLIED PHYSICAL SCIENCES WITH INDUSTRIAL CHEMISTRY PROGRAMME (CBCS)

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course offered</th>
<th>Course name</th>
<th>Credits</th>
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<tbody>
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<td>Ability Enhancement</td>
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<td>Core Course Industrial-Chemistry-I</td>
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<td>Atomic structure, bonding, General Organic Chemistry &amp; Aliphatic hydrocarbons</td>
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<td>Ability Enhancement</td>
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<td>Core Course Chemistry-II</td>
<td>Chemical Energetics, Equilibria &amp; Functional Group Organic Chemistry-I</td>
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<td>Core Course Mathophysics-II Practical</td>
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<td>III</td>
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* Wherever there is practical there will be no tutorials and vice versa
DETAILS OF COURSES

CORE COURSES: Industrial Chemistry

I. Industrial Chemicals and Environment
II. Industrial Chemistry - Fossil Fuels, Cleansing Agents and Food Additives
III. Industrial Chemistry - Inorganic Materials
IV. Industrial Chemistry - 4: Pharmaceuticals, Fermentation, Pesticides & Perfumes

CORE COURSES: Chemistry

I. Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
II. Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I
III. Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II
IV. Chemistry of s- and p-block elements, States of matter & Chemical kinetics

CORE COURSES: Mathophysics

I. Mechanics
II. Calculus and Matrices
III. Algebra
IV. Wave and Optics

DISCIPLINE SPECIFIC ELECTIVES: Industrial Chemistry (Any two)

1. Green Chemistry
2. Industrial Chemicals and Environment
3. Polymer Chemistry
4. Inorganic Materials of Industrial Importance
5. Project Work
6. Dissertation
DISCIPLINE SPECIFIC ELECTIVES Chemistry (two)

1. Chemistry of d-Block elements, Quantum Chemistry & Spectroscopy (Compulsory Chemistry DSE-I)
2. Organometallics, Bio-inorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy
3. Applications of Computers in Chemistry
4. Analytical Methods in Chemistry
5. Molecular Modelling & Drug Design
7. Research Methodology for Chemistry
8. Molecules of life
9. Dissertation

DISCIPLINE SPECIFIC ELECTIVES Mathophysics

(One each from Maths and Physics)

1. Electricity and Magnetism
2. Elements of Modern Physics
3. Medical Physics
4. Differential Equations
5. Calculus and Geometry

SKILL ENHANCEMENT COURSE Industrial Chemistry (two)

1. IT Skills for Chemists
2. Basic Analytical Chemistry
3. Analytical Clinical Biochemistry
4. Chemical Technology and Society
5. Cheminformatics
6. Green Methods in Chemistry
7. Instrumental Methods of Analysis

SKILL ENHANCEMENT COURSE Chemistry (two)
1. Business Skills for Chemist
2. Intellectual Property Rights
3. Pharmaceuticals Chemistry
4. Pesticide Chemistry
5. Fuel Chemistry

Learning Outcome-based Approach to Curriculum Planning

- **Introduction**

  The learning outcome-based approach for B.Sc. Applied Physical Science with industrial chemistry is to design curriculum framework to suit the requirements of the various industries. The course structure has been designed to allow flexibility in program and course content development while at the same time maintaining a basic uniformity in structure in comparison with other universities across the country. The core courses in Chemistry, mathematics and physics are designed to build strong foundation in theory and principles useful for practical applications. The core courses in industrial chemistry has been designed to familiarize the students with the industrial processes involved in the commercial production of the products. The program also offers wide range of discipline specific electives, skill enhancement, and compulsory Ability Enhancement and Environmental science courses to prepare students to improve their skills required in academic, research and in industrial projects using greener technology which are environmental friendly.

- **Objective of the program**

  Bachelor course in Industrial Chemistry offers the synergism of basic concepts of Chemistry with Industrial applications. The main objective of this degree course is to produce graduates
with enhanced skills, knowledge and research aptitude to carry out higher studies or research and development in the various industrial areas. This degree course of Industrial Chemistry mentored the students for immediate entry to the workplace with sound theoretical, experimental knowledge in the area of fuels and energy, environment, health, foods, cosmetics, polymers and related multidisciplinary fields. Overall, the course offers basic foundation in chemistry, physics and maths which enables the students to understand the concepts in chemical processing, engineering and industrial management.

- **Graduate Attributes in the subject**

Some of the major attribution of an Industrial Chemistry graduate may include:

- In depth knowledge of basic and applied area of industrial chemistry.
- Capability to demonstrate knowledge and understanding of major chemistry concepts, theoretical principals and experimental findings and ability to use modern instrumentation techniques with chemical analysis and separation.
- In depth knowledge of connection between transformation processes and final products.
- Ability to transfer chemical products and techniques developed at laboratory scale to the industrial level.
- Advanced knowledge of fundamentals of industrial chemistry with enhanced command over modern scientific methods, techniques and chemical processes equipped with environment safety measures.
- Understanding of various methods of safe handling, storages and health hazards of chemicals and processes used in the laboratories.
- Awareness of the role and importance of industrial chemistry in interdisciplinary research as well as in daily life.
- Enabled with quality of team work and strength of interacting with people from diverse backgrounds.
- Developed scientific logics and approaches towards problems with critical reasoning.
- Excellent communication skills to transmit complex technical information related to chemistry in a clear and concise written and verbal manner as oral presentations and compilation in the form of scientific reports.
- Able to employ critical thinking and efficient problem solving skills in the basic areas of chemistry (analytical, organic, inorganic, physical and material).
- Cultivated independent thinking and is able to integrate knowledge from other disciplines to fit various industrial areas.
- Acquired with awareness of work ethics and ethical issues in scientific research as well as plagiarism policies.

**Learning outcome of the program**

On successful completion of the course of B. Sc. Programme Industrial Chemistry the student will be able to:

- Describe the chemical industry and identify the distinguishing features of its component,
- Explain the importance and roles of process optimization in chemical processing,
- Describe the industrial production of a number of important organic and inorganic compounds/chemicals,
- Evaluate environmental issues pertaining to the chemical industry,
- Able to use modern instrumentation techniques for chemical analysis and separation,
- Able to communicate the results of their work to chemists and non-chemists.

**Knowledge attainment:** Students will gain comprehensive knowledge of cutting-edge developments in a field of science by discussion and exchange of experiences and knowledge. In this course fundamental and applied aspects of organic, inorganic, physical and analytical chemistry as well as key major concepts, theoretical principles and experimental findings in industrial chemistry will be covered. Students will have firm foundation in the fundamentals and scientific theories. Further, they will be proficient in application of current aspects of industrial chemistry. Students will be able to use chemical techniques relevant to academia and industry, generic skills and global competencies including knowledge and skills that enable the students to undertake further studies in the field of industrial chemistry or a related field, and work in chemical and non chemical sector.
**Laboratory Skills:** Students will become efficient in using Standard operating procedures and will be well versed with the regulations for safe handling and use of chemicals. They will be able to design, execute, record and analyse the results of chemical experiments. They will undertake hands on lab work and practical activities which develop problem solving abilities required for successful career in pharmaceuticals, chemical industries, teaching research, environmental monitoring, product quality, consumer good industries, food products, cosmetic industries, oils and lubricants industries, fuels, petrochemicals and energy sector, etc.

**Critical Thinking:** Students will become efficient in managerial skills, able to employ critical thinking, analytical reasoning, problems solving and interpretation and documentation of laboratory experiments at a level suitable to succeed at an entry-level position in chemical industry or a chemistry graduate program. They will be able to identify and explore new areas of research and planning, execute and report the results of an experiment or investigation, critical thinking and scientific inquiry in the performance, design. They can recognize and appreciate the importance of the chemical sciences and its application in academic, industrial, economic, environmental and social context.

**Inquisitiveness:** This course will be able to enhance the ability to assimilate, discuss scholarly articles and research papers showcasing interdisciplinary areas of industrial chemistry and capability for asking questions relating to issues and problems in the field of industrial chemistry.

**Team leader/worker:** The students will learn to work effectively in a group in the classroom, laboratory, industries and field-based situations. They could interact with peers from diverse backgrounds with developed confidence to lead a team.

**Skilled manager:** Students will be capable of identifying appropriate resources required for an assigned task/project to accomplish it. They will become efficient in using standard operating procedures and will be proficient with safe handling regulations and use of chemicals. They will be able to identify the ethical and environmental dimensions of problems and issues facing chemists.
**ICT enabled:** Students will be trained to use modern library searching and retrieval methods to obtain information about a topic, relating to Industrial chemistry. Communicate and present their ideas effectively through power-point presentations and appropriate software for analysis of data.

**Lifelong learners:** Students will be capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development. They will keep themselves updated with the best international practices and latest development in technologies which will help them to gain a broader Global perspective of the subject.

**Career Opportunity:** Graduates with B. Sc. Programme Industrial Chemistry, will have possibility to find employment in government departments, research and development institutes, production, biotechnology, quality control, pharmaceutical industry, process industry, fertilizer production industry, plastics industry, pulp and paper industry, tanning industry, consumer industry, oil and petroleum industry, textile industry, dyes and paints industry, cosmetics industry, cement industry, glass industry, water purification and waste water purification engineering including forensic science and patents, defence, education and research, and areas related to polymer chemistry. The course provides an opportunity to graduates to undertake masters in chemistry/ industrial chemistry/ biotechnology and allied courses. After their post-graduation, they may opt for Ph.D. in multidisciplinary areas.

**Teaching learning process**

A student-centered approach which actively engages the students in the learning process is critical if skills which result in healthy behavior are to be fostered and developed. The B. Sc. Program Industrial Chemistry course is aims to make the students proficient in industrial chemistry through the transfer of knowledge in the classroom as well as in the laboratory. Industrial Chemistry program is designed to encourage the learning strategies that could be incorporated in a comprehensive approach that include self-directed learning, cooperative learning, and peer education. In the classroom this will be done through blackboard and chalk lectures, charts, PowerPoint presentations, and the use of audio visual resources that are available on the internet such s virtual lab. The process of effective learning to a great extent
will be based on teacher’s experiences, identifying the slow learners and individual attention of the teacher towards them. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning, practicum and project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments etc. will be adopted. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies. A feedback method with more anonymity will be preferred. An interactive mode of teaching will be used. The students will be encouraged to participate in the discussions and deliver seminars on the course related topics. A problem solving approach will be adopted wherever suitable. In the laboratory, the students will first learn good laboratory practice and then get hands on training on basic instrumentation techniques and methods. Emphasis on laboratory work is particularly important keeping in mind the practical nature of the subject, and the time devoted to practical will enable the students to better understand the applications of the different courses. The students will participate in field trips to various industries that will facilitate their understanding of the practical aspects of the program and enable them to gain exposure to future places/ areas of employment.

**Assessment Methods**

The assessment of students achievements in Industrial Chemistry will be aligned with the course/program learning outcomes and the academic and professional skills that the program is designed to develop. The students will be assessed over the duration of the program by many different methods. A variety of appropriate assessment methods within the disciplinary area of industrial chemistry will be used. Learning outcomes will be assessed using the following direct measures:

- Oral and written examinations,
- Closed book and open book tests
- Classroom quiz,
- Focused group discussion,
- Short objective type quizzes
- Group discussion and presentations
- Assignments
- Problem-solving exercises,
- Experimental design planning
- Execution of experiments
- Observation of practical skills
- Individual project reports
- Seminar presentation
- Case study presentations
- Viva voce interviews
- Computerized adaptive testing
- Literature surveys and evaluations
- Outputs from collaborative work
- Portfolios on industrial visits undertaken
- Preparation of reports
- Presentation of practical records.

Exchange program with different colleges and universities from different parts of the state will be provided. Brainstorming small group discussion supposed to organised, wherein the students can identify a list of techniques and strategies that best fit their classes. Besides standardized tests, interim benchmarks, daily assessments, observations, interviews and formal assessments to individualize interventions will be carried out to enhance overall student performance.

**Overall, a wide range of assessment tasks that aim to break the monotony of having a single assessment method will be provided.**
Course Objective

The aim of this course is to make students aware of different industrial processes in detail. This course is basically designed to understand the chemistry of the industrial processes like Purification techniques, handling of important gases, acids, bases, pollutants, Industrial effluent and water treatment. The analytical approach of this course is to enhance the reasoning and to understand the mechanical part of the industry. The aim of this course is that the students will learn the conventional and latest techniques used in abatement of environmental pollution (air, water and industrial effluents) and understand important issues in pollution abatement.

Course Learning Outcomes

- To know the various purification techniques used in industries like distillation, absorption, adsorption and solvent extraction.
- Understand the production, storage and handling of important gases like oxygen, argon, helium, hydrogen and acetylene.
- Understand and develop efficacy in handling and preparation of frequently used inorganic chemicals like acids, bases, oxidizing and disinfecting chemicals.
- Learn major causes of air pollution, its control and alarming problem of global warming.
- Qualitative and quantitative measurements of water treatment, conservation and handling of industrial effluent.

Unit 1 Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry.

(15 Lectures)
Unit 2 Industrial Gases and Inorganic Chemicals

(a) 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. (b) Inorganic Chemicals: Industrial preparation with the help of flowchart, 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.

(20 Lectures)

Unit 3 Environment

(a) Air Pollution: Pollutants and their sources, pollution by SO$_2$, CO$_2$, CO, NO$_x$, H$_2$S and other foul smelling gases. Methods of estimation of CO, NO$_x$, SO$_2$ and their control procedures. Green house effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, Removal of sulphur from coal. Particulate matter and its types.


(25 Lectures)

Practical

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 method. (AgNO$_3$ and potassium chromate)
6. Estimation of total alkalinity of water samples (CO$_3^{2-}$, HCO$_3^-$) using double titration method.
7. Isolation of compound using solvent extraction method.
8. A survey based study on common bio-indicators of pollution and SPM in air samples.
9. Preparation of borax and boric acid.

References


### Teaching Learning process

To accomplish a goal, it is very important to learn in a strategic manner. There are different components of learning and the capacity of each learner varies. ‘How’ to teach and ‘What’ to teach in the defined curriculum not only depends on the content and the knowledge of the teacher but critically more so on designing, i.e. how to introduce the concept to the students in a very effective way. Different ways of teaching include classical board teaching method, visual conceptual method, application based practical demonstration of the concept etc. In fact the pedagogy is to make a class interesting and thus learning becomes enjoyable.

### Keywords:
- Industrial Chemicals, Purification techniques, Handling of acids and bases, air pollutants, Industrialeffluents.

### Assessment Methods

The effectiveness of learning can be judged by assessing the students. Assessment can be in question answer form, quiz form, project form etc. Students should also engage in self-assessment and peer group learning activities.

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**Atomic Structure, Bonding, General Organic & Aliphatic Hydrocarbons**

**Total Credits: 06**
*(Credits: Theory-04, Practicals-02)*
*(Total Lecture: Theory- 60, Practicals-60)*

### Objectives:

- The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of Chemical Bonding in compounds. It provides basic knowledge about Ionic, Covalent and Metallic bonding and explains that Chemical Bonding is best regarded as a continuum between the three cases. It discusses the Periodicity in properties with reference to the sand p block, which is necessary in understanding their group chemistry. The course is also infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space. To establish the
applications of these concepts, the functional groups—alkanes, alkenes, alkynes and aromatic hydrocarbons—are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

**Learning Outcomes:**

By the end of the course, the students will be-

1. Able to solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p, and d orbitals, and periodicity in atomic radii, ionic radii, ionization energy and electron affinity of elements.
2. Able to draw the plausible structures and geometries of molecules using Radius Ratio Rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).
3. Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
4. Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
5. Learn and identify many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution.

**Unit 1**

**Section A: Inorganic Chemistry-1 (30 Periods)**

Atomic Structure
Review of: Bohr’s theory and its limitations, Heisenberg Uncertainty principle. Dual behaviour of matter and radiation, de-Broglie’s relation. 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 $\psi$ and $\psi^2$, 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 $m_l$ and $m_s$. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number ($m_s$).

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.

(Lectures: 14)
Chemical Bonding and Molecular Structure

**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 (no derivation), 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 (H₂O, NH₃, PCl₅, SF₆, ClF₃, SF₄) 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 (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO⁺.

(Lectures:16)

**Section B: Organic Chemistry-1**

**Unit 3 Fundamentals of Organic Chemistry**


(Lectures :8)

**Unit 4:**

**Stereochemistry**

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).

(Lectures :10)

**Unit 5:**

**Aliphatic Hydrocarbons**

Functional group approach for the following reactions (preparations physical property & chemical reactions) to be studied with mechanism in context to their structure.

**Alkanes:** Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe’s synthesis, Grignard reagent. Reactions: Free radical Substitution: Halogenation.
Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO$_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: Preparation: Acetylene from CaC$_2$ and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides and acidity of alkynes, addition of bromine and alkaline KMnO$_4$, ozonolysis and oxidation with hot alk. KMnO$_4$. Hydration to form carbonyl compounds

(Lectures :12)

Practical:

Section A: Inorganic Chemistry - Volumetric Analysis
1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO$_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO$_4$.
4. Estimation of Fe (II) ions by titrating it with K$_2$Cr$_2$O$_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na$_2$S$_2$O$_3$.

Section B: Organic Chemistry
1. Purification of OC by crystallisation (from water and alcohol) and distillation.
2. Criteria of purity: Determination of M.P./B.P.
3. Detection of extra elements (N, S, Cl, Br, I) in organic compounds
4. Separation of mixtures by Chromatography: Measure the R$_f$ value in each case (combination of two compounds to be given)
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

References:

Theory:

- J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.17
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand
- Atkins, Overton, Rourke, Weller, Armstrong, Shriver and Atkins Inorganic Chemistry, Oxford

Practical:

Teaching Learning Process:

- Lectures in class rooms
- Peer assisted learning.
- Hands-on learning using 3-D models, videos, presentations, seminars
- Technology driven Learning.
- Industry visits

Assessment Methods:

Following assessment methods can be adopted to evaluate the students:

- Conventional Class tests
- Open Book tests
- Assignments
- Online tests --objective or subjective
- Quizzes
- Presentation on a topic in front of the classmates
- Performing a new experiment based on the concepts learned in the course.

Keywords

Atomic structures, quantum numbers, lattice energy, stereochemistry, resonance, inductive effect, hyperconjugation

SEMESTER-II

INDUSTRIAL CHEMISTRY-FOSSIL FUELS, CLEANSING AGENTS AND FOOD ADDITIVES
(Industrial Chemistry1--4(ii))
Core Course - (CC) Credit:6
Theory: Credits-04, Lectures-60   Practical: Credits-02, Lectures-60

Course Objective

After studying this course, student shall be able to understand the different aspects of industrial processes of fossil fuels in detail. Sensible use of limited resources of non-renewable energy and technology investment in improving the production of renewable cleaner energy sources. The analytical approach of this course is to enhance the reasoning and to understand the mechanical part of the industry.
Course Learning Outcomes

- To know about fuels, composition, carbonization of coal, gasification, liquefaction, and coal tar based chemicals and layout for key processes in oil refining.
- To understand different fossil fuel products and processes. Types of lubricants their property based on viscosity index, cloud point, pore point and applications of lubricant in Industry.
- To know types of oils, fat splitting, familiarized with rancidity, saponification value, iodine number, Superiority of synthetic detergent and role of Surfactants.
- An increasing demands of food additives- Merit and Demerits of synthetic and natural colouring, flavouring and sweetening agents.

Unit-1


(a) Coal: Introduction of coal, Uses of coal (fuel and non-fuel) in various industries (atleast three examples), its types and composition, carbonization of coal. Coal gas, producer gas and water gas—composition and their uses. Industrial methods for the fractionation of coal tar, uses of coal tar based chemicals, Requisites of a good metallurgical coke, Industrial method with flowchart for the Coal gasification (Hydro and Catalytic gasification), Coal liquefaction and Solvent Refining.

(b) Petroleum and Petrochemical Industry: 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 Xylene.

(c) Lubricants: Classification and properties of lubricants- (viscosity index, cloud point, pore point), lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

(40 Lectures)

Unit-2

Oils and Fats: Classification of oils, fat splitting, distillation of completely miscible and non-miscible oils, hydrogenation of oils, rancidity, saponification value, iodine number, acid value, Soap and Synthetic Detergent, preparation of soap and detergent, different types of soap and their composition, surfactants (LAS, ABS, LABS), detergent binders and builders.

(15 Lectures)
Unit-3

**Food additives**: A general study of food flavours, colours and preservatives, artificial sweeteners

*(5 Lectures)*

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Practical

*(Credits 2)*

1. Determination of alkali in water samples and soaps.
2. Extraction of essential oils from flowers and fruits by soxhlet extraction method.
3. Extraction of natural coloring and flavoring agent from flowers and fruits.
4. Determination of iodine value of the oils/fats.
5. Determination of saponification value of the oils/fats.
6. Determination of acid value of the oils/fats.
8. Estimation of glucose in food samples.

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References

Keywords: Renewable and non-renewable resources, synthetic fuels, calorific value, Refining, Cracking, Petrochemicals, Lubricants, Rancidity, Synthetic Detergents, Food additives.

Chemical Energetics, Equilibria and Functional Organic Chemistry-I

Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

The objective of this paper is to develop basic understanding of the chemical energetics, laws of thermodynamics, chemical and ionic equilibria. To enable the students to understand the behaviour of electrolytes and their solutions. To acquaint students with the functional group approach to study organic compounds. To describe structure, methods of preparation and reactions for the following functional groups: Aromatic Hydrocarbons, Alkyl and Aryl Halides, Alcohols, Phenols and Ethers. To establish a relationship between the structure and physical and chemical characteristic of compounds containing these functional groups.

Learning Outcomes:

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

- Students will understand the laws of thermodynamics, thermochemistry and equilibria.
- Students will be able to understand concept of pH and its effect on the various physical and chemical properties of the compounds.
- The students will be able to use the concepts learnt to predict feasibility of chemical reactions and for studying behaviour of reactions in equilibrium.
- This course will help students to understand the fundamentals of functional group chemistry through the study of methods of preparation, properties and and chemical reactions with underlying mechanism.
- The students will be able to use concepts learnt to understand stereochemistry of a reaction and predict the outcome of a reaction.
- The students will be able to design newer synthetic routes for various organic compounds.

Unit 1:
Chemical Energetics

- 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.

(8 Lectures)

Unit 2:

Chemical Equilibrium


(8 Lectures)

Unit 3:

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.

(12 Lectures)

Unit 4:

Aromatic Hydrocarbons

Functional group approach for the following reactions (preparations physical properties and Chemical reactions) to be studied in context to their structure and underlying mechanisms for all the functional groups mentioned in Units IV to VI

Structure and aromatic character of benzene.

Preparation: Methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonnic acid.

Reactions: Electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft’s alkylation and acylation with emphasis on carbocationic rearrangement ,Side chain oxidation of alkyl benzenes.

(7 Lectures)
Unit 5:

Alkyl and Aryl Halides

A) Alkyl Halides (upto 5 carbons):

Structure of haloalkanes and their classification as 1°, 2° & 3°.

Preparation: starting from alcohols (1°, 2° & 3°) and alkenes with mechanisms and regioselectivity (Markovnikov’s rule and Anti-Markovnikov’s rule)

Reactions: Nucleophilic Substitution Reactions with mechanism and their types (SN1, SN2 and SNi). Stereochemical aspects of each type. Reactivity order of 1°, 2° & 3° haloalkanes in SN1 & SN2 mechanisms and competition with elimination reactions (Elimination Vs Substitution) Nucleophilic Substitution Reactions with specific examples from: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation and Williamson’s ether synthesis.

B) Haloarenes:

Structure and resonance

Preparation: Methods of preparation of chloro, bromo & iodobenzene from benzene (electrophilic substitution), and from aniline (Sandmeyer and Gattermann reactions)

Reaction: Nucleophilic Aromatic Substitution by OH group (Bimolecular Displacement Mechanism). Effect of nitro substituent on reactivity of haloarenes. Reaction with strong bases like KNH2 in NH3 (or NaNH2/NH3). (Elimination-Addition Mechanism involving Benzyne Intermediate). Relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides

Unit 6:

Alcohols, Phenols and Ethers

A) Alcohols (upto 5 Carbon):

Structure and classification of alcohols as 1°, 2° & 3°.

Preparation: Methods of preparation of 1°, 2° & 3° by using Grignard reagent, Ester hydrolysis and reduction of aldehydes, ketones, carboxylic acids and esters.

Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alk KMnO4, acid K2Cr2O7 and conc HNO3), Oppeneauer Oxidation.

B) Diols (upto 6 Carbons): Oxidation and Pinacol-Pinacolone rearrangement.

C) Phenols: Structure, relative reactivity and comparison of acidity of alcohols and phenols and factors affecting the acidity of phenols.
Preparation: Methods of preparation from Cumene, diazonium salts and benzene sulphonlic acid.


D) Ethers (aliphatic & aromatic):

Williamson's ether synthesis, Cleavage of ethers with HI (SN1 & SN2 mechanisms)

(11 Lectures)

Practical:

Section A: Physical Chemistry

Energetics:

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. 3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
5. Determination of enthalpy of hydration of copper sulphate.

Ionic equilibria and pH measurements:

1. 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.
2. 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.

Section B: Organic Chemistry

Preparations: (Mechanism of various reactions involved to be discussed)
1. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
2. (a)Bromination of Phenol/Aniline
3. (b) Benzoylation of amines/phenols
4. Systematic Qualititive organic analyses of organic compounds possessing monofunctional groups (Alcohols, Phenols, Carbonyl,- COOH) and preparation of one suitable derivative.

References:

Theory:

Practical:

- B. D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

Teaching Learning Process:

- The teaching learning process will involve the blended learning technique along with traditional chalk and black board method wherever required.
- Certain topics like stereochemistry of nucleophilic substitution, elimination reactions and their underlying stereochemistry, where traditional chalk and talk method may not be able to convey the concept, are especially taught through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.

Assessment Methods:

Students evaluation will be done on the basis of regular class test, assignments and presentations during the course.

Keywords:

Hydrocarbons, Haloalkanes and haloarenes, Alcohols, Phenols and Ethers.

SEMESTER III
INDUSTRIAL CHEMISTRY-INORGANIC MATERIALS
(IndustrialChemistry1)
Core Course - (CC) Credit:6
Theory: Credits-04, Lectures-60  Practical: Credits-02, Lectures-60

Course Objective
The paper imparts basic knowledge of chemistry of inorganic materials such as Silicates, Non-silicates, Ceramics, Cement etc. This paper is designed in such a way that it will enrich students with the knowledge of various type of surface coatings, Fillers, Thinners, Enamels, Emulsifying agents. The paper has been drafted to impart the theoretical and practical knowledge of estimation and determination of various industrially important chemicals.

Course Learning Outcomes

- To establish an appreciation of the role of inorganic chemistry in the chemical sciences.
- Students gain sound knowledge of inorganic materials like silicates, ceramics and cement.
- Students develop skills to estimate various components of fertilizers.
- Students understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing industrial chemists.
- Skilled in scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Are able to identify various concepts of industrial metallurgy which will help them to explore new innovative areas of research.
- Knows scientific methods employed in inorganic chemistry.

Unit 1

Silicate Industries

(a) Glass: Glassy state and its properties, Classification (Silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass and photosensitive glass.

(b) Ceramics: Ceramic, their types and manufacture. High technology ceramics and their applications, super conducting and semi conducting oxides, fullerenes carbon nanotubes and carbon fiber, clays and feldspar.

(c) Cement: Classification of cement, ingredients and their role Manufacture of cement and the setting process, quick setting cements

(20 Lectures)

Unit 2

Surface Coatings

Objectives of surface coatings, preliminary treatment of surface and classification of surface coatings.


Metallic coatings (electrolytic and electroless), metal spraying and anodizing.
Unit 3

Batteries
Primary and secondary batteries, battery components and their role and Characteristics of Battery.
Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery.
Fuel Cells, Solar cell and polymer cell.

Unit 4

Alloys
Classification of alloys, Ferrous and Non- Ferrous alloys, Specific properties of elements in alloys.
Industrial manufacture of Steel (removal of silicon decarbonization, demagnetization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing).
Composition and properties of different types of steel.

Unit 5

Industrial Metallurgy
Preparation of metals (ferrous and nonferrous) and ultra pure metals for semiconductor technology.

Practical
1. Preparation of carbon nanotubes (CNTs).
2. Preparation of paints.
3. Determination of metal ions using complexometric titration.
4. Analysis of (Cu, Ni) (Cu, Zn) in alloy or synthetic samples.
5. Preparation of pigment (zinc oxide).
6. Study the loss of raw iron in acidic medium.
7. Study the loss of raw iron in basic medium.
References


Keywords: Glass, Ceramics, Cements, Surface coatings, Alloys, Primary and Secondary batteries, Fullerenes

Solutions, Phase Equilibrium, Conductance, Electrochemistry and Functional Group Organic Chemistry-II

Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lecture: Theory- 60, Practicals-60)

Objectives:

In Section A of this course students will learn about ideal and non-ideal solutions, Raoult's law, azeotropes, concept of EMF of a cell and measurement of emf of a cell. Nernst equation, Calculation of thermodynamic properties from EMF data. In Section B of this course, students will learn: carboxylic acids and their derivatives, key biomolecules like carbohydrates, amino acids and proteins.
Learning Outcomes:

Students will be able to learn:

- About reactions of acids and acid derivatives.
- Hoffman and Saytzeff elimination.
- Diazonium chemistry and use of diazonium salts in functional group transformations.
- Concept of zwitterion and isoelectric point in amino acids.
- Difference in primary, secondary and tertiary structure of proteins.
- Reactions of carbohydrates.
- Absolute configuration of monosaccharides.
- To understanding different complex reactions
- Synthesis and designing of new drugs.

Section A: Physical Chemistry-2 (30 Lectures)

Unit 1:

Solutions


(6 Lectures)

Unit 2:

Phase Equilibrium

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, FeCl3-H2O and Na-K only).

(6 Lectures)

Unit 3:

Conductance


(8 Lectures)

Unit 4:

Electrochemistry

(10 Lectures)

Section B: Organic Chemistry-3 (30 Lectures)

Unit 5:


(6 Lectures)

Unit 6:


(8 Lectures)

Practical:

Section A: Physical Chemistry

Phase Equilibria

1. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
2. Determination of critical solution temperature and composition of phenol water system and study the effect of impurities on it.

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations: a) Strong acid vs strong base b) Weak acid vs strong base.
Potentiometry

Perform the following potentiometric titrations: a) Strong acid vs strong base b) Weak acid vs strong base

Section B: Organic Chemistry

1. Systematic qualitative analysis of organic compounds possessing monofunctional groups: alcohols, phenols, carbonyl, acids, nitro, amide, amines, hydrocarbons and halo hydrocarbons and preparation of one derivative.
2. Determination of the concentration of glycine solution by formylation method.

References:

- I.L. Finar; Organic Chemistry (Vol 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Teaching Learning Process:

Conventional teaching methods as well as power point presentations. Group discussions.

Assessment Methods:

Student evaluation will be done on the basis of regular class test, assignments and presentations during the course.

Keywords:

Raoult's law, Lever rule, azeotropes, critical solution temperature, transference number, EMF, mutarotation, carbylamine test, starch, cellulose.

SEMESTER IV

INDUSTRIAL CHEMISTRY-4: PHARMACEUTICALS, FERMENTATION, PESTICIDES AND PERFUMES
(IndustrialChemistry1)
Core Course - (CC) Credit:6
Theory: Credits-04, Lectures-60 Practical: Credits-02, Lectures-60

Course Objective

The objectives of this paper are to provide basic knowledge of chemistry of pharmaceuticals, cosmetics, perfumes and pesticides considering their importance for human beings. This paper is designed in a manner that it forms a cardinal part of the learning of industrial chemistry for the students. The paper has been designed to impart the theoretical and practical knowledge on the basic chemistry and uses of various pharmaceuticals, cosmetic products and pesticides.
Course Learning Outcomes

1. Students will have sound knowledge of pharmaceuticals, cosmetics, perfumes and pesticides.

2. Students will become well equipped to design, carry out, record and analyze the industrial preparations

3. Students will understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing industrial chemists.

4. Become skilled in problem solving, critical thinking and analytical reasoning.

5. Are able to identify and solve chemical problems and explore new innovative areas of research.

6. Knows the proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures.

Unit 1

Drugs and Pharmaceuticals

Drug discovery, design and development; Retrosynthetic approach (with any two examples).

Synthesis of the representative drugs of the following classes: analgesics, antipyretics, anti-inflammatory agents (Aspirin, Paracetamol, Ibuprofen), antibiotics (Penicillin, Cephalosporin, Chloromycetin, Streptomycin and Chloramphenicol); antibacterial and antifungal agents (Sulphonamides, Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir). Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular drugs (Glyceryl trinitrate), antileprosy drug (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

(20 Lectures)

Unit 2

Cosmetics and Perfumes

Introduction to cosmetics and perfumes, preparation and uses of the following: Hair dye, hair spray. Shampoo. Sun-tan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours.

Essential oils and their importance in cosmetic industries with reference to Eugenol. Geraniol, Sandalwood oil, Eucalyptus, Rose oil, Jasmone, Civetone, Muscone

(15 Lectures)
Unit 3

**Pesticides**
Introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides.

Structure activity relationship, synthesis and technical manufacture, uses of representative pesticides in the following classes: Organochlorines (DDT, Gammaxene), Organophosphates (Malathion, Parathion), Carbamates (Carbofuran and carbaryl), Quinones (Chloranil), Anilides (Alachlor and Butachlor).

(15 Lectures)

Unit 4

**Fermentation**

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid; (ii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12, Vitamin C.

(10 Lectures)

Practical

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of nail enamel
4. Preparation of hair remover.
5. Preparation of face cream.
7. Preparation of nail polish and nail polish remover.
8. To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
11. Estimation of free acidity in ammonium sulphate fertilizers

References

Teaching Learning process

To accomplish a goal, it is very important to learn in a strategic manner. There are different components of learning and the capacity of each learner varies. ‘How’ to teach and ‘What’ to teach in the defined curriculum not only depends on the content and the knowledge of the teacher but critically more so on designing, i.e. how to introduce the concept to the students in a very effective way. Different ways of teaching include classical board teaching method, visual conceptual method, application based practical demonstration of the concept etc. In fact the pedagogy is to make a class interesting and thus learning becomes enjoyable.

Assessment Methods

The effectiveness of learning can be judged by assessing the students. Assessment can be in question answer form, quiz form, project form etc. Students should also engage in self-assessment and peer group learning activities.

Keywords: Drugs, Pharmaceuticals, Pesticides, Cosmetic Products, Perfumes, Flavours, Ingredients, Formulations, Raw materials,
Objectives:
The course aims to provide understanding about the general principle of Metallurgy, extraction and purification of s-, p-block elements. To understand the trends exhibited by s and p block elements and their compounds with emphasis on synthesis, structure, bonding and applications. Also to understand states of matter and interchange of states, intermolecular interactions and kinetics of chemical reaction, catalysis and photochemical reactions.

Learning Outcomes:
The students will be able:

- To learn the fundamental principles of metallurgy.
- To know about the diversity and fascination of inorganic chemistry through the properties and utilities of s- and p-block elements in the periodic table.
- To define the average and instantaneous rate of reaction.
- To discuss the postulates of kinetic theory of gases and derivation of kinetic gas equation.
- To discuss the surface tension and viscosity of liquids and determination of surface tension by using Stalagmometer and coefficient of viscosity by Ostwald Viscometer.
- To discuss different forms of solids, symmetry elements, unit cells and crystal systems.
- To explain the laws of crystallography.
- To be able to define rate of reactions and the factors that affect the rates of reaction.
- To understand the concept of rate laws e.g., order, molecularity, half life etc. and their determination.

Unit 1:

Section A – Inorganic Chemistry (Lectures-30)

General Principles of Metallurgy
Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.
Hydrometallurgy with reference to cyanide process for silver and gold, Methods of purification of metals (Al, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, van Arkel-de Boer process. Mond's process and Zone Refining.

(4 Lectures)
Unit 2:

s and p block elements

- Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Winker), and Allred-Rochow scales. Allotropy in C, S, and P.
- Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides, inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.
- Compounds of s- and p-Block Elements
- Diborane and concept of multicentre bonding
- Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial and environmental chemistry.
- Hydrides of nitrogen (NH₃, N₂H₄, N₃H, NH₂OH) Oxoacids of P, S and Cl.
- Halides and oxohalides: PCl₃, PCl₅, SOCl₂ and SO₂Cl₂

(26 Lectures)

Unit 3:

Section B: Physical Chemistry

Kinetic Theory of Gases

- 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, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(10 Lectures)

Unit 4:

Liquids

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)

(3 Lectures)
Unit 5:

Solids


(6 Lectures)

Unit 6:

Chemical Kinetics


Theories of Reaction Rates: Collision theory and Activated Complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only).

(11 Lectures)

Practical:

Section A: Inorganic Chemistry

Semi-micro qualitative analysis of mixtures using H₂S or any other scheme- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:
   Cations : NH₄⁺, Pb²⁺, Br⁻, Cu²⁺, Fe³⁺, Al³⁺, Co²⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, K⁺.
   Anions : CO₃²⁻, S²⁻, SO₃²⁻, NO₂⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₃⁻, SO₄²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻.
(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

(I) 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.
(II) Viscosity measurement (use of organic solvents excluded).
   a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
   b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
(III) Chemical Kinetics
   Study the kinetics of the following reactions by integrated rate method:
   a) Acid hydrolysis of methyl acetate with hydrochloric acid.
   b) Saponification of ethyl acetate.
References:

Theory:

- J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.

Practical:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- B.D. Khosla, Practical Chemistry

Teaching Learning Process:

- Through chalk and Talk method.
- Revising and asking questions from students at the end of class
- Motivating students to do some activity related to the topic
- Power point presentation
- To provide latest knowledge and skills to students.
- Correlating the topic with real life cases.
- Quiz contest among some important topic of syllabus

Assessment Methods:
To encourage students to visit one factory and prepare a report on that visit.

- Through assignment and test.
- To encourage students to prepare salient feature of the topic given by teacher and assessing them.
- Quizzes.
- Response of individual student throughout the year and at the end of class .
- Presentations.
- Essays.
- To write an article that is graded for content and style.

Keywords
Metallurgy, Periodicity,Anomalous behaviour , Ellingham diagrams, Hydrometallurgy , Periodicity , Allotropy, Diagonal relationship, Multicentre bonding , Kinetic Theory, Arrhenius Equation, Bravais Lattice, Miller indices,
DISCIPLINE ELECTIVE COURSES (DSE)
CHEMISTRY (Choose any two)

Applications of Computers in Chemistry

Chemistry DSE 2-4(i)

Total Credits: 06  (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory-60)

Objectives:

The aim of the paper is to make the students of chemistry familiar with the working of computer, programming language, QBASIC and use of software as a tool to understand chemistry, and solve chemistry based problems.

Learning Outcomes:

After completing the course the student should be able to:

1. Have knowledge of most commonly used commands and library functions used in QBASIC programming.
2. Develop algorithm to solve problems and write corresponding programs in BASIC.
3. Write BASIC programs for performing calculations involved in laboratory experiments and research work.
4. Use various spreadsheet software to perform calculations and plot graphs.

Unit 1:

Basic Computer system (in brief)

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS,
Unit 2:

Use of Programming Language for solving problems in Chemistry

Computer Programming Language - QBASIC, (for solving some of the basic and complicated chemistry problems). QB4 version of QBASIC can be used.

Programming Language – QBASIC; arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the following QBASIC commands: INPUT and PRINT; GOTO, IF, ELSEIF, THEN and END IF; FOR and NEXT; Library Functions (ABS, ASC, CHR$, EXP, INT, LOG, RND, SQR, TAB and trigonometric Functions), DIM, READ, DATA, REM, RESTORE, DEF FNR, GOSUB, RETURN, SCREEN, VIEW, WINDOW, LINE, CIRCLE, LOCATE, PSET

Simple programs using above mentioned commands.

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods, binary bisection and Regula Falsi); Numerical differential, Numerical integration (Trapezoidal and Simpson’s rule), Simultaneous equations, Matrix addition and multiplication, Statistical analysis.

QBASIC programs for Chemistry problems - Example: plotting van der Waal Isotherms (Simple Problem, available in general text books) and observe whether van der Waal gas equation is valid at temperatures lower than critical temperature where we require to solve a cubic equation and calculation of area under the curves (Complicated Problem, not available in general text books).

(40 Lectures)

Unit 3:

Use of Software Products

Computer Software like Scilab, Excel, LibreOffice Calc, etc., to solve some of the plotting or calculation problems. Handling of experimental data

(15 Lectures)

Practical:
(Credits: 2, Lectures: 60)

- **Computer programs using QBASIC based on numerical methods**
  1. Roots of equations: (e.g. volume of gas using van der Waals equation and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy/enthalpy change from heat capacity data).
4. Probability distributions (gas kinetic theory) and mean values.
5. Mean, standard deviation and Least square curve fitting method for linear equation.
6. Matrix operations: addition, multiplication and transpose
7. Graphic programs related to Chemistry problems. e.g. van der Waals isotherm, Compressibility versus pressure curves, Maxwell distribution curves, concentration-time graph, pH metric titration curve, conductometric titration curves, Lambert Beer’s law graph, s, p, d orbital shapes, radial distribution curves, particle in one dimensional box.

- **Use of Software Products**

1. Computer Software like Scilab and Excel, etc for data handling and manipulation.
2. Simple exercises using molecular visualization software.
3. Open source chemistry software to draw structures.

**References:**

- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001)

**Teaching Learning Process:**

Since the course involves programming and use of software, the teaching learning process becomes more efficient when the theory classes are well coordinated with practical exercises. Once the students learn BASIC commands, they may be encouraged to make their own programs. 

QBASIC is a DOS based language which does not run on 64 bits Windows and Linux based operating systems. This problem can be solved by using DOSBOX emulator for different operating systems and running QB45 in it. 

Another version which runs on WINDOWS is QB64. This is compatible with most of the QBASIC commands.

**Assessment Methods:**

- The students to be assigned projects based on chemistry problems done in class or in practical classes and use BASIC program to solve it. The projects to be a part of internal assessment.
- Presentation
- Test
- Semester end examination
Keywords:

Hardware, software, programming language, ASCII, BCD, QBASIC, Library commands, mathematical operators, QBASIC commands

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Analytical Methods in Chemistry

Chemistry DSE 2-4(ii)

Total Credits: 06  
(Credits: Theory-04, Practicals-02)
(Total Lectures: Theory-60)

Objectives:

The objective of this course is to make student aware of the:

1. Concept of sampling, Accuracy, Precision, Statistical test data-F, Q, and t test.
2. The course exposes students to the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectra. Thermal and electroanalytical methods of analysis are also dealt with. Students are exposed to important separation methods like solvent extraction and chromatography. The practicals expose students to latest instrumentation and they learn to detect analytes in a mixture.

Learning Outcomes:

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

1. How to perform experiment with accuracy and precision.
2. Develop methods of analysis for different samples independently.
3. Test contaminated water samples.
4. Understand basic principle of instrument like Flame Photometer, UV-VISIBLE.
5. Learn separation of analytes by chromatography.
6. Apply knowledge of geometrical isomers and keto-enol tautomers to analysis.
Unit 1:

Qualitative and quantitative aspects of analysis:
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression. Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit 2:

Optical methods of analysis

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Lambert-Beer law...

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

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.

Unit 3:

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

Unit 4:

Electroanalytical methods:
Classification of electroanalytical methods, 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.

Unit 5:

Separation techniques:
Solvent extraction:
Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation, 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 non-aqueous media.
Chromatography:
Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion exchange, Development of chromatograms: frontal, elution and displacement methods.

(Lectures: 15)

References:

Theory:

- Dilts, R.V. Analytical Chemistry – Methods of separation Van Nostrand 1974

Practical:

(Credits: 2, Lectures: 60)

Teaching Learning Process:

- Teaching through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Presentations by Individual Student/ Small Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- Objective type Chemical quizzes based on contents of the paper.
- End semester University Theory and Practical Examination
Keywords:

Separation techniques, Solvent extraction, ion-exchange, Optical methods, Flame Atomic Absorption and Emission Spectrometry, indeterminate errors, statistical test of data; F, Q and t tests.

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Molecular Modelling and Drug Design

(Chemistry DSE 2-4(iii))

Total Credits: 06  
(Credits: Theory-04, Practicals-02)

(Total Lectures: Theory- 60)

Objectives:

Objective of this course is to make students learn the theoretical background of principles of computational techniques in molecular modelling, evaluation and applications of different methods for various molecular systems, energy minimization techniques, analysis of Mulliken Charge & ESP Plots and elementary idea of drug design.

Learning Outcomes:

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

Able to understand theoretical background of computational techniques, selective application to various molecular systems, draw energy minimization, ESP Plots by suitable softwares, electron rich and electron deficient sites, compare computational and experimental results and explain deviations.

Unit 1:

Introduction: Overview of Classical and Quantum Mechanical Methods (Ab initio, Semi-empirical, Molecular Mechanics, Molecular Dynamics and Monte Carlo). General considerations.

Coordinate systems: Cartesian and Internal Coordinates, Bond lengths, bond angles and torsion angles, Writing Z-matrix (ex: methane, ethane, ethene, ethyne, water, \( \text{H}_2\text{O} \) \( \text{\text{,}} \) 5 classes)

(Lectures: 06)

Unit 2:

Potential Energy Surfaces: Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, concept of transition state with examples: Ethane, propane, butane, cyclohexane. Meaning of rigid and relaxed PES.
Applications of computational chemistry to determine reaction mechanisms.


(Lectures: 12)

**Unit 3:**

**Molecular Mechanics**: Force Fields, Non-bonded interactions (van der Waals and electrostatic), how to handle torsions of flexible molecules, van der Waals interactions using Lennard-Jones potential, hydrogen bonding interactions, electrostatic term, Parameterization. Applications of MM, disadvantages, Software, Different variants of MM: MM1, MM2, MM3, MM4, MM+, AMBER, BIO+, OPLS.GUI.

(Lectures: 10)

**Unit 4:**


Brief introduction to Langevin and Brownian dynamics.

**Monte Carlo Method**: Metropolis algorithm.

(Lectures: 10)

**Unit 5:**

**Huckel MO** with examples: ethane, propenyl, cyclopropenyl systems. Properties calculated – energy, charges, dipole moments, bond order, electronic energies, resonance energies, Oxidation and reduction (cationic and anionic species of above systems)

Extension to Extended Huckel theory and PPP methods.

**Ab-initio methods**: Writing the Hamiltonian of a system, Brief recap of H – atom solution, Units in quantum mechanical calculations, Born-Oppenheimer approximation (recap), Antisymmetry principle, Slater determinants, Coulomb and Exchange integrals,

Examples of He atom and hydrogen molecule, Hartree-Fock method

Basis sets, Basis functions, STOs and GTOs, diffuse and polarization functions. Minimal basis sets.

Advantages of ab initio calculations. Koopman’s theorem, Brief idea of Density Functional Theory.

(Lectures: 12)

**Unit 6:**
Semi-empirical methods:  Brief idea of CNDO, INDO, MINDO/3, MNDO, AM1, PM3 methods. Other file formats – PDB. Visualization of orbitals – HOMO, LUMO, ESP maps etc.

QSAR: Structure-activity relationships. Properties in QSAR (Partial atomic charges, polarizabilities, volume and surface area, log P, lipophilicity and Hammet equation and applications, hydration energies, refractivity). Biological activities (LD50, IC50, ED50 etc).

(Lectures: 8)

Practicals:

1. Plotting a 3D graph depicting a saddle point in a spreadsheet software.
2. Determine the enthalpy of isomerization of cis and trans 2-butene.
3. Determine the heat of hydrogenation of ethylene.
5. Perform a conformational analysis of butane.
6. Compare the basicities of the nitrogen atoms in ammonia, methylamine, dimethylamine and trimethylamine by comparison of their Mulliken charges and ESP maps.
7. Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

\[
\text{BH}^+ + \text{NH}_3 \rightarrow \text{B} + \text{NH}_4^+
\]

where \( \text{B} = \text{CH}_3\text{NH}_2, \ (\text{CH}_3)_2\text{NH}, \ (\text{CH}_3)3\text{N} \)
8. 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.
9. Compare the optimized bond angles \( \text{H}_2\text{O}, \text{H}_2\text{S}, \text{H}_2\text{Se} \) using PM3.
10. Compare the HAH bond angles for the second row hydrides (\( \text{BeH}_2, \text{CH}_4, \text{NH}_3, \text{H}_2\text{O} \)) and compare with the results from qualitative MO theory.
11. (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 how the shapes affect the trend in boiling points: \( 118 \ °\text{C}, 100 \ °\text{C}, 108 \ °\text{C}, 82 \ °\text{C}, \) respectively.
12. Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
13. Plot the electrostatic potential mapped on electron density for benzene and use it to predict the type of stacking in the crystal structure of benzene dimer.
14. Predict the aromaticity of thiophene with respect to benzene by comparing the enthalpies of the following reactions:
   (a) Hydrogenation of benzene to 1,3-cyclohexadiene and then 1,3-cyclohexadiene to cyclohexene.

(b)

15. Docking of Sulfonamide-type D-Glu inhibitor into MurD active site using Arguslab.

Note: Software: ArgusLab (www.planaria-software.com).
Recommended Texts:

References:
Theory:

1. E. Lewars, Computational Chemistry, Kluwer academic Publisher, 2003
3. Alan Hinchcliffe, Modelling Molecular Structures, John wiley & Sons, 1996

Practicals:


Keywords:

Molecular modelling, Quantum Mechanical Method, Cartesian Coordinates, Molecular Dynamics, Force Field, Softwares of Computational Chemistry.

Novel Inorganic Solids

Chemistry - DSE 1 (i)
Total Credits: 06
(Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60)

Objectives:

Solid-state chemistry also referred as material chemistry currently has emerged with great focus on novel inorganic solids. It has found enormous applications in both industrial and research arenas and have helped to shape modern day recyclable adsorbents and catalysts. Novel inorganic-organic hybrid nanocomposites have received a lot of attention because of their abundance and cost-effective nature they can be utilized as catalysts, as a nano reactor to host reactants for synthesis and for the controlled release of biomolecules. Materials such as semiconductors, metals, composites, nanomaterials, carbon or high-tech ceramics make life easier in this era and are great sources of industrial growth and technological changes. Therefore, its exposure to the undergraduates with science backgrounds can groom them for future researches.

Course Learning Outcomes:

By the end of the course, the student would be able to:
(i) Understand the mechanism of solid-state synthesis.
(ii) Explain about the different characterization techniques and their principle.
(iii) Understand the concept of nanomaterials, their synthesis and properties.
(iv) Explain the mechanism of growth of self-assembled nanostructures.
(v) Appreciate the existence of bioinorganic nanomaterials.
(vi) Explain the importance of composites, conducting polymers and their applications.
(vii) Understand the usage of solid materials in various instruments, batteries, etc. which help them to appreciate the real life importance of these materials

**Unit 1:**

**Basic introduction of solid-state chemistry:** Semiconductors, different types of semiconductors and their applications.

**Synthesis and modification of inorganic solids:** Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Ion-exchange and Intercalation method.

(10 Lectures)

**Unit 2:**

**Characterization techniques of inorganic solids:** Powder X-ray Diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier-Transform Infrared (FTIR) spectroscopy, Brunauer–Emmett–Teller (BET) surface area analyser, Dynamic Light Scattering (DLS)

(10 Lectures)

**Unit 3:**

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments.

One-dimensional metals, molecular magnets, inorganic liquid crystals.

(10 Lectures)

**Unit 4:**

**Nanomaterials:** Overview of nanostructures and nanomaterials, classification, preparation and optical properties of gold and silver metallic nanoparticles, concept of surface plasmon resonance, carbon nanotubes, inorganic nanowires, Bioinorganic nanomaterials, DNA and its nanomaterials, natural and artificial nanomaterials, self-assembled nanostructures, control of nanoarchitecture, one dimensional control.

(10 Lectures)

**Unit 5:**

(10 Lectures)

Unit 6:

Speciality polymers:

Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene, polyaniline and polypyrrole, applications of conducting polymers, ion-exchange resins and their applications.

Ceramic & Refractory:

Introduction, classification, properties, manufacturing and applications of ceramics, refractory and superalloys as examples.

(10 Lectures)

Practical:

(Credits: 2, Lectures: 60)

CHEMISTRY PRACTICAL - DSE LAB: NOVEL INORGANIC SOLIDS

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.

2. Synthesis of silver nanoparticles by green approach methods and characterization using UV-visible spectrophotometer.


5. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.

6. Synthesis of inorganic pigments (PbCrO₄, ZnCrO₄, Prussian Blue, Malachite).

7. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

8. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.
References:

Theory

- West, A. R., Solid State Chemistry and Its Application, Wiley
- West, A. R., Application of Solid State Chemistry, Wiley

Practical

- Industrial Inorganic Pigments edited by Gunter Buxbaum, Wiley-VCH

Additional Resources:

https://www.youtube.com/watch?v=RuyP9kqRcLg

https://www.youtube.com/watch?v=BGPaywY1wvs

https://www.youtube.com/watch?v=x5OD2KZXd54

Teaching Learning Process:

Blackboard, Power point presentations, Assignments, Field Trips to Industry, Different working models ICT enabled classes, Interactive sessions, Debate, recent literature using internet and research articles

Assessment Methods:

Written Examination, Presentations, Quiz
Keywords:

Research Methodology for Chemistry

Chemistry DSE 2-4 (v)
Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory-75, Tutorial-1)

Objectives:
The objective of this paper is to formulate the research problems and connect the research outcomes to the society. It further helps in gaining the knowledge of safety and ethical handlings of chemicals in lab and households.

Learning Outcomes:
By the end of the course, the students will be-

1) Able to identify research problems.
2) Able to find out local solution.
3) Able to communicate the research at appropriate level.

Unit 1:
Literature Survey:
Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

(20 Lectures)

Unit 2:
Methods of Scientific Research and Writing Scientific Papers:

Reporting practical and project work. Idea about public funding agencies of research, Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism. Assessment of locally available resources.

(20 Lectures)

Unit 3:

Chemical Safety and Ethical Handling of Chemicals:

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals. Hazardous Chemicals in Households.

(12 Lectures)

Unit 4:

Data Analysis:

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.


(13 Lectures)

Exposure of chemistry softwares:

Chemistry Students must be given exposure to applications of molecular modelling softwares e.g. Hyperchem, Schrodinger etc. Hands on experiments of docking.

(10 Lectures)

References

Theory:
• Harris, D. C. *Quantitative chemical analysis. 6th Ed.*, Freeman Chapters 3-5, 2007.
• OSU safety manual 1.01.

**Additional Resources:**

• Introductory Biostatistics by Chap T Le.

**Teaching Learning Process**

• Lecture with conventional teaching aids, presentations, invited talks on thrusting areas, group discussions

**Assessment Methods**

• writing review on identified research problem
• Poster presentation
• university examination

75 % University Exam and 25 % Internal Assessment( Assignment, regularity and presentation)

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**Chemistry of d-Block Elements, Quantum Chemistry and Spectroscopy**

**Total Credits: 06** (Credits: Theory-04, Practicals-02)
(Total Lecture: Theory- 60, Practicals-60)

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**Objectives:**

Inorganic (Section A):
The course introduces the students to d and f block elements and highlights the concept of horizontal similarity in a period and stresses on their unique properties. It also familiarizes them with coordination compounds which find manifold applications in diverse fields.

Physical (Section B):

1. With the concepts and methodology of quantum mechanics.
2. Its applications to spectroscopy.
3. Basic knowledge of relation between structure determination and spectra.

Learning Outcomes:

The student is expected to learn/understand the following:

1. Properties of d and f block elements
2. Latimer Diagrams
3. Properties of coordination compounds
4. VBT and CFT for bonding in coordination compounds
5. Basic principles of quantum mechanics : operators, eigen values, averages, probability distributions.
6. Quantisation of translational, rotational and vibrational energies
7. Basic concepts of microwave, IR and UV-VIS spectroscopy

Unit 1:

Transition Elements (3d series)

General properties of elements of 3d series with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties and ability to form complexes. A brief introduction to Latimer diagrams (Mn, Fe and Cu) and their use to identify oxidizing, reducing species and species which disproportionate. Calculation of skip step potentials.

Lanthanoids and actinoids: Electronic configurations, oxidation states displayed. A very brief discussion of colour and magnetic properties. Lanthanoid contraction(causes and consequences), separation of lanthanoids by ion exchange method.

(10 Lectures)

Unit 2:

Coordination Chemistry

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

(6 Lectures)
Unit 3:

Bonding in coordination compounds

Valence Bond Theory (VBT): salient features of theory, Concept of Inner and outer orbital complexes of Cr, Fe, Co and Ni. Drawbacks of VBT

Crystal Field Theory


(14 Lectures)

Unit 4:

Quantum Chemistry

1. Postulates of quantum mechanics, quantum mechanical operators.
2. Free particle. Particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy.
3. Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.
4. Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels

(12 Lectures)

Unit 5:

Spectroscopy

- Microwave (pure rotational) spectra of diatomic molecules. Selection rules. Structural information derived from rotational spectroscopy.

(12 Lectures)
Unit 6:

Photochemistry


(6 Lectures)

Practical:

Section A: Inorganic Chemistry

- Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
- Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
- Estimation of total hardness of a given sample of water by complexometric titration.
- Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} - phenanthroline complex in solution by Job’s method.

Section B: Physical Chemistry

UV/Visible spectroscopy

- Study the 200-500 nm absorbance spectra of KMnO_{4} and K_{2}Cr_{2}O_{7} (in 0.1 M H_{2}SO_{4}) and determine the \lambda_{\text{max}} 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 K_{2}Cr_{2}O_{7}.
- 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 of organic compounds.

Colorimetry

- Verify Lambert-Beer’s law and determine the concentration of CuSO_{4}/KMnO_{4}/K_{2}Cr_{2}O_{7} in a solution of unknown concentration
- Analyse the given vibration-rotation spectrum of HOI(g)

References:

- J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
• A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
• B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

Additional Resources:

Teaching Learning Process:
• Lectures to introduce a topic and give its details.
• Discussions so that the student can internalize the concepts.
• Problem solving to make the student understand the working and application of the concepts.

Assessment Methods:
There should be a multi-pronged approach for evaluating a student's understanding of the key concepts. Some of the methods that can be used are:

• Class assignments
• Short quiz
• Presentations

Keywords:
d block, actinoids, lanthanoids, VBT, crystal field theory, splitting of d levels, coordination compounds, quantisation, selection rules, Schrodinger equation, operator, spectrum, quantum efficiency, fluorescence.

Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy

Total Credits: 06  (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)
Objectives:

The purpose of the course is to introduce students of Honours courses other than Chemistry to some important 3d metals and their compounds which they are likely to come across. 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. The topics of Polynuclear and Heteronuclear aromatic hydrocarbons are introduced through some specific examples. The learners are introduced to Spectroscopy, an important analytical tool which allows identification of organic compounds without the aid of reagents.

Learning Outcomes:

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

- Understand the chemistry of the different oxidation states of 3d metals
- Get an idea of the preparation and important properties of the familiar compounds potassium dichromate, potassium permanganate and potassium ferrocyanide
- Bonding in organometallic compounds
- Use IR data to explain the extent of back bonding in carbonyl complexes
- Recognize the role of metal ions present in biological systems with special reference to Na^+, K^+, Mg^{2+}, Fe ions
- Get a general idea of toxicity of metal ions through the study of Hg^{2+} and Cd^{2+} in the physiological system
- The concept of aromaticity and resonance
- The preparation, reactions, structure elucidation and toxicity of these aromatic compounds
- A new tool for identifying the functional group in organic compounds: Spectroscopy.
- The basic theoretical principles underlying UV-visible and IR spectroscopy and their application to qualitative organic analysis in lieu of reagents used for identification of functional groups.

Unit 1:

Chemistry of 3d metals

General discussion of 3d metals. Oxidation states displayed by Cr, Fe, Co, Ni and Cu. A study of the following compounds (including preparation and important properties):

- \( \text{K}_2\text{Cr}_2\text{O}_7 \)
- \( \text{KMnO}_4 \)
- \( \text{K}_4[\text{Fe(CN)}_6] \)

(6 lectures)

Unit 2:

Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise’s salt. Structure and physical properties of ferrocene. 18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. pi-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.
Unit 3:

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. Brief introduction to oxygen transport and storage (haemoglobin-myoglobin system). Brief introduction about toxicity of metal ions (Hg\(^{2+}\) and Cd\(^{2+}\)).

(12 lectures)

Unit 4:

Polynuclear aromatic compounds

Naphthalene: Aromaticity, resonance and toxicity; preparation using Haworth synthesis; structure elucidation. Reactions of naphthalene: reduction, oxidation, electrophilic substitution and Charge transfer complex formation (picrate).

Anthracene: Aromaticity, resonance and toxicity; preparation using Friedel-Crafts reaction and Diels-Alder reaction. Reactions of anthracene: reduction, oxidation, addition (Diels-Alder reaction), reaction with alkali metals, electrophilic substitution and charge transfer complex formation (picrate).

(6 lectures)

Unit 5:

Heteronuclear aromatic compounds

Study of the following compounds: furan, pyrrole, thiophene and pyridine. Special emphasis has to be given to the following aspects: aromaticity, resonance and toxicity; basicity of pyrrole and pyridine; Hantzsch synthesis of pyrrole and pyridine; reduction, oxidation, addition reactions (Diels-Alder reaction) and electrophilic substitution reactions; nucleophilic substitution reactions of pyridine.

(6 lectures)

Unit 6:

- UV-Visible and Infrared Spectroscopy and their application to Simple Organic Molecules
- Electromagnetic radiations and their properties; Double Bond Equivalence and Hydrogen deficiency
- **UV-Visible Spectroscopy (Electronic Spectroscopy)**: General electronic transitions, $\lambda_{\text{max}}$ & $\varepsilon_{\text{max}}$, chromophores & auxochromes, bathochromic & hypsochromic shifts. Application of Woodward Rules for calculation of $\lambda_{\text{max}}$ for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; $\alpha,\beta$-unsaturated aldehydes and ketones, charge transfer complex.
- **Infrared (IR) Spectroscopy**: Infrared radiation and types of molecular vibrations, significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on $>\text{C}=\text{O}$ stretching absorptions).

(18 Lectures)

**Practical:**

**Section A: Inorganic Chemistry**

1. Separation of mixtures of two ions by paper chromatography and measurement of $Rf$ value in each case:
   - Fe$^{3+}$, Al$^{3+}$ and Ni$^{2+}$, Co$^{2+}$, Mn$^{2+}$ and Zn$^{2+}$
2. Preparation of the following complexes and measurement of their conductivity:
   - (i) Tetraamminecopper(II) sulphate
   - (ii) Potassium trioxalatoferrate(III) trihydrate

**Section B: Organic Chemistry**

1. Flame Test for different aromatic hydrocarbons
2. Preparation of picrate of naphthalene/ anthracene (Compare the UV-Visible spectra of the reactants and the picrate formed)
3. Simple tests for the functional group identification of the monofunctional organic compounds containing the groups: carboxylic acid, alcohol, phenol, aldehyde and ketone.
4. Identification of simple organic compounds containing the above functional groups by IR spectroscopy through examination of spectra (spectra to be provided).

**References:**

**Theory:**

- J.D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S

**Practical:**

- V.K. Ahluwalia, Sunita Dhingra and Adarsh Gulati: *College Practical Chemistry*,
University Press (India) Ltd. (2005).

Additional Resources:


Keywords

3d metals; Organometallic Chemistry; Metal Carbonyl; Ferrocene; 18-electron rule; synergic bonding; Bioinorganic Chemistry; sodium potassium pump; haemoglobin-myoglobin system; polynuclear hydrocarbons; heteronuclear hydrocarbons; aromaticity; toxicity; UV-visible spectroscopy; IR spectroscopy; charge transfer spectra

Molecules of Life

Total Credits: 06
(Credits: Theory-04, Practicals-02)  
(Total Lectures: Theory- 60, Practicals-60)

Objectives:

1. To deliver information about biochemically significant features of the chemistry of carbohydrates, proteins, enzymes, nucleic acids and lipids, using suitable examples. This includes classification, reaction chemistry and biological importance of biomolecules.
2. To extend the knowledge of synthetic organic chemistry to chemistry of biomolecules
3. Key emphasis is placed on understanding the structural principles that govern reactivity/physical/biological properties of biomolecules as opposed to learning structural detail.

Course Learning Outcomes:

1. Students will be able to understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
2. The students will gain an insight into mechanism of enzyme action and inhibition.
3. The students will understand the basic principles of drug-receptor interaction and SAR.
4. The students gain an insight into biological processes like replication, transcription, and translation.
5. Students will be able to demonstrate an understanding of metabolic pathways, their inter-relationship, regulation, and energy production from biochemical processes.

Unit 1:

Carbohydrates


(10 Lectures)

Unit 2:

Amino Acids, Peptides and Proteins

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. 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 (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Denaturation of proteins.

(12 Lectures)

Unit 3:

Enzymes and correlation with drug action


(10 Lectures)

Unit 4:

Nucleic Acids

Components of Nucleic acids: Adenine, Guanine, Thymine, Cytosine and Uracil (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), difference between DNA and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

(10 Lectures)

Unit 5:

Lipids

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, Trans fats, Hydrogenation, Hydrolysis, Acid value, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(8 Lectures)

Unit 6:

Concept of Energy in Biosystems


(8 Lectures)

Practical:

1. Separation of amino acids by paper chromatography
2. Study of titration curve of glycine and determination of its isoelectric point.
3. Estimation of proteins by Lowry's method
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. Qualitative tests for carbohydrates- Molisch test, Barfoed's reagent test, rapid furfural test, Tollen's test and Fehling solution test (Only these tests are to be done in class)
9. Qualitative tests for proteins
10. Extraction of DNA from onion/cauliflower

References:

Theory:

- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
Practical:

- Introduction to Practical Biochemistry by S K Swahney and Randhir Singh, Nerosa Publications.

Teaching Learning Process:

- The teaching learning process will involve the traditional chalk and black board method.
- Certain topics like Mechanism of enzyme action and enzyme inhibition, transcription and translation etc. where traditional chalk and talk method may not be able to convey the concept, are taught through audio-visual aids.
- Students are encouraged to participate actively in the classroom through regular presentations on curriculum based topics.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

Students evaluation done on the basis of regular class test and assignments during the course as per the curriculum.

Keywords:

Biomolecules, Enzymes, Mechanism of enzyme action and inhibition, SAR, Drug Receptor Theory, Energy concept in biological system, catabolic pathways and their inter-relationship.

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DISCIPLINE ELECTIVE COURSES (DSE)
INDUSTRIAL CHEMISTRY

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Green Chemistry
Objectives:

Today's society is moving towards becoming more and more environmentally conscious. There is rising concern of environmental pollution, depleting resources, climate change, ozone depleting, heaps and heaps of landfill s piling up, legislation which is getting stringent with strict environmental laws, rising cost of waste deposits and so on. We are faced with a challenge to work towards sustainable practices. Green chemistry has arisen from these concerns. It is not a new branch of chemistry but the way chemistry should be practiced. Innovations and applications of green chemistry in education has helped companies not only environmental benefits but at the same time achieve economic and societal goals also. This is possible because these undergraduate students are ultimate scientific community of tomorrow.

Learning Outcomes:

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

1. Understand the twelve principles of green chemistry and will build the basic understanding of toxicity, hazard and risk of chemical substances.
2. Understand stoichiometric calculations and relate them to green chemistry metrics. They will learn about atom economy and how it is different from percentage yield.
3. Learn to design safer chemical, products and processes that are less toxic, than current alternatives. Hence, they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harm you".
4. Understand benefits of use of catalyst and bio catalyst, use of renewable feed stock which helps in energy efficiency and the environment, renewable energy sources, importance led reactions in various green solvents.
5. Appreciate the use of green chemistry in problem solving skills, critical thinking and valuable skills to innovate and find out solution to environmental problems. Thus the students are able to realise that chemistry can be used to solve rather than cause environmental problems.
6. Green chemistry is a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. Success stories and real world cases also motivate them to practice green chemistry. These days customers are demanding to know about a product: Is it green? Does it contribute to global warming? Was it made from non depletable resources? Students have many career opportunities as "green" is the path to success.

Unit 1:

Introduction to Green Chemistry

What is Green Chemistry? Some important environmental laws, pollution prevention Act of 1990, emergence of green chemistry, Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry

(5 Lectures)
Unit 2:

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry and their explanation with examples

Special emphasis on the following:

- Designing a Green Synthesis using these principles; Prevention of Waste/ by products: maximum incorporation of the materials used in the process into the final products, Environmental impact factor
- Green metrics to assess greenness of a reaction, e.g. 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 x exposure: waste or pollution prevention hierarchy
- Designing safer chemicals with minimum toxicity yet has the ability to perform the desired functions
- Green solvents: super critical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, solvents obtained from renewable resources and how to compare greenness of solvents
- Energy requirements for reactions – alternative sources of energy: use of microwaves, ultrasonic energy and photochemical energy
- Selection of starting materials; should be renewable rather than depleting
- Avoidance of unnecessary derivatization – careful use of blocking/protecting groups
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, bio catalysis, asymmetric catalysis and photo catalysis.
- Design for degradation: A product should not persist after the commercial function is over e.g. soaps and detergents and some more
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route o carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

(25 Lectures)

Unit 3:

Examples of Green Synthesis/ Reactions

- Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
- Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
- Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

(10 Lectures)

Unit 4:
Real world case studies based on the Presidential green chemistry awards of EPA

- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
- A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic out of pressure treated wood.
- An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
- Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.
- Using a naturally occurring protein to stimulate plant growth, improve crop quality, increase yields, and suppress disease.

(10 Lectures)

Unit 5:

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimcry and green chemistry, biomimetic, multifunctional reagents , combinatorial green chemistry, mechanochemical and solvent free synthesis of inorganic complexes; co crystal controlled solid state synthesis (C²S³); Green chemistry in sustainable development.

(10 Lectures)

Practical:
(Credits: 2, Lectures: 60)

CHEMISTRY PRACTICAL - DSE LAB: GREEN CHEMISTRY
Characterization by m. pt., U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method should be done (wherever applicable).

1. Safer starting materials
Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

2. Using renewable resources
Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.

3. Use of enzymes as catalysts
Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

1. Alternative Green solvents
   - Extraction of D-limonene from orange peel using liquid CO₂ prepared form dry ice.
   - Mechanochemical solvent free, solid–solid synthesis of azomethine using p- toluidine and o-vanillin/p-vanillin (various other combinations of primary amine and aldehyde can also be tried).

2. Alternative sources of energy
• Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
• Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

3. Reducing waste

Designing and conducting an experiment by utilizing the products and by products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey. Some representative examples:

• Use of nanoparticles as catalyst for a reaction
• Benzoin converted into Benzil and Benzil into Benzilic acid by a green method
• Use of azomethine for complex formation
• Rearrangement reaction from Benzopinacol to Benzopinacolone
• Conversion of byproduct of biodiesel to a useful product

References:

Theory:

• M. C. Cann and ,Thomas P Umile, Real world cases in Green chemistry vol 11, American chemical Society,Washington (2008)
• http// Biomimicry.org/askingnature

Practical:

• Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. Indu Tucker Sidhwan et al. University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1,February 2015, ISSN: 2395-2334

Teaching Learning Process:

• Conventional chalk and board teaching
• Power point presentations
Interactive sessions
- Literature survey and critical thinking to design to improve a traditional reaction and problem solving
- Visit to a green chemistry lab
- Some motivating short movies in green chemistry especially in bio mimicry

Assessment Methods:
- Presentation by students
- Class Test
- Written Assignment
- End Semester University Theory and Practical Exams

Keywords:
Green chemistry, 12 principles of green chemistry, atom economy, waste minimization, green metric, green solvents, solvent free, catalyst, bio-catalyst, renewable energy sources, hazardous, renewable feedstock, ionic liquids, supercritical fluids, inherent safer design, green synthesis, co-crystal controlled solid state synthesis, sustainable development, Presidential green chemistry awards

Industrial Chemicals and Environment

(Chemistry DSE 2-4(vii))
Total Credits: 06
(Credits: Theory-04, Practicals-02)
(Total Lectures: Theory-60)

Objectives:
The objective of this course is to make students aware about the following concepts:

- Different gases and their industrial production, uses, storage and hazards.
- Manufacturing, applications, analysis and hazards of the Inorganic Chemicals.
- Preparation of Ultra-Pure metals for semiconducting technology.
- Air and Water pollution, control measures for Air and Water Pollutants.
- Catalyst and Biocatalyst.
- Energy and Environment.

**Learning Outcomes:**

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

1. What are the different toxic gases and their toxicity hazards.
2. Safe design systems for large scale production of industrial gases.
3. How Inorganic chemicals are manufactured, handled, stored.
5. Why Ultra-Pure metals are required for the semiconducting technologies.
6. Composition of air, various Air Pollutants, Control measures of Air Pollutants.
7. Effects of Air Pollutants: Global Warming, Ozone Depletion
8. Different Sources of Water, Water quality parameters, Impacts of Water Pollution.
9. Water treatment and purification methods.
10. Different industrial effluents and their treatment methods.
11. Different Sources of Energy.
12. How nuclear waste is generated and its disposal?
   Study of nuclear disasters.
13. What is Green Chemistry and its importance in Chemical Industries?
   Use of Biocatalyst in Chemical industries.

**Unit 1:**

**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, and sulphur dioxide.

(6 Lectures)

**Unit 2:**

**Inorganic Chemicals:** Manufacture, applications, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potassium dichromate and potassium permanganate

(10 Lectures)

**Unit 3:**
**Industrial Metallurgy:** Preparation of ultrapure metals for semiconductor technology.

(4 Lectures)

**Unit 4:**

**Environment and its segments**


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. Major sources of air pollution. Pollution by $\text{SO}_2$, $\text{CO}_2$, $\text{CO}$, $\text{NO}_x$, $\text{H}_2\text{S}$ and other foul smelling gases. Methods of estimation of $\text{CO}$, $\text{NO}_x$, $\text{SO}_x$ and control procedures. Effects of air pollution on living organisms and vegetation.

Greenhouse effect and Global warming,

Environmental effects of ozone, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens,

Air pollution control. Settling Chambers, Venturi Scrubbers, Cyclones, Electrostatic Precipitators (ESPs).

(15 Lectures)

**Unit 5:**

**Water Pollution:**

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.

Sludge disposal. Industrial waste management, incineration of waste.

Water treatment and purification (reverse osmosis, electro dialysis, ion exchange).

Water quality parameters for wastewater, industrial water and domestic water.

(15 Lectures)

**Unit 6:**

**Energy & Environment:**


Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysis: Importance in Green Chemistry and Chemical Industry.

(10 Lectures)

**References:**

• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

Practical:
(Credits: 2, Lectures: 60)

CHEMISTRY PRACTICAL-DSE LAB: INDUSTRIAL CHEMICALS & ENVIRONMENT

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 method (AgNO₃ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO₃²⁻, HCO₃⁻) using double titration method.
7. Measurement of dissolved CO₂
8. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
9. Preparation of borax/ boric acid.

References:

• E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
• S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.

Teaching Learning Process:

• Conventional chalk and board teaching.
• Visit to chemical industries to get information about the technologies, methods to check pollutants and its treatment.
• ICT enabled classes.
• Power point presentations.
• Interactive sessions, Debate.
• To get recent information through the internet.

Assessment Methods:

• Presentations by Individual Student
Keywords:

Industrial gases, Inorganic chemicals, Metals, Ultrapure metals, Environment, Water pollution, Air pollution, Sources of energy, Biocatalysis, Green chemistry

Objectives:

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

Learning Outcomes:

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

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

This paper will give glimpse of polymer industry to the student and help them to choose their career in the field of polymer chemistry.

Unit 1:
Introduction and history of polymeric materials:

History of polymeric materials, Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.  

(4 Lectures)

Functionality and its importance:


(8 Lectures)

Unit 2:

Kinetics of Polymerization:

Mechanism of step growth polymerization, kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic), Mechanism and kinetics of copolymerization, polymerization techniques.  

(8 Lectures)

Unit 3:

Glass transition temperature (Tg) and determination of Tg. Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).  

(8 Lectures)

Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.  

(4 Lectures)

Nature and structure of polymers-Structure Property relationships.  

(2 Lectures)

Unit 4:

Determination of molecular weight of polymers (M\_n, M\_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.  

(8 Lectures)

Polymer Solution: Criteria for polymer solubility and Solubility parameter. Thermodynamics of polymer solutions, entropy, enthalpy and free energy change of mixing of polymers solutions.  

(4 Lectures)

Polymer Degradation- Thermal, oxidative, hydrolytic and photodegradation  

(4 Lectures)
Unit 5:

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties). 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 polypyrrole, polythiophene)].

Practical:

CHEMISTRY PRACTICAL - DSE LAB: POLYMER CHEMISTRY

Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA).
2. Preparation of nylon 6,6
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight of polyvinyl propyldene in water by viscometry;
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 of polymethacrylic acid.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. IR studies of polymers
3. DSC (Differential Scanning Calorimetry) analysis of polymers
4. TG-DTA (Thermo-Gravimetry-Differential Thermal analysis) of polymers

Suggested Additional Experiment:

1. Purification of Monomer.
2. Emulsion Polymerization of a monomer.

References:

Theory:

- Seymour’s Polymer Chemistry, Marcel Dekker, Inc.
Practical:
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.

Teaching Learning Process:
Chalk and Talk method, ICT enabled teaching. Students need to make presentations.

Assessment Methods:
Assessment through continuous evaluation, assignments, class tests, presentations, quiz, projects.

Keywords:
Bonding, texture, polymerization, degradation, polymer solution, crystallization, Properties, applications.

Inorganic Materials of Industrial Importance

(CHEMISTRY DSE-1 (i)
Total Credits: 06 (Credits: Theory-04, Practicals-02)
(Total Lectures: Theory- 60, Practicals-60)
Objectives:

The course introduces learners to the diverse roles of inorganic materials in the industry. It gives an insight into how these raw materials are converted into products used in day to day life. Students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction as well as the emerging area of nano-sized materials. The course helps develop the interest of students in the frontier areas of inorganic and material chemistry.

Learning Outcomes:

By the end of the course, the students will be-

1. Give the composition and applications of the different kinds of glass.
2. Understand glazing of ceramics and the factors affecting their porosity.
3. Give the composition of cement and discuss the mechanism of setting of cement.
4. Explain the suitability of fertilizers for different kinds of crops and soil.
5. Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
6. Explain the principle, working and applications of different batteries.
7. List and explain the properties of engineering materials for mechanical construction used in day to day life.
8. Explain the synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

Unit 1:

Silicate Industries

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, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.


Unit 2:

Fertilizers:

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates,
superphosphate of lime, potassium chloride and potassium nitrate.  

(Lectures: 10)

**Unit 3:**

**Surface Coatings:**

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC) and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing.

Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.  

(Lectures: 18)

**Unit 4:**

**Batteries:**

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li-ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.  

(Lectures: 08)

**Unit 5:**

**Batteries: Engineering materials for mechanical construction:**

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, superalloys, thermoplastics, thermosets and composite materials.  

(Lectures: 08)

**Unit 6:**

**Nano dimensional materials**

Introduction to zero, one and two-dimensional nanomaterial: Synthesis, properties and applications of fullerenes, carbon nanotubes, carbon fibres, semiconducting and superconducting oxides.  

(Lectures: 06)
Practical:

(Credits: 2, Lectures: 60)

PRACTICALS-DSE LAB: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.

2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.

3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.

4. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).

5. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).

6. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry).

7. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.


References:

Theory:

- West, A. R., Solid State Chemistry and Its Application, Wiley
Practical:


Additional Resources:

- https://www.youtube.com/watch?v=RuyP9kqRcLg
- https://www.youtube.com/watch?v=BGPaywY1wvs
- https://www.youtube.com/watch?v=x5OD2KZXd54

Teaching Learning Process:

Blackboard, Power point presentations, Assignments, Field Trips to Industry

Assessment Methods:

- Written Examination
- Presentations
- Quiz

Keywords:

Silicates, Ceramics, Cement, Fertilizers, Surface Coatings, Batteries, Engineering materials for mechanical construction, Nano Dimensional Materials

PROJECT WORK

DISSERTATION

SKILL-ENHANCEMENT COURSES (SEC) CHEMISTRY (Choose any four)
Objectives:

The objective of this course is to introduce the students to fundamental mathematical techniques and basic computer skills that will help them in solving chemistry problems. It aims to make the students understand the concept of uncertainty and error in experimental data. Learn the use of different software for data tabulation, calculation, graph plotting, data analysis and document preparation.

Course Learning Outcomes:

After completing this course, a student is expected to:

1. Become familiar with the use of computers
2. Use software for tabulating data, plotting graphs and charts, carry out statistical analysis of the data.
3. Solve chemistry problems and simulate graphs.
4. Prepare documents that will incorporate chemical structure, chemical equations, mathematical expressions from chemistry.

Unit 1:

Mathematics

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, interconversion of units, constants and variables, equation of a straight line, plotting graphs.

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities.


Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms). Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary –bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).

Numerical integration (Trapezoidal and Simpson’s rule, e.g. entropy/enthalpy change from heat capacity data).
Unit 2:

Introductory writing activities: Introduction to word processor and structure drawing (ChemSketch) software. Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg’s law, van der Waals equation, etc.) into word processing documents.

Unit 3:

Handling numeric data: Spreadsheet software (Excel/ LibreOffice Calc), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs. Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck’s distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as function of temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations.

Unit 4:

Numeric modelling: Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting, linear regression (rate constants from concentration-time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data).

Unit 5:

Statistical analysis: Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel. Statistical significance testing: The t test. The F test. Presentation: Presentation graphics

Practical:

The major emphasis of the course is on hands on learning that will be carried out during practical class.

References:


Teaching Learning Process:

This course has major components of hands on exercises. The teaching learning process will require
conventional teaching along with hands on exercise on computers.

**Assessment Methods:**

Assessment on solving chemistry related problems using spreadsheet. Presentation on documentation preparation on any chemistry topic involving tables and graphs. Semester end practical and theory examination.

**Keywords:**

Uncertainty in measurements, roots of quadratic and polynomial equations, Newton Raphson's method, binary bisection, numerical integration, trapezoidal rule, Simpson's rule, differential calculus, least square curve fitting method, Spreadsheet, charts, tables, graphs, LINEST, t-test, F-test

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**BASIC ANALYTICAL CHEMISTRY**

**ChemistrySEC1-4(ii)**

(Credits: Theory-02, Practicals-02)

(Hands on Exercises: 60 Lectures)

**Total Credits: 04**

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**Objectives:**

The aim of this course is to make students aware about the following concepts:

Knowledge of chemical analysis including water and soil, separation techniques like Chromatography, Column, ion-exchange chromatography, etc. Instrumental demonstrations of flame photometry and determinations of macro-nutrients using flame photometry.

**Learning Outcomes:**

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

1. How to handle analytical data
2. How to determine composition and pH of soil which can be useful in agriculture
3. Quantitative analysis metal ions in water
4. Separations techniques
5. Estimation of macro nutrients using Flame photometry

**Unit 1:**
Introduction:

Introduction to Analytical Chemistry and its interdisciplinary nature, Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Significant figures, Presentation of experimental data and results.

(4 Lectures)

Unit 2:

Analysis of soil:

Composition of soil, Concept of pH and its measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

(12 Lectures)

Unit 3:

Analysis of water:

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

(12 Lectures)

Unit 4:

Chromatography:

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

Paper chromatographic separation of mixture of metal ion (Ni$^{2+}$ and Co$^{2+}$).

(12 Lectures)

Unit 5:

Ion-exchange:

Column, ion-exchange chromatography etc.
Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Suggested Applications (Any one):
- To study the use of phenolphthalein in trap cases.
- To analyze arson accelerants.
- To carry out analysis of gasoline.

(10 Lectures)

Unit 6:

Instrumental demonstrations:

- Estimation of macro-nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
- Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
- Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in soft drink.

(10 Lectures)

References:

- Cooper, T.G. (Ed.) The Tools of Biochemistry, John Wiley and Sons, N.Y. 1977
- Svehla, G., Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class room interactions and group discussions
- Lab demonstrations and experiments after completion of theory part
- ICT enabled classes

Assessment Methods:
Keywords:
Analytical chemistry, sampling, accuracy, precision, significant figures, Soil analysis, Analysis of water, Chromatography, Ion exchange chromatography, Flame photometry

CHEMICAL TECHNOLOGY AND SOCIETY

Chemistry SEC 1-4(iii)  
(Credits: Theory-02, Practicals-02)  
(Hands on Exercises: 60 Lectures)

Total Credits: 04

Objectives:
This course will help students to connect chemical technology for societal benefits. It would fulfill the gap between academia and industries.

Course Learning Outcomes:
The students will be able to learn:

- Use of basic chemistry to chemical engineering
- Various chemical technology used in industries
- To develop scientific solutions for societal needs

Unit 1:

Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.
Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants).

**Sources of energy**

Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar, Hydrogen, geothermal, tidal and Hydel

**Properties of Polymers (Physical, thermal, Flow & Mechanical Properties)**

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 polyprrole, polythiophene)].

**Natural Polymers**

Structure, properties and applications of shellac, lignin, starch, nucleic acids and proteins.

**Basics of drug synthesis**

Application of genetic engineering.

**Teaching Learning Process:**

- Lectures using teaching aid (chalk/power point/videos)
- Group discussion
- Presentations
- Advise to students to prepare a report on technological applications
- Visit to nearby industries
- Invite people of industries for interaction with students

**Assessment Methods:**

- Internal assessment of 25% marks including class attendance.
- Theory paper of 75% marks

**Keywords:**

Chemical Technology; Society; Energy; Polymer; Pollutants
Objectives:

The aim of the course is to introduce the students to computation drug design through structure-activity relationship, QSAR and combinatorial chemistry. The students will learn about the target analysis, virtual screening for lead discovery, structure based and ligand based design method and the use of computational techniques, library preparation and data handling.

Learning Outcomes:

The student will be able to learn:

1. Have a comprehensive understanding of drug discovery process and techniques including structure activity relationship, quantitative structure activity relationship and the use of chemoinformatics in this, including molecular modelling and docking studies
2. Appreciate role of modern computation techniques in the drug discovery process and perform their own modelling studies

Unit 1:

Introduction to Chemoinformatics: History and evolution of chemoinformatics, Use of chemoinformatics, Prospects of chemoinformatics,

(2 Lectures)

Unit 2:

Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

(2 Lectures)

Unit 3:

Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

(6 Lectures)

Unit 4:

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-
Property Relations; Descriptor Analysis; Model Building; Modeling Toxicity

(6 Lectures)

Unit 5:

Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design

(6 Lectures)

Unit 6:

Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Chemoinformatics in Drug Design.

(8 Lectures)

Practical:

Practicals/Hands on Exercises: (4 Periods per week / 60 Periods)

1. Overview of Rational Drug Design, Ligands and Targets

2. In silico representation of chemical information

   - CIF IUCr Crystallographic Information Framework
   - CML Chemical Markup Language
   - SMILES -- Simplified Molecular Input Line Entry Specification
   - InChi -- IUPAC International Chemical Identifier
   - Other representations

3. Chemical Databases and Data Mining

   - Cambridge Structural Database CCDC CSD
   - Crystallographic Open Database COD
   - Protein Data Bank PDB Ligand Explorer
   - Chemspider
   - Other Data Bases

4. Molecular Drawing and Interactive Visualization

   - ChemDraw
   - MarvinSketch
   - ORTEP
   - Chimera, RasMol, PyMol
5. Computer-Aided Drug Design Tools

- Molecular Modeling Tools
- Structural Homology Modeling Tools
- Docking Tools and Screening Tools
- Other tools

6. Building a Ligand

- Building ab initio
- Building from similar ligands
- Building with a known macromolecular target
- Building without a known macromolecular target
- Computational assessment of activity and toxicity and drugability.

References:

  Gasteiger, J. Handbook of cheminformatics: from data to knowledge in 4 volumes.

Additional Resources:

Bajorath, Jürgen (Ed.) Chemoinformatics Concepts, Methods, and Tools for Drug Discovery, Springer

Teaching Learning Process:

The course aims to introduce students to different cheminformatics methods and its use in drug research through practicals. It is a rather new discipline of science. It concerns with the applications of computer to solving the chemistry problems related to drug designing and drug discovery.

The course will give emphasis on active learning in students through a combination of lectures, tutorials and practical sessions. The underlying principles will be explained in lectures and the practicals will establish the understanding of these principles through applications to drug research.

Assessment Methods:

- Formative assessment supporting student learning in Cheminformatics practicals
- Summative assessment
- Review of a case study
- Exercise based on SAR and QSAR-Report
- Practical exam of five hours

Keywords:
BUSINESS SKILLS FOR CHEMISTS

CHEMISTRY SEC 1-4 (v)
Total Credits: 04
(Credits: Theory-02, Practicals-02)
(Total Lecture: Theory-30, Practicals-60)

Objectives:

1. To enhance the Business and Entrepreneurial Skills of undergraduate chemistry students and improve their Employment Prospects.
2. To orient the students to understand the Industry linkage with Chemistry, Challenges and Business Opportunities.
3. To Introduce the concept of Intellectual Property Rights, Patents and Commercialisation of innovations.

Learning Outcomes:

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

2. They will learn to understand the product development and Business Planning that includes Environmental Compliancy.
3. Through real life case studies, they will learn the process by which technical innovations are conceived and converted into successful business ventures.
4. The course also orients the students on the Intellectual Property Rights and Patents to drive business viability and Commercialisation of Innovation.
5. After going through this course the students will be able to relate to the importance of chemistry in daily life, along with the employment and business opportunities. They will effectively use the skills to contribute towards the well-being of the society and derive commercial value.

Unit 1:

Chemistry in industry

- Current challenges and opportunities for the chemistry based industries
- Role of chemistry in India and global economies
- Chemistry Based Products in the market

(10 Lectures)

Unit 2:
Business Basics

- Key business concepts
- Business plans
- Market need
- Project management
- Routes to market
- Concept of entrepreneurship

(12 Lectures)

Unit 3:
Project Management

Different stages of a project

- Ideation
- Bench work
- Pilot trial
- Production
- Promotion/ Marketing

(10 Lectures)

Unit 4:
Commercial Realisation and Case Studies

- Commercialisation
- Case study of Successful business ideas in chemistry
- Case study of Innovations in chemistry
- Financial aspects of business with case studies

(10 Lectures)

Unit 5:
Intellectual Property Rights

- Introduction to IPR & Patents

(6 Lectures)

Unit 6:
Environmental Hazards
Industries involving Hazardous chemicals. Importance of development of cost-effective alternative technology. Environmental Ethics.

Practical:

- Students can be taken for industrial visits for practical knowledge and experience.
- Group of 4-5 students may be asked to prepare business plan based on some innovative ideas and submit as a project/presentation discussing its complete execution.

References:

- www.rsc.org
- Lawerence I. Nwaeke, Business Concepts and Perspectives
- Titus De Silva, Essential Management Skills for Pharmacy and Business Managers

Teaching Learning Process:

- Class room teaching board method or power point presentations
- Class room interactions and group discussions
- Through videos and online sources
- Visit to chemical industries for real understanding of whole process

Assessment Methods:

- Written Examination and Class tests
- Oral presentation of project proposal along with written assignment

Keywords:


**SKILL-ENHANCEMENT COURSES (SEC)**

**INDUSTRIAL CHEMISTRY**

**GREEN METHODS IN CHEMISTRY**
Objectives:

- To inspire the students about the chemistry which is good for human health and environment.
- To evaluate suitable technologies for the remediation of hazardous substances.
- To make students aware of how chemical processes can be designed, developed and run in a sustainable way.
- Students will acquire the knowledge of the twelve principles of Green Chemistry and how to apply in Green synthesis.
- Spread awareness about the benefits of using green chemistry.
- By studying the course students will have the idea of Biocatalytic Process—Conversion of Biomass into chemicals.
- To make the students as the policy maker in solving the major issues of the chemical industries and environmental issues.

Learning Outcomes:

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

- Get idea of Toxicology, environmental law, energy and the environment
- Aspiring students those who are hoping to pursue a career can take manufacturing jobs in pharmaceuticals, polymers or food engineering.
- Students can think to design and develops materials and processes that reduce the use and generation of hazardous substances in Industry.
- Students can think a chemical method for recovering metals from used electronics
- Students can get ideas of innovative approaches to environmental and societal challenges.
- How chemicals can have an adverse/potentially damaging effect on human and vegetation.
- Critically analyse the existing traditional chemical pathways and processes and creatively think about bringing reformations in these protocols so that the environmental credentials some of the real-world examples where green chemistry has been incorporated to improve.
- Students will get idea of role of catalysts in the conversion pathways and how to focus on the optimization of catalyst efficiency and on the design of heterogeneous catalyst.
- Idea of resources, chemical composition of Biomass, utilization of waste, green chemical technologies for their conversion to valuable chemicals.

Unit 1:

Introduction

- Definition of Green Chemistry and how it is different from conventional chemistry and Environmental Chemistry?
• Need of Green Chemistry
• Importance of Green Chemistry in- daily life, Industries and solving human health problems (four examples each).
• A brief study of Green Chemistry Challenge Awards (Introduction, Award categories and study about five last recent awards).

(8 Lectures)

Unit 2:

Twelve Principles of Green Chemistry

• A brief introduction of the twelve principles of the Green Chemistry with their explanations
• Designing a Green Synthesis using these Principles with emphasis on
  o Prevention of Waste / Byproducts
  o Atom economy, calculation of atom economy
  o Green solvents-Supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.
• Catalysis and Green Chemistry- Comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
• Green Energy and Sustainability
• Real-time analysis for Pollution Prevention
• Prevention of chemical accidents, designing greener processes, inherent Safer Design, Principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route of carcarbaryl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

(14 lectures)

Unit 3:

The following Real-world Cases in Green Chemistry should be discussed:
Surfactants for Carbon Dioxide – Replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
Designing of Environmentally safe marine antifoulant.
Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

(8 Lectures)

Practical:

Characterization by m. pt.; U.V.-Visible spectroscopy, IR spectroscopy, and any other specific method should be done (wherever applicable).

• Preparation and characterization of nanoparticles of gold using tea leaves/ silver nanoparticles using plant extracts.
• Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.
• Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
• Mechanochemical solvent free, solid-solid synthesis of azomethine using p-toluidine and o-vanillin (various other combinations of primary amine and aldehyde can also be tried).
• Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
• Designing and conducting an experiment by utilizing the products and by products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey.

Some representative examples:

• Use of nanoparticles as catalyst for a reaction
• Use of azomethine for complex formation
• Conversion of byproduct of biodiesel to a useful product

References:

Theory:

• A.S. Matlack : Introduction to Green Chemistry, Marcel Dekker (2001)
• M. C. Cann and Thomas P. Umile ; Real-World Cases in Green Chemistry, American Chemical Society.
• Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002)

Practical:

• Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated “A social Awareness Project” Indu Tucker Sidhwani, Geeta Saini, Sushmita Chowdhury, Dimple Garg, Malovika, Nidhi Garg, Delhi University Journal of Undergraduate Research and Innovation, Vol 1, Issue 1, Feb 2015. ISSN: 2395-2334.
Teaching Learning Process:

- ICT enabled classes
- Power point presentations
- visit to pharmaceutical industry
- Through videos classes
- Interactive classes

Assessment Methods:

- Power point presentations.
- Discussions on the problems
- Asking students to make charts showing the solutions of the surrounding problems
- Real world problems solutions discussion
- quiz
- Test
- Assignments

Keywords:

Green Chemistry, 12 Principles

INTELLECTUAL PROPERTY RIGHTS

CHEMISTRY SEC 1-4 (vi)
Total Credits: 04
(Total Lecture: Theory-60)

Objectives:

1. The course aims to give insights into the basics of the Intellectual Property (IP) and in its wider purview it encompasses intricacies relating to IP.
2. This course is designed to introduce a learning platform to those who may be involved in the making and creation of various forms of IP.
3. The course may also provide cursory understanding of the overall IP ecosystem in the country.

Learning Outcomes:
At the end of this paper, students will be able to:

1. Learn theoretical concepts of evolution of Intellectual Property Laws, and to differentiate between the different kinds of IP.
2. Know the existing legal framework relating to IP in India.
3. Comprehend the value of IP and its importance in their respective domains.

- This course may motivate the students to make their career in multifaceted field of intellectual property rights.

**Unit 1:**

**Introduction**


(8 Lectures)

**Unit 2:**

**Copyright and Related rights**

Introduction to copyright and its relevance, Subject matter & conditions of protection, Ownership and term of copyright, Rights under copyright law, Infringement of copyright and remedies, Exceptions to infringement/Public rights.

(10 Lectures)

**Unit 3:**

**Patents**

Introduction, Criteria for obtaining patents, Patentable subject matter, Non patentable inventions, Procedure for registration, Term of patent and Rights of patentee, Patent Cooperation Treaty & International registration, Basic concept of Compulsory license and Government use of patent, Infringement of patents and remedies, Software patents and importance for India, Utility model & patent, Trade secrets and know-how agreement, Traditional Knowledge and efforts of Indian Govt. for its protection.

(15 Lectures)

**Unit 4:**

**Trade Marks**

Meaning of mark and Trademark, Categories of Trademark : Service Mark, Certification Mark, Collective Mark,
Well known Mark and Non-conventional Mark, Criteria for registerability of trademark : Distictiveness & non-deceptiveness, A good Trade Mark & its functions, Procedure for registration and Term of protection, Grounds for refusal of trademark registration, Assignment and licensing of marks (Character merchandising), Infringement and Passing Off, Salient Features of Indian Trade Mark Act,1999

(8 Lectures)

Unit 5:

Designs, GI and Plant Varieties Protection

Designs: Meaning of design protection, Concept of original design, Registration & Term of protection, Copyright in Designs

Geographical Indication: Meaning of GI, Difference between GI and Trade Marks, Registration of GI, Term & implications of registration, Concept of Authorized user, Homonymous GI

Plant Variety Protection and Farmer’s Right: Meaning, Criteria of protection, Procedure for registration, effect of registration and term of Protection, Benefit Sharing and Farmer’s rights

(12 Lectures)

Unit 6:

Enforcement of Intellectual Property Rights, Counterfeiting and Piracy, Understanding Enforcement of IP, Enforcing IPRs, Enforcement under TRIPS Agreement, Role of Customs and Police in IPR Protection

(7 Lectures)

Practical:

No Practical as such. However, students may be asked to prepare a project on different topics of IPR and present them before the class.

References:


Additional Resources:

- [https://www.wipo.int](https://www.wipo.int)
Teaching Learning Process:

This course must be taught through lecture in class and by invited talks of experts. The students must visit the nearby intellectual property office or some law firm to have an idea of the way the work being done there.

Assessment Methods:

The course is designed to be completed in 60 periods. The internal assessment shall be 25% (Class Test 10%, Assignment/project presentation 10% and attendance 5%) and the semester exam at the end of semester shall be 75%. The students will earn 02 credits after completion/passing of this course.

Keywords:

Intellectual Property, IP Laws, Patents, Copyright, Trademark, WIPO.

Instrumental Methods of Chemical Analysis

Total Credits: 06

(Credits: Theory-04, Practicals-02)
(Total Lecture: Theory- 60)

Objectives:

The Objective of this course is to make students aware about the following concepts:

2. Knowledge of analytical data analysis and classification of analytical methods.
3. Basic components in Infrared, UV, Visible and near IR and Mass spectrophotometer.
4. Advantages of Fourier-Transform Infrared (FTIR) and NMR spectroscopy.
5. Portable instrumentation and issues regarding quality assurance and quality control.
7. Interpretation like quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags.
8. Separation techniques like Chromatography, Electrophoresis and DNA techniques.
10. Electroanalytical Methods, Radiochemical Methods, X-ray analysis and electron spectroscopy.

Learning Outcomes:
At the end of the course the student would be able to know:

- How to handle Analytical data.
- Basic Components of IR, FTIR, UV-Visible and Mass spectrometer.
- Interpretation of IR, FTIR, UV-visible spectra and their applications.
- Signal detections in photocells, photomultipliers, etc.
- Use of single and double beam instruments.
- Separations techniques like Chromatography, DNA techniques.
- Mass spectra and its applications.
- Elemental analysis, NMR spectroscopy, Electroanalytical Methods, Radiochemical Methods, X-ray analysis and electron spectroscopy.

**Unit 1:**

**Introduction to analytical methods of data analysis:**

Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiations.

(4 Lectures)

**Unit 2:**

**Molecular spectroscopy:**

**Infrared spectroscopy:** Interaction of radiations 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 Infrared (FTIR) spectroscopy.

Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

(8 Lectures)

**Unit 3:**

**UV-Visible/ Near IR Spectroscopy**

Emission, absorption, fluorescence and photoacoustic. 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, photoacoustic, fluorescent tags).

(8 Lectures)

**Unit 4:**
Separation techniques

Chromatography: Gas chromatography, liquid chromatography, 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. *Immunoaassays and DNA techniques.*

(8 Lectures)

Unit 5:

Mass spectroscopy:

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.

(8 Lectures)

Unit 6:

Elemental analysis:

Mass spectrometry (electrical discharges).
Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas). Wave length 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).

(8 Lectures)


(4 Lectures)

Electroanalytical Methods: Potentiometry & Voltammetry.

(4 Lectures)

Radiochemical Methods.

(4 Lectures)

X-ray analysis and electron spectroscopy (surface analysis)

(4 Lectures)

References:

- Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.
- P.W. Atkins: Physical Chemistry.
- G.W. Castellan: Physical Chemistry.
- C.N. Banwell: Fundamentals of Molecular Spectroscopy.
Practical:
(Credits: 2, Lectures: 60)

DSE LAB: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

1. Determination of the isoelectric pH of a protein.
2. Titration curve of an amino acid.
3. Determination of the void volume of a gel filtration column.
4. Determination of a Mixture of Cobalt and Nickel (UV-visible spectroscopy).
5. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water).
6. IR Absorption Spectra (Study of Aldehydes and Ketones).
7. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption spectroscopy.
8. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride).
9. Separation of Carbohydrates by HPLC.
10. Determination of Caffeine in Beverages by HPLC.
12. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple.
13. Use of Nuclear Magnetic Resonance instrument and to analyse the spectra of methanol and ethanol.
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.

At least 10 experiments to be performed.

Reference:

Please add references

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and group discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student
- Class Tests
- Written assignment(s)
- End semester University Theory and Practical Examination
Keywords:

Analytical methods of data analysis, Infrared spectroscopy, UV-Visible spectroscopy, Chromatographic Techniques, Mass spectra, Elemental analysis methods, NMR spectroscopy, Electroanalytical methods, Radiochemical methods, X-ray analysis, Electron spectroscopy