

**NOIDA INTERNATIONAL UNIVERSITY**

**GREATER NOIDA**

**CHOICE BASED COURSE SYLLABUS**

**BSc. HONOURS -CHEMISTRY**

**(ALL SEMESTERS)**

**Effective from the Session: 2019-2020**

**DEPARTMENT OF CHEMISTRY**

**SCHOOL OF SCIENCES**

### **Aims of Bachelor's degree programme in Chemistry**

The broad aims of bachelors degree programme in Chemistry are:

The aim of bachelor's degree programme in chemistry is intended to provide:

- (i). Broad and balance knowledge in chemistry in addition to understanding of key chemical concepts, principles and theories.
- (ii). To develop students' ability and skill to acquire expertise over solving both theoretical and applied chemistry problems.
- (iii). To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/entrepreneurship.
- (iv). To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and its significance is fostered in this framework, rather than mere theoretical aspects.
- (v). To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemisry graduate as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.
- (vi). To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.
- (vii). To enable the graduate prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination.

### **Program Learning Outcomes**

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

□ **Core competency:** Students will acquire core competency in the subject Chemistry, and in allied subject areas.

- (i). Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.
- (ii). Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.
- (iii). The students will be able to understand the characterization of materials.
- (iv). Students will be able to understand the basic principle of equipment's, instruments used in the chemistry laboratory.
- (v). Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.
- (vi). **Disciplinary knowledge and skill:** A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related soft-wares for in-depth characterization of materials/chemical analysis and separation technology.

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

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### Study & Evaluation Scheme for B.Sc (Chemistry Honors)

#### Total Scheme

#### UNDERGRADUATE PROGRAMME

#### Choice Based Credit System (CBCS)

The course learning outcomes are aligned with program learning outcomes but these are specific-to-specific courses offered in a program. The course level learning shall be reflected as program level learning. The core courses shall be the backbone of this framework whereas discipline electives, generic electives and skill enhancement courses would add academic excellence in the subject together with multi-dimensional and multidisciplinary approach. In course learning outcomes, the student will attain subject knowledge in terms of individual course as well as holistically.

1. Core Papers=14 (Credit: 06 each) C 1-14
2. Discipline Specific Elective Papers=04 (Credit: 06 each) - DSE 1-4
3. Skill Enhancement Courses= 02 (Credit: 02 each)- SEC1-2
4. Ability Enhancement Compulsory Courses=02 (Credit: 02 each)- AECC 1-2
5. Generic Elective Papers=04 (Credit: 06 each) For other Departments/Disciplines- GE 1-4
6. Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6<sup>th</sup> Semester
7. Wherever there is a practical there will be no tutorial and vice-versa

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6
C1	C3	C5	C8	C11	C13
C2	C4	C6	C9	C12	C14
GE1	GE2	C7	C10	DSE1	DSE3
AECC1	AECC2	GE3	GE4	DSE2	DSE4
		SEC1	SEC2		
Credit=20	Credit=20	Credit=26	Credit=26	Credit=24	Credit=24

**Total Credit=140**

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**Study & Evaluation Scheme for B.Sc (Chemistry Honors)  
1<sup>st</sup> Year, SEMESTER I**

S.No	Course Code	Subject	Period			Evaluation Scheme					Credit	CBSC
						Sessional Exam			External Exam	Subject Total		
			L	T	P	CA	TA	Total				
1	STUGC/C01	Structure and Bonding	4	0	0	20	20	40	60	100	4	C1
2	STUGC/C02	Chemical Management with Safety	4	0	0	20	20	40	60	100	4	C2
3	GE 01	Generic Elective	4	0	0	20	40	60	60	100	4	GE 1
4	AECC 1	Environmenta l Sciences	2	0	0	20	20	40	60	100	2	AECC 1
Practical												
7	SPUGC/C01	Structure And Bonding	0	0	2			25	25	50	2	C1 LAB
8	SPUGC/C02	Chemical Management with Safety – Workshop	0	0	2			25	25	50	2	C2 LAB
9	GE 01	Generic Elective Lab	0	0	2			25	25	50	2	AECC 1 LAB
Total										550	20	

**Assessment method :** (Continuous Internal Assessment = 40% , Final Examination = 60%)

Assessment -1	- 05%
Assessment-2	- 05%
Assessment-3(Midexam)	- 20%
Assessment-3	- 05%
Assessment-4	- 05%
<b>Total Internal Assessment</b>	<b>- 40%</b>

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**Study & Evaluation Scheme for B.Sc Honours (Chemistry)**  
**1<sup>st</sup> Year, SEMESTER II**

S.N o	Course Code	Subject	Period			Evaluation Scheme					Credit	CBCS
						Sessional Exam			External Exam	Subject Total		
			L	T	P	CA	TA	Total				
1	STUGC/ C03	Elements & Properties	4	0	0	20	20	40	60	100	4	C3
2	STUGC/ C04	Analytical Chemistry	4	0	0	20	20	40	60	100	4	C4
3	GE2	Generic Elective	3	0	0	20	20	40	60	100	4	GE2
4	AECC2	Technical Communi- Cation	2	0	0	20	20	40	60	100	2	AECC 2
Practical												
7	SPUGC/ C04	Elements & Properties Lab	0	0	2			25	25	50	2	C4 LAB
8	SPUGC/ C05	Analytical chemistry Lab	0	0	2			25	25	50	2	C5 LAB
9	GE2	Generic Elective Lab	0	0	2			25	25	50	2	GE2 LAB
Total										550	20	

**Reference Books:** for Laboratory Guide:.

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
- F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman (1960).
- Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

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**Study & Evaluation Scheme for B.Sc. Honors -Chemistry  
2<sup>nd</sup> Year, SEMESTER III**

S.No	Course Code	Subject	Period			Evaluation Scheme					Credit	CBCS
						Sessional Exam			External Exam	Subject Total		
			L	T	P	CA	TA	Total				
1	STUGC/C05	Organic Chemistry-I	4	0	0	20	20	40	60	100	4	C5
2	STUGC/C06	Physical Chemistry-I	4	0	0	20	20	40	60	100	4	C6
3	STUGC/C07	Environmental Chemistry	4	0	0	20	20	40	60	100	4	C7
4	GE3	Generic Elective	4	0	0	20	20	40	60	100	4	GE 3
5	STUGC/SEC1	Intellectual Property Rights	2	0	0	20	20	40	60	100	2	SEC 1
Practical												
1	SPUGC/C05	Organic Chemistry-I Lab	0	0	2			25	25	50	2	C5 LAB
2	SPUGC/C06	Physical Chemistry-I Lab	0	0	2			25	25	50	2	C6 LAB
3	SPUGC/C07	Environmental Chemistry Lab	0	0	2			25	25	50	2	C7 LAB
9	GE3	Generic Elective Lab	0	0	2			25	25	50	2	GE LAB
Total										700	26	

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**Study & Evaluation Scheme for B.Sc Honors -Chemistry**  
**2<sup>nd</sup> Year, SEMESTER IV**

S.No	Course Code	Subject	Period			Evaluation Scheme					Credit	CBSC
						Sessional Exam			Exter nal Exam	Subject Total		
			L	T	P	CA	TA	Total				
1	STUGC/C 08	Inorganic Chemistry-I	4	0	0	20	20	40	60	100	4	C8
2	STUGC/C 09	Organic Chemistry-II	4	0	0	20	20	40	60	100	4	C9
3	STUGC/C 10	Green Chemistry	4	0	0	20	20	40	60	100	4	C10
4	GE4	Generic Elective	4	0	0	20	20	40	60	100	4	GE 4
5	STUGC/S EC2	Food Chemistry	2	0	0	20	20	40	60	100	2	SEC 2
Practical												
6	SPUGC/C08	Inorganic Chemistry-I Lab	0	0	2			25	25	50	2	C8 LAB
7	SPUGC/C09	Organic Chemistry-II Lab	0	0	2			25	25	50	2	C9 LAB
8	SPUGC/C10	Green Chemistry Lab	0	0	2			25	25	50	2	C10 LAB
9	GE4	GE Lab	0	0	2			25	25	50	2	GE LAB
Total										700	26	



**Noida International University**  
**Study & Evaluation Scheme for B.Sc Honors -Chemistry**  
**3<sup>rd</sup> Year, SEMESTER V**

S.No	Course Code	Subject	Period			Evaluation Scheme					Credit	CBCS
						Sessional Exam			External Exam	Subject Total		
			L	T	P	C A	TA	Total				
1	STUGC/C 11	Advance Organic Chemistry	4	0	0	20	20	40	60	100	4	C11
2	STUGC/C12	Polymers Chemistry	4	0	0	20	20	40	60	100	4	C12
3	STUGC/DSE 1	Industrial Chemistry-I	4	0	0	20	20	40	60	100	4	DSE 1
4	STUGC/DSE 2	Forensic Chemistry	4	0	0	20	20	40	60	100	4	DSE 2
Practical												
6	SPUGC/C11	Advance Organic Chemistry Lab	0	0	2			25	25	50	2	C11 LAB
7	SPUGC/C12	Polymers Chemistry Lab	0	0	2			25	25	50	2	C12 LAB
8	SPUGC/DSE 1	Industrial Chemistry-I Lab	0	0	2			25	25	50	2	DSE 1 Lab
9	SPUGC/DSE 2	Forensic Chemistry Lab	0	0	2			25	25	50	2	DSE 2 Lab
Total										600	24	

**Noida International University**  
**Study & Evaluation Scheme for BSc. Honors -Chemistry**  
**3<sup>rd</sup> Year, SEMESTER VI**

S.No	Course Code	Subject	Period			Evaluation Scheme					Credit	CBCS
						Sessional Exam			External Exam	Subject Total		
			L	T	P	C A	TA	Total				
1	STUGC/C 13	Physical Chemistry-A Molecular Approach -II	4	0	0	20	20	40	60	100	4	C 13
2	STUGC/C 14	Organic Chemistry-III	4	0	0	20	20	40	60	100	4	C 14
3	STUGC/DSE 3	Industrial Chemistry-II	4	0	0	20	20	40	60	100	4	DSE 3
4	STUGC/DSE 4	Drug Synthesis	4	0	0	20	20	40	60	100	4	DSE 4
Practical												
6	SPUGC/C13	Physical Chemistry-II Lab	0	0	2			25	25	50	2	C 13 LAB
7	SPUGC/C14	Organic Chemistry-III Lab	0	0	2			25	25	50	2	C14 LAB
8	SPUGC/DSE 3	Industrial Chemistry-II Lab	0	0	2			25	25	50	2	DSE 3 LAB
9	SPUGC/DSE 4	Drug Synthesis Lab	0	0	2			25	25	50	2	SEC 4 LAB
Total										600	24	

**Course Code : STUGC/C01**  
**Bonding**  
**Course Credit Hour : 4hr**

**Course Name: Structure and**  
**Total Contact Hour : 60hr**

**Course Objective :**

- Elementary knowledge of chemistry.
- Application based learning of the subject.
- Elementary idea of periodic table and their periodic trends, structure, bonding, hybridization and stereochemistry.
- Understand the importance of the elements in the periodic table including their physical and chemical nature and role in the daily life.

**Course Description :**

- Students will be able to compare and contrast the elements of s, p and d block elements.
- To know the basic properties of elements based on their relative position in group and column.
- To understand the bonding and structure of different kinds of molecules.
- To gain a brief information on chemical properties and reactions of alkanes, alkenes and alkynes.
- To understand Fischer, Saw-horse and Newman projection formulae, Chirality-optical activity,
- To understand the difference between enantiomerism and diastereoisomerism.

**Course Contents: L-4 T-0 P-2**

**Unit 1:**

**Basic Concepts of Inorganic Chemistry:** Introduction: Elements, Classification of Elements (metals, non-metals and metalloids). Periodic table and modern periodic law, classification of periodic table in groups and column. Classification of periodic table into s-block, p-block and d-block elements.

**Unit 2: Atomic Structure:**

Schrodinger wave equation; H atom; Radial and angular wave functions: quantum numbers and concept of orbitals; Slater orbitals.

**Unit 3: Bonding:**

Molecular orbital theory and molecular energy level diagram of Homo- and Hetero-nuclear molecules. Hybridization, its definition and hybridization involving s, p and d-orbitals. VB and MO approach of H<sub>2</sub> molecule

**Chemical Bonding:** Chemical bonding, types of bonding (ionic, covalent, coordinate, metallic and hydrogen bonding).

**Unit 4: Hydrocarbons:** Alkanes: Chlorination of methane, Alkenes: Addition reactions (Electrophilic and Free radical), Hydration, hydroxylation, hydroboration, epoxidation and ozonolysis. Alkynes: Reduction, Electrophilic addition, acidity and metal acetylides.

**Unit-5: Stereochemistry:**

Fischer, Saw-horse and Newman projection formulae, Chirality-optical activity, enantiomerism and diastereoisomerism involving one and two chiral centres. Configuration; D/L, erythrose, threose and R/S nomenclatures. Geometrical isomerism and E/Z nomenclatures. Conformations of n-butane.

**Course Learning Outcomes (CLOs) :**

**CLO-1:** To understand the elements, their arrangement in periodic table, periodic law and significance of atomic numbers and electronic configuration as the basis for periodic classification.

**CLO-2:** To know the discovery of electron, proton and neutron and their characteristics. To understand the nature of electromagnetic radiation, quantum theory and orbital concept.

**CLO-3:** To study different types of molecular orbitals, hybridization and chemical bonding involved in bond formation. To explain the concepts of geometry of simple molecules.

**CLO-4:** To learn about major reactions and their mechanism of alkanes, alkenes and alkynes hydrocarbons.

**CLO-5:** To know about the concepts of stereochemistry and understand the difference between configuration and conformation. To study the reactivity and stability of an organic molecule based on structure, including conformation and stereochemistry and their nomenclature.

**Text Books:**

1. *Basic Inorganic Chemistry*, F. A. Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
2. *Concise Inorganic Chemistry*, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
3. *Organic Chemistry*, Paula Y. Bruice, 2nd Edition, Prentice-Hall, International Edition (1998).
4. *Organic Chemistry*, I. L. Finar, Vol. I, 6th Edition (1973), ELBS and Longman Ltd., New Delhi.
5. *Organic Chemistry*, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.

6. Organic Chemistry, Paula Y. Bruice, 2nd Edition, Prentice-Hall, International Edition (1998).

**Reference books :**

1. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, , Oxford Univ. Press, Oxford (2001).
2. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
3. Organic Chemistry, I. L. Finar, Vol. I, 6th Edition (1973), ELBS and Longman Ltd., New Delhi.
4. “Inorganic Chemistry”, Puri and Sharma
5. “Advanced Inorganic Chemistry”, Sathyaprakash.

**Online links for study & reference materials:**

1. <https://www2.chemistry.msu.edu>
2. <https://chem.libretexts.org>
3. <http://web.uvic.ca/~rlipson/C347-2014/5%20A%20CHEM%20347%20Applications%20of%20SWE%20free%20p%20article%20ID%20PIB%20UNFILLED.pdf>
4. [https://chem.libretexts.org/Textbook\\_Maps/Organic\\_Chemistry/Map%3A\\_Organic\\_Chemistry\\_\(McMurry\)/Chapter\\_07%3A\\_Alkenes%3A\\_Structure\\_and\\_Reactivity/7.07\\_Electrophilic\\_Addition\\_Reactions\\_of\\_Alkenes](https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry/Map%3A_Organic_Chemistry_(McMurry)/Chapter_07%3A_Alkenes%3A_Structure_and_Reactivity/7.07_Electrophilic_Addition_Reactions_of_Alkenes).
5. <http://www.chem.ucalgary.ca/courses/350/Carey5th/Ch06/ch6-2.html>
6. <https://www.quora.com/What-are-the-applications-of-the-Schrodinger-wave-equation>.
7. <https://www.quora.com/What-is-isomerism>

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**Course Code : STUGC/C02**  
**Safety**

**Course Name: Chemical Management With**

**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- This introductory course in laboratory chemical safety is required for all entering chemistry graduate students. Topics to be covered include laboratory emergencies, chemical hazards, lab inspections and compliance, managing and working with chemicals, waste handling, case studies of university accidents, laboratory equipment, biosafety, radiation, and animals, and microfabrication and nanomaterials.

- Negligence in chemical industry could result in devastating consequences. Incidences could arise at any stage and at any time such as during erection, commissioning, manufacturing, maintenance, disposal or transportation. Whenever it happens, chemical incidents might end up with fire and/or toxic releases. A major mishap could spill catastrophe in terms of loss of life, occupational disease, and threat to the environment. As a result, organizations may face high consequence incidents, incur costs of treatment and rehabilitation, face legal costs and may have to pay fines and compensation claims.
- The course aims to provide a deep understanding of chemical safety which will yield benefit in terms of reducing serious accidents involving hazardous chemicals handling, storage and transportation, moreover, it would lead to improvement while working in the lab and will be boosting student's productivity while working in chemical industry in future.

### **Course Description :**

- In this course, several useful topics will be there as safety and risk management; material hazards; hazard evaluation and risk assessment techniques; laboratory safety; PPE kit, handling, storage and transportation of hazardous chemicals, handling, storage and transportation of gas cylinders; safety devices; utilities; radiation safety; environmental impact assessment; management practice, Emergency preparedness, Disposal of chemical waste and Environmental health and safety guidelines.

### **Course Contents :**

**L-4 T-0 P-2**

#### **Instructor(s):**

**Unit 1: Introduction to Laboratory Safety:** Introduction: The Texas Tech incident (Lessons to be learned: shared responsibilities), Risks in a research laboratory health effects due to "Hazardous" chemical exposure (How does one determine the hazards associated with specific chemicals, exposure routes, toxicity risk assessment), Personal protective equipment (PPE), proper attire (eye/face protection, lab coats, gloves, respirators, disposal/removal of PPE), Emergency equipment safety showers/eye washes, Key campus and department chemical safety contacts, Environmental health and safety (EHS), Case study: Dartmouth chemical poisoning (Key Lessons).

**Unit 2: Laboratory Emergencies: Spills and Fires:** General preparation for emergencies, Handling the accidental release of hazardous materials, working with compressed gases (parts of the cylinder, cylinder pressure regulator, storage guidelines, transporting cylinders, handling compressed gas cylinders), working with cryogenics (Health Hazards, Liquid N<sub>2</sub>) spill containment and clean-up, Leaking gas cylinders, Fires classification, fire extinguishers (how they work, types), risk assessment, Case study: University of Texas Austin sodium fire (lessons learned).

**Unit 3: Chemical Hazards:** Chemical hygiene plan: Introduction to laboratory safety, the new safety data sheets (SDS) versus the old material safety data sheets (MSDS),

Assessment of chemical toxicity: Toxic hazards (dose, risk assessment, types of toxins), Chemical hazards associated with microfabrication and nanoparticles, instrument hazards associated with microfabrication, Flammable Hazards: flammability characteristics, flammability classes, causes of ignition, reactive hazards, explosives, Precautions for minimizing exposure – Handling, Case study: University of Wisconsin – LiAlH<sub>4</sub> explosion (lessons learned).

**Unit 4: Lab Inspections and Compliance:** Ordering and receiving chemicals, Regulatory compliance – History of occupational safety and environmental laws, Current research regulations, Regulatory inspections that occur at University, Environmental health & safety department (roles, responsibilities, organization), Inspections (EHS, self-inspections), Case studies: DuPont facility – Phosgene release (lesson learned)

**Unit 5: Managing and Working with Chemicals:** General considerations (chemical segregation, transfer and transport, chemical fume hoods (safety, types, operation), other types of ventilation), waste handling: characterization of waste, collection and storage (lids, leaks, labels, location, containers), consequences of mixing incompatibles, solid wastes (chemicals, broken glass, sharps, cylinders, pick-up), Special Cases, hazardous waste minimization, Biosafety, radiation, and animals. Case Studies. the “UCLA Incident” (Looper)

#### **Course Learning Outcomes (CLOs) :**

After completion of the course Student will learn followings

**CLO-1:** Identification of hazardous substances at work, Compliance with existing rules and regulations as well Clean-up of chemical spills using appropriate protective apparel and equipment. Hazard signs and symbols.

**CLO-2:** Control of exposure/Emergencies, Storage and handling of chemical as acids, ethers, toxic and poisonous chemicals, Enable students to apply these concepts when working in a laboratory.

**CLO-3:** Identification of hazardous activities and their elimination, Use of hazard identification tool like HAZOP (hazard and operability study) to mitigate hazards, Recognize common laboratory hazards

**CLO-4:** Chemical hygiene plans (CHP), Reporting all accidents and potential chemical exposures immediately, Emergency preparedness

**CLO-5:** Control measures, including, Engineering controls (equipment such as hoods, ventilation systems, and safety interlocks), Administrative controls (procedures, processes, and training), Personal protective equipment (PPE), Properly disposing of all hazardous waste material.

#### **Text books :**

1. Robert H. Hill, Jr., David C. Finster, Laboratory safety for chemistry students, Wiley, ISBN: 978-0-470-34428-6
2. Najat Rashid , Ramnik Sood Manual of Laboratory Safety, JBP, ISBN: 978-9350906224
3. National Research Council, Safe Science: Promoting a Culture of Safety in Academic Chemical Research, National Academies Press 9780309300940, 0309300940

4. Pooja Sharma, S. C. Bhatia, Shweta Sharma ,Environmental Chemistry, CBS Publishers & Distributors, ISBN: 9788123908267, 9788123908267
5. Hill Robert H. ,Laboratory Safety for Chemistry Students, John Wiley and Sons Ltd, ISBN: 9781119027669, 9781119027669

**Reference books :**

6. L. Bretherick, Handbook of Reactive Chemical Hazards, Elsevier Science, fourth, ISBN: 9781483162508, 1483162508
7. Richard P. Pohanish, Stanley A. Greene, Wiley Guide to Chemical Incompatibilities, Wiley, second, ISBN: 9780471721628, 047172162X

**Online links for study & reference materials:**

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8. <https://www.shponline.co.uk/ppe-personal-protective-equipment/>
9. <https://www.carleton.edu/environmental-health-safety/work-practices/compressed-gas/>
10. [https://nsc.nasa.gov/docs/default-source/system-failure-case-studies/sfcs-2015-04-14-deadlyexposure-presentation.pdf?sfvrsn=ad4eecf8\\_2](https://nsc.nasa.gov/docs/default-source/system-failure-case-studies/sfcs-2015-04-14-deadlyexposure-presentation.pdf?sfvrsn=ad4eecf8_2)
11. [https://sunypoly.edu/sites/default/files/Research/Contractor%20Forms%20and%20Training/EHS-00005%20R12%20Chemical%20Handling%20and%20Storage\\_0.pdf](https://sunypoly.edu/sites/default/files/Research/Contractor%20Forms%20and%20Training/EHS-00005%20R12%20Chemical%20Handling%20and%20Storage_0.pdf)

**Course Code :**  
**Applications**

**Course Name: Fundamentals Of Computer**

**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- Write about what is intended to teach & Learn in this course.
- Write about 3 to 4 lines

**Course Description :**

- Write a brief summary indicating how this will be conducted specifying the key topics of the whole course.
- Write about 4 to 5 lines or till 7 lines, if some course description demands.

**Course Contents : L-2 T-0 P-2**

**Unit-I Fundamental:** H/W and S/W part of computer system, Computer Block Diagram, online processing, time sharing system, real time system, batch system, ultra programming, multiprocessing, SPOOLING, distributed data processing. Element of



computer file, types of files, file processing activities, file design factors, access methods, pros and cons of file organization

**Unit-II: MS office:** Introduction to MS Office; Introduction to MSWord; Features & area of use. Working with MS Word.; Menus & Commands; Toolbars & Buttons; Shortcut Menus, Wizards & Templates; Creating a New Document; Different Page Views and layouts; Applying various Text Enhancements; Working with – Styles, Text Attributes; Paragraph and Page Formatting; Text Editing using various features ; Bullets, Numbering, Auto formatting, Printing & various print options

**Unit-III: MS Excel:** Introduction and area of use; Working with MS Excel.; concepts of Workbook & Worksheets; Using Wizards; Various Data Types; Using different features with Data, Cell and Texts; Inserting, Removing & Resizing of Columns & Rows; Working with Data & Ranges; Column Freezing, Labels, Hiding, Splitting etc.; Using different features with Data and Text; Use of Formulas, Calculations & Functions; Cell Formatting including Borders & Shading; Working with Different Chart Types; Printing of Workbook.

**Course Learning Outcomes(CLOs) :**

CLO-1 : CLOs can be identified from each units and written here.

CLO-2 :

CLO-3 :

CLO-4 :

**Text books :**

- Joe Habraken, Microsoft Office 2000, 8 in 1 by, Prentice Hall of India
- Deitel & Deitel: C How to Program (Prentice Hall), 1996.
- Yashwant Kanetker, Let us C, BPB Publications.
- R. B. Patel, Fundamental of Computers and Programming in C, Khanna Book Publishing Company PVT.LTD. Delhi, India, 1st edition, 2008, ISBN: 13: 978-81-906988-7-0, pp. 1-962.
- Gottfried, Programming with C, Tata McGraw Hill.
- Brian W. Kernighan, Dennis M. Ritchie, The C Programming Language, 2nd Ed., Prentice Hall of India.

**Reference books :** Author, Title of text book, edition, name of publisher, isbn number

**Online links for study & reference materials :**

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**Course Credit Hour:** 2hr

**Total Contact Hour:** 47hr

**Course Objective:**

- The Compulsory course on Environmental Science at Undergraduate level (AECCI) aims to train students to cater to the need for ecological citizenship through developing a strong foundation on the critical linkages between ecology-society-economy.

**Course Description:**

- Graduates will evolve into ecologically informed and socially responsible citizens who are empowered to protect the natural resources while ensuring sustainable lifestyle and developmental model.

**Course Contents:**

**Unit 1: Introduction to Environmental Studies (2 lectures)**

- Multidisciplinary nature of environmental studies
- Scope and importance; Concept of sustainability and sustainable development

**Unit 2: Ecosystem (8 lectures)**

- Definition and concept of Ecosystem
- Structure of ecosystem (biotic and abiotic components); Functions of Ecosystem
- Physical (energy flow), Biological (food chains, food web, ecological succession)
- Biogeochemical (nutrient cycling) processes. Concepts of productivity, ecological pyramids and homeostasis
- Types of Ecosystem – Tundra, Forest, Grassland, Desert, Aquatic (ponds, streams, lakes, rivers, oceans, estuaries) – their importance and threats on them with relevant examples from India Ecosystem services (Provisioning, Regulating, Cultural and Supporting). Basics of Ecosystem restoration

**Unit 3: Natural Resources (6 lectures)**

- Land resources and land use change Land degradation, soil erosion and desertification
- Forest resources and causes of deforestation; impacts of mining and dam building on environment, forests, biodiversity and tribal populations
- Water resource: Use and over exploitation of surface and ground water, floods, drought conflicts over water (international & inter-state)
- Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs
- Case studies: National Solar Mission, Cauvery river water conflict etc

**Unit 4: Biodiversity and Conservation (8 lectures)**

- Definition of Biodiversity; Levels of biological diversity: genetic, species and ecosystem diversity; Biogeographic zones of India

- India as a mega-biodiversity nation; Endemic and endangered species of India; IUCN Red list; biodiversity hotspots
- Value of biodiversity: Ecological, economic, social, ethical, aesthetic and informational value of biodiversity with examples; sacred groves and their importance with example
- Current mass extinction crisis; Threats to biodiversity: Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasion with emphasis to Indian biodiversity
- Biodiversity conservation strategies: in-situ and ex-situ methods of conservation; Biosphere reserves; Keystone and Flagship species; Species reintroduction and translocation
- Case studies: Project Tiger, Vulture breeding program etc

#### **Unit 5: Environmental pollution (8 lectures)**

- Environmental pollution (Air, water, soil, thermal and noise): causes, effects and controls; Air and water quality standards
- Nuclear hazards and human health risks
- Solid waste management: Control measures of urban and industrial waste
- Pollution case studies: Ganga Action plan (GAP), Delhi air pollution and public health issues etc

#### **Unit 6: Global Environmental Issues and Policies (8 lectures)**

- Climate change, Global warming, Ozone layer depletion, Acid rain and impacts on human communities and agriculture
- International agreements: Earth Summit, UNFCCC, Montreal and Kyoto protocols and Convention on Biological Diversity (CBD)
- Sustainable Development Goals and India's National Action Plan on Climate Change Environment legislation in India: Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act 1980, Air (Prevention & Control of Pollution) Act, 1981; Environment Protection Act, 1986; Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

#### **Unit 7: Human Communities and the Environment (7 lectures)**

- Human population growth: Impacts on environment, human health and welfare
- Resettlement and rehabilitation of project affected persons; case studies
- Disaster management: floods, earthquake, cyclones and landslides
- Environmental movements: Chipko movement, Silent valley movement, Bishnois of Rajasthan, Narmada Bachao Andolan etc
- Environment justice: National Green Tribunal and its importance
- Environmental ethics: Role of Indian and other religions and cultures in environmental conservation
- Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi, Swachh Bharat Abhiyan)

#### **Field work/ Practicals (Equal to 5 lectures)**

- Field visit to any of the ecosystems found in Delhi like Delhi Ridge/ Sanjay lake/ Yamuna river and its floodplains etc. or any nearby lake or pond, explaining the theoretical aspects taught in the classroom
- Visit to any biodiversity park/ reserve forests/ protected area/ zoo/ nursery/ natural history museum in and around Delhi, explaining the theoretical aspects taught in the classroom
- Visit to a local polluted site (Urban/Rural/Industrial/Agricultural), Wastewater treatment plants
- Study of common plants, insects, birds and basic principles of identification
- Organize a seminar/ conference/ workshop/ panel discussion on relevant topics for enhancing awareness, capacity building and critical reasoning among students

**Course Learning Outcomes (CLOs):** The course will empower the undergraduate students by helping them to:

**CLO-1** Gain in-depth knowledge on natural processes that sustain life, and govern economy.

**CLO-2:** Predict the consequences of human actions on the web of life, global economy and quality of human life.

**CLO-3:** Develop critical thinking for shaping strategies (scientific, social, economic and legal) for environmental protection and conservation of biodiversity, social equity and sustainable development.

**CLO-4:** Acquire values and attitudes towards understanding complex environmental-economic social challenges, and participating actively in solving current environmental problems and preventing the future ones..

**CLO-5:** Adopt sustainability as a practice in life, society and industry.

**Text books:**

1. William P. Cunningham, Mary Ann Cunningham, Barbara Woodworth Saigo, Environmental Science: A global concern, McGrawHill 2003
2. William Cunningham, Mary Cunningham, Principles of Environmental Science: Seventh Edition, Mc Graw Hill 2014 UGC DOCUMENT ON LOCF ENVIRONMENTAL SCIENCE 24
3. Rogers PP, Jalal, KF, Boyd JA, An introduction to sustainable development, Earthscan

**Reference books:**

1. Roosa SA, Sustainable Development Handbook, CRC Press 2008 —
2. Atkinson G., Dietz S., Neumayer E., Agarwala M, Handbook of Sustainable Development, Edward Elger, 2014 —

3. Robbins P., Hintz J., Moore S.A., Environment and Society: A critical introduction, Wiley Blackwel 2014

**Online links for study & reference materials:**

<https://www.hzu.edu.in/bed/E%20V%20S.pdf>

**Course Code : BPHY102      Course Name : Fundamentals of C Programming**

**Course Credit Hour : 2hr**

**Total Contact Hour : 30hr**

**Course Objective :**

- Write about what is intended to teach & Learn in this course.
- Write about 3 to 4 lines

**Course Description :**

- Write a brief summary indicating how this will be conducted specifying the key topics of the whole course.
- Write about 4 to 5 lines or till 7 lines, if some course description demands.

**Course Contents : L-4 T-0 P-2**

**Unit 1 Introduction**

Elements of C: C Character set, Constants, Variables and Keywords, Types of C Constants, Rules for Constructing Integer Constants, Rules for Constructing Real Constants, Rules for Constructing Character Constants, Types of C Variables, Rules for Constructing Variable Names, identifiers, data types, declaration and definition, storage classes in C- Global, local, register, types conversion, types of error, 'C' macro, macros vs function

**Unit 2 Operator**

Operators: Arithmetic, Relational, logical, bitwise, unary, assignment and conditional operator and their hierarchy & associativity, Integer and Float Conversions, Type Conversion in Assignments, Data input/output.

**Unit 3 Control Statement**

Control Statements: Sequencing, Selection: The *if* Statement, The *if-else* Statement, Nested *if-elses*, The *else if* Clause Loops, The *while* Loop, The *for* Loop, Nesting of Loops, Multiple Initialisations in the *for* Loop, The *break* Statement, The *continue* Statement, The *do-while* Loop, Decisions Using *switch*, *switch* Versus *if-else*, The *goto* Keyword.

## **Unit 4 Array & Functions**

What are Arrays, A Simple Program Using Array, Array Initialization, Passing Array Elements to a Function, Pointers and Arrays, Functions: Definition, prototypes, passing parameters, recursion.

## **Unit 5 Data Structure and Pointer**

Pointers: Declaration, operations on pointers, array of pointer, pointers to array, Data Structure: Why Use Structures, Declaring a Structure, Accessing Structure Elements, and How Structure Elements are stored structure, union, structure vs Union.

### **Course Learning Outcomes(CLOs) :**

CLO-1 : CLOs can be identified from each units and written here.

CLO-2 :

CLO-3 :

CLO-4 :

CLO-5 :

### **Text books :**

1. Gupta: Computer Concepts & C Programming, Comdex
2. Jones, C Programming with problem solving, Wiley India
3. Let Us C : Yashwant Kanetkar [BPB]
4. Mastering C ,K.R.Venugopal,S.R.Prasad [TMH]
5. Computer Science- A Structured Programming Approach Using C, by Behrouz A. Forouzan, Richard F. Gilberg, Thomson, [India Edition]

### **Reference books :**

Author, Title of text book, edition, name of publisher, issbn number

### **Online links for study & reference materials :**

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**Course Code: STUGC/C03**

**Course Name: ELEMENTS AND PROPERTIES**

**Course Credit Hour: 4hr**

**Total Contact Hour: 60hr**

### **Course Objective:**

- Application based learning of the subject. Students will learn to apply and incorporate the scientific principles. To understand the importance of the Periodic

table of the elements, how it came to be, and its role in organizing chemical information.

### **Course Description:**

- Students will be able to compare and contrast the properties of s, p and d block elements. To convert scientific equation in straight line to get physical parameter for slope and intercept. To understand the deviation of real gas from ideal behavior. To Understand critical constant and Vander Waals constant and basic idea of surface tension.

### **Course Contents: L-4 T-0 P-2**

#### **Unit 1:**

**Periodic trends and properties:** Size, Ionization Energy, Electron Affinity, Electronegativity, Lattice and Hydration Energies, Use of redox potential and reaction feasibility.

#### **Unit 2:**

**Chemistry of s and p-block elements:** Alkali and alkaline earth metals: Hydrides and Complexation tendencies. Structural features of hydrides, halides, oxides and oxyacids.

#### **Unit 3:**

**Chemistry of d-block elements:** Salient features, characteristic properties of 3d-elements with reference to oxidation states, colour, magnetic behaviour, and complex formation tendency.

### **Physical Chemistry**

#### **Unit 4:**

**Gaseous State:** Kinetic theory of gases, ideal gas laws based on kinetic theory. Collision in a gas- mean free path, collision diameter, collision number. Behaviour of real gases - the van der Waal's equation. Critical phenomena - critical constants of a gas and their determination, the van der Waals equation and critical state, Principle of corresponding states.

#### **Unit 5:**

**Liquid State:** Surface tension of liquids - capillary action, experimental determination of surface tension, temperature effect on surface tension. Viscosity of liquids, experimental determination of viscosity coefficient, its variation with temperature.

### **Course Learning Outcomes (CLOs):**

**CLO-1:** To study the periodic trends, properties and study the use of redox potential and reaction feasibility.

**CLO-2:** To classify the elements into a s, p, d and f blocks and learn their main characteristics.

**CLO-3:** To study the chemistry of *d*-block elements and its characteristic properties with reference to oxidation states, colour, magnetic behaviour, and complex formation tendency.

**CLO-4:** To differentiate between gaseous state and vapour. To explain the kinetic theory of gases. To state and apply the laws of thermodynamics; perform calculations with ideal and real gases.

**CLO-5:** To learn depth knowledge about liquid states. To explain the properties of liquids. To describe condition required for liquefaction of gases.

**Text books:**

1. *Basic Inorganic Chemistry*, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
2. *Concise Inorganic Chemistry*, J.D. Lee, 5th Edition (1996), Chapman & Hall, London.
3. *Physical Chemistry*, P. Atkins and J. De Paul, 8th Edition (2006), International Student Edition, Oxford University Press.
4. *Physical Chemistry*, K. J. Laidler and J. M. Meiser, 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999)

**Reference books:**

1. Principles of Physical Chemistry”, B.R. Puri, L.R. Sharma and M.S. Pathania, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.
2. “Physical Chemistry”, N. Kundu and S.N. Jain.
3. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), Sarat Book House, Calcutta.

**Online links for study & reference materials:**

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1. <https://www2.chemistry.msu.edu>.
2. <https://chem.libretexts.org>.
3. <https://chemistry.tutorvista.com/inorganic-chemistry/oxidation-states.html>.
4. <http://www.uou.ac.in/sites/default/files/slm/BSCCH-201.pdf>
5. <https://www.bing.com/videos/search?q=liquid+states+of+matter&&view=detail&mid=888BE9D5C1C2757422F9888BE9D5C1C2757422F9&&FORM=VRDGA R&ru=%2Fvideos%2Fsearch%3Fq%3Dliquid%2Bstates%2Bof%2Bmatter%26qpvt%3Dliquid%2Bstates%2Bof%2Bmatter%26FORM%3DVDRE>



6. <https://www.bing.com/videos/search?q=liquid+states+of+matter&qpv=liquid+states+of+matter&view=detail&mid=82FE5301226D18B8C5D182FE5301226D18B8C5D1&&FORM=VRDGAR&ru=%2Fvideos%2Fsearch%3Fq%3Dliquid%2Bstates%2Bof%2Bmatter%26qpv%3Dliquid%2Bstates%2Bof%2Bmatter%26FORM%3DVDRE>
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**Course Code :** STUGC/C02

**Course Name :** Analytical Chemistry

**Course Credit Hour :** 4hr

**Total Contact Hour :** 60hr

**Course Objective:**

- The course aims to provide a deep understanding of Analytical chemistry and an overview of important analytical methods and their range of application within detection of inorganic and organic compounds. It is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results. Finally, this course will help students to develop critical, independent reasoning which they can apply to new problems in chemistry and its related fields.

**Course Description:**

- Analytical chemistry covers the fundamentals of experimental and analytical methods and the role of chemistry around us. It also includes the concepts of handling and storage of toxic chemicals inside the lab, sampling, analyses of real samples, statistical analysis and calibration. The quantitative principles of solution equilibria and applications to complexometric titrations Gravimetric and volumetric techniques of analysis. Electrochemical methods (e.g. potentiometry, coulometry, voltammetry) will be introduced, both from the point of view of theory and the associated instrumentation. The basic principles of chromatography will be introduced and the associated instrumentation.

**Course Contents : L-4 T-0 P-2**

Objectives 1. To help the student to develop the habit of accurate manipulation and an attitude of critical thinking. 2. To learn the basic analytical methods and appreciate what is involved in an analysis.

**UNIT 1: HANDLING OF CHEMICALS AND ANALYSIS (8 h)**

1.1 Safety and hygiene in the Chemistry Lab Storage and handling of chemicals, handling of acids, ethers, toxic and poisonous chemicals, antidotes, threshold vapour concentration and first aid procedure. Heating methods, stirring methods filtration techniques. Calibration of pipette, standard measuring flask and burette. Weighing principle in chemical balance and single pan balance.

1.2 Error in chemical analysis Accuracy, precision, Types of error-absolute and relative error, methods of eliminating or minimizing errors. Methods of expressing precision: mean, median, deviation, average deviation and coefficient of variation. Significant figures and its application with respect to the glassware used. Normal error curve and its importance.

## **UNIT 2: SEPARATION AND PURIFICATION TECHNIQUES**

2.1 General purification techniques Purification of solid organic compounds, recrystallisation, use of miscible solvents, use of drying agents and their properties, sublimation. Purification of liquids. Experimental techniques of distillation, fractional distillation, distillation under reduced pressure. Extraction, use of immiscible solvents, solvent extraction. Chemical methods of purification and test of purity. 2.2 Chromatography Principle of adsorption and partition chromatography. Column chromatography: adsorbents, classification of adsorbents, solvents, preparation of column, adsorption and applications. Thin Layer Chromatography: choice of adsorbent, choice of solvent, preparation of chromatogram, sample, R<sub>f</sub> value and its applications. Paper chromatography, solvent used, R<sub>f</sub> value, factors which affect R<sub>f</sub> value. Ion exchange chromatography, resins used, experimental techniques, applications. Gas Chromatography, principle, detector (FID, TCD, ECD), Applications.

## **UNIT 3: TITRIMETRIC METHODS OF ANALYSIS**

3.1 General Introduction General principle. Types of titrations. Requirements for titrimetric analysis. Concentration systems: Molarity, formality, normality, wt% ppm, milliequivalence and millimoles-problems. Primary and secondary standards, criteria for primary standards, preparation of standard solutions, standardization of solutions. Limitation of volumetric analysis, endpoint and equivalence point.

3.2 Acid-base Equilibria pH of strong and weak acid solutions. Buffer solutions. Henderson equations. Preparation of acidic and basic buffers. Relative strength of acids and bases from K<sub>a</sub> and K<sub>b</sub> values. Neutralisation-titration curve, theory of indicators, choice of indicators. Use of phenolphthalein and methyl orange.

3.3 Complexometric titrations Stability of complexes, titration involving EDTA. Metal ion indicators and characteristics.

3.4 Problems based on titrimetric analysis.

## **UNIT 4: SOLUBILITY EQUILIBRIA**

4.1 General Separation Techniques Solubility and solubility products, expressions for solubility products. Determination of solubility from solubility products.

4.2 Precipitation titrations Argentometric titrations, indicators for precipitation titrations involving silver. Determination of chloride by Volhard's method. Adsorption indicators.

4.3 Gravimetric methods of analysis Separation by precipitation, factors affecting solubility, gravimetric factor. Purity of precipitates, von Weiman ratio. Co-precipitation, post precipitation.

## **Course Learning Outcomes (CLOs) :**

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

**CLO-1:** Control of exposure/Emergencies, Storage and handling of chemical as acids, ethers, toxic and poisonous chemicals, Enable students to apply these concepts when working in a laboratory, as well calibration of all the analytical apparatus.

**CLO-2:** Will be able to evaluate the analytical data in terms of statistics as types of errors in chemical analysis, expresses the terms such as mean, median, precision, accuracy, absolute error and relative error.

**CLO-3:** Explain the theoretical principles of various separation techniques in chromatography, and typical applications of chromatographic techniques.

**CLO-4:** Explain the theoretical principles and important applications of classical analytical methods within titration (acid/base titration, complexometric titration, redox titration, precipitation titration), and various coulometric methods as well interprets the redox titrations.

**CLO-5:** Will be able to interpret different gravimetric analysis methods, properties of precipitate and precipitating agents, employs the gravimetric calculations, solves problems related to gravimetric method applications.

### **Text books :**

1. D.A. Skoog, D.M. West and F.J. Holler, Analytical Chemistry: An Introduction, 5th edition, Saunders college publishing, Philadelphia, 1990.
2. U.N. Dash, Analytical Chemistry: Theory and Practice, Sultan Chand and sons Educational Publishers, New Delhi, 1995.
3. R.A. Day Jr. A.L. Underwood, Quantitative Analysis, 5th edition, Prentice Hall of India Private Ltd., New Delhi, 1988.
4. R. Gopalan, Analytical Chemistry, S. Chand and Co., New Delhi

### **Reference books**

1. Elementary Organic Spectroscopy: Principles and Chemical Applications, S.Chand and company Ltd., Ram Nagar, New Delhi, 1990.
2. V.K. Srivastava, K.K. Srivastava, Introduction to Chromatography: Theory and Practice, S. Chand and company, New Delhi, 1987.
3. R.M. Roberts, J.C. Gilbert, L.B. Rodewald, A.S. Wingrove, Modern Experimental Organic Chemistry, 4th edition, Holt Saunders international editions.
4. A.K. Srivastava, P.C. Jain, Chemical Analysis: An Instrumental Approach for B.Sc. Hons. and M.Sc. Classes, S. Chand and company Ltd., Ram Nagar, New Delhi.

### **Reference Books**

1. U.N. Dash, Analytical Chemistry: Theory and Practice, Sultan Chand and sons Educational Publishers, 1st edition, ISBN-13 : 978-8180549533
2. Recent Advances in Analytical Chemistry Muharrem Ince and Olcay Kaplan, Intech open ISBN:9781789858099, 1789858097
3. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, 7<sup>th</sup> Edition, ISBN 13:978-1-305-57721-3
4. G. H. JEFFERY J. BASSETT J. MENDHAM R C. DENNEY, Text book of quantitative analysis, 5<sup>th</sup> Edition, ISBN 0-582-Wb93
5. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, 2<sup>nd</sup> edition, ISBN:9781285607191, 1285607198

6. C. Krupadanam, G.L.D.Vijaya Prasad, D.Varaprasad Rao, K.Reddy, K.L.N.Sudhakar, Analytical Chemistry, Universities Press, 1<sup>st</sup> edition, ASIN : 8173713855

**Online links for study & reference materials:**

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1. <http://www.airproducts.com/~media/Files/PDF/company/safetygram-11.pdf>
2. [https://sunypoly.edu/sites/default/files/Research/Contractor%20Forms%20and%20Training/EHS-00005%20R12%20Chemical%20Handling%20and%20Storage\\_0.pdf](https://sunypoly.edu/sites/default/files/Research/Contractor%20Forms%20and%20Training/EHS-00005%20R12%20Chemical%20Handling%20and%20Storage_0.pdf)
3. <https://www.chem.ucla.edu/~bacher/General/30BL/tips/TLC1.html>
4. <https://ijpsr.com/bft-article/an-overview-on-thin-layer-chromatography/?view=fulltext>
5. [https://chem.libretexts.org/Bookshelves/Analytical\\_Chemistry/Book%3A\\_Analytical\\_Chemistry\\_2.1\\_\(Harvey\)/07%3A\\_Obtaining\\_and\\_Preparing\\_Samples\\_for\\_Analysis/](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Book%3A_Analytical_Chemistry_2.1_(Harvey)/07%3A_Obtaining_and_Preparing_Samples_for_Analysis/)

**Course Code:** AECC2  
Communication

**Course Name:** Technical

**Course Credit Hour:** 2Hr

**Total Contact Hour:** 30hr

**Course Objective:**

- The course aims to provide insights related to communication skills. It aims to train the student in the basic concept of effective communication and Interview preparation.

**Course Description:**

- This course introduces the fundamental concepts of communication skills, writing skills presentation skills, and interview skills. Topic includes an introduction to Grammar, speaking skills, Writing Skills, Presentation skills, Interview skills.

**Course Contents:**

**Unit 1: Communicative Grammar and learning: (6lecture)**

Spotting the errors about nouns, pronouns, adjectives, and adverbs; Principle of proximity between subject and verb. Changing the voice: from Active to Passive and Passive to Active. Idioms and Phrases; Words often confused; One-Word Substitutes; Formation of words (suffixes, prefixes).

**Unit 2: Oral Communication and Vocabulary building: (6 lectures)**

Introduction to principal components of spoken English – Transcription, Word accent, Intonation, developing listening and speaking skills through various activities, such as

(a) role-play activities, (b) Practicing short dialogues (c) Group discussion (d) Debates (e) Speeches (f) Listening to news bulletins (g) Viewing and reviewing T.V. programmes, etc.

### **Unit 3: Written Communication: (6 lectures)**

Developing reading and writing skills through such tasks/activities as developing outlines, key expressions, situations, slogan writing and theme building exercises, dialogue writing, interpreting pictures/cartoons.

### **Unit 4: Book Review and Technical writing – (6lecture)**

Herein the students will be required to read and submit a review of a book (Literary or non-literary) of their own choice. This will be followed by a presentation of the same in the class. Violence and War- Amitav Ghosh, ‘Ghosts of Mrs. Gandhi’  
Living in a Globalized World- Imtiaz Darker, ‘At the Lahore Karhai’

### **Technical Writing:**

- (a) Business Letters, Format of Business letters, and Business letter writing
- (b) E-mail writing
- (c) Reports, Types of Reports, and Format of Formal Report.

### **Unit-5: Proper use of Language (6 lecture)**

Communication Skills, The effective Speech.

**Effective self-presentation & facing interview:** The interview process & preparing for it, the presentation skills.

### **Course Learning Outcomes (CLOs):**

CLO-1: Develop vocabulary building and basic grammar concepts.

CLO-2: Inculcate speaking skills and listening skills.

CLO-3: Develop the writing skills.

CLO-4: Understand technical writing skills.

CLO-5: Demonstrate all skills in presentation and interviews.

### **Textbooks:**

1. Raman, Meenakshi & Sangeeta Sharma. *Technical Communication Principles and Practice*. New Delhi Oxford University Press, 2004.
2. Spoken English for India, R.K. Bansal & J.B. Harrison, Orient Longman, Delhi.

3. Objective English, Tata Mc. Graw Hill Publishing Company Ltd., New Delhi.
4. The sounds of English, Veena Kumar, Makaav Educational Software, New Delhi.

**Reference books:**

- (i) English Phonetics & Phonology, P. Roach, Cambridge University Press, London
- (ii) Common Errors in English, Abul Hashem, Ramesh Publishing House, New Delhi.

**Course Code :** BSC 203  
to operating system

**Course Name :** Introduction

**Course Credit Hour :** 4hr

**Total Contact Hour :** 60hr

**Course Objective :**

- To study concepts related to operating systems, like process management, concurrency and control of processes, deadlocks, memory management, processor and disk scheduling, parallel processing, and file system organization and implementation. Also to study different methods for protection and security that are becoming vital now-a-days.

**Course Description :**

- To master the basic concepts related to operating systems. To learn in detail about process management. To master concurrency and control of processes like critical-section problems and its solution. To understand memory management functions of operating systems. To be familiar with principles of deadlock and its prevention. To understand the concepts of file system interface.

**Course Contents :**

**Unit – I:** Operating system and function, Evolution of operating system, Batch, Interactive, multiprogramming, Time Sharing and Real Time System, multiprocessor system, Distributed system, System protection. Operating System structure, Operating System Services, System Program and calls.

**Unit – II:** Process concept, State model, and process scheduling, job and process synchronization, structure of process management, Threads interprocess Communication and Synchronization: Principle of Concurrency, Producer Consumer Problem, Critical Section problem, Semaphores, Hardware Synchronization, Critical Regions, Conditional critical region, Monitor, Inter Process Communication. CPU Scheduling: Job scheduling functions, Process scheduling, Scheduling Algorithms, Non Preemptive and preemptive. Strategies, Algorithm Evaluation, Multiprocessor Scheduling. Deadlock: System Deadlock Model, Deadlock Characterization, Methods for handling deadlock, Prevention strategies, avoidance and Detection, Recovery from deadlock combined approach.

**UnitIII:** Single Contiguous Allocation: H/W support, S/W support, Advantages and disadvantages, Fragmentation, Paging, Segmentation, Virtual memory concept, Demand paging,

Performance, Paged replaced algorithm, Allocation of frames, Thrashing, Cache memory, Swapping, Overlays

**Unit – IV:** Principles of I/O hardware, Device controller, Device Drivers, Memory mapped I/O,

Direct Access Memory, Interrupts, Interrupt Handlers, Application I/O interface, I/O Scheduling, Buffering, Caching, Spooling, Disk organization, Disk space management, Disk allocation Method, Disk Scheduling, Disk storage.

**Unit - V :** File Concept, File Organization and Access Mechanism, File Directories, Basic file system, File Sharing, Allocation method, Free space management. Policy Mechanism, Authentication, Internalexcess Authorization.

**Course learning outcomes (CLOs) :**

**CLO1 :** To master the basic concepts related to operating systems. To learn in detail about process management.

**CLO2:** : To master concurrency and control of processes like critical-section problems and its solution. To understand memory management functions of operating systems.

**CLO3:** To be familiar with principles of deadlock and its prevention. To understand the concepts of file system interface.

**CLO4 :**To familiar with file system implementation. To understand mass storage management functions of operating systems.

**CLO5:** To familiar with Protection and security aspects of operating systems. To expose to other operating systems like distributed OS, Multi-processor OS, RTOS and Mobile OS.

**Text books :**

1. Operating System by alvin Operating System by Tanenbaum
2. Operating System by William Stalling

**Online links for study & reference materials :**

<https://www.cse.iitb.ac.in/~mythili/os/>

**Course Code : BPHY102**

**Course Credit Hour : 4hr**

**Course Name : Organic Chemistry -I**

**Total Contact Hour : 60hr**

**Course Objective :**

- On completion of this course, the students will be able to understand the reactivity for hydrocarbons with mechanisms of halocarbons, alkenes, dienes, and arenes by understanding and applying concepts of organic chemical structure and bonding and stability.

## **Course Description :**

- Student will learn to write a brief summary indicating how this will be conducted specifying the key topics of the whole course like aromaticity, aromatic electrophilic substitution mechanism, aryl halogen compounds, nucleophilic aromatic substitutions, Carbonyl compounds-Preparations, reactions with mechanisms, Phenols-preparation and reactions, Comparative study of Acidity of the molecules like phenol, alcohol and carboxylic acid. Nitrogen Containing compounds-Comparative basicity of aliphatic and aromatic amines and Diazonium Salts-synthetic applications.

## **Course Contents : L-4 T-0 P-2**

### **Unit 1:**

Aromaticity: Aromaticity and Huckel rule - A general concept. Molecular orbital picture of benzene. Aromatic Electrophilic Substitution: Mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts (alkylation and acylation) reactions. Effects of substituents on orientation and reactivity.

### **Unit-2:**

Aryl Halogen Compounds: Chlorobenzene-electrophilic and nucleophilic aromatic substitutions; side chain chlorination of toluene.

### **Unit-3:**

Chemistry of Carbonyl compounds: Preparations and reactions: addition and condensation reactions; Cannizzaro, Perkin, aldol, benzoin, haloform, oxidation and reduction reactions. Important reactions of acids, HVZ reaction, Relative reactivity of acid chlorides, acid anhydrides, amides and esters. Comparative acidity of carboxylic and sulphonic acids.

### **Unit-4:**

Phenols: General methods of preparation and reactions. Reimer-Tiemann and Kolbe reactions. Relative acidity of phenol, alcohol and carboxylic acid.

### **Unit-5:**

Nitrogen Containing compounds: Nitrobenzene and reduction products.  
Comparative basicity of aliphatic and aromatic amines.  
Diazonium Salts: Preparation and synthetic applications.

## **Course Learning Outcomes (CLOs) :**

**CLO-1 :** To understand the concept of aromaticity, aromatic electrophilic substitution reactions with mechanisms.

**CLO-2 :** To understand the Aryl Halogen Compounds Reactivity, stability of organic molecules, structure, stereochemistry.



**CLO-3 :** To learn the Chemistry of Carbonyl compounds-nomenclature, structure, acidity, preparations, reactions and mechanisms.

**CLO-4 :** To learn the Phenols nomenclature, structure, acidity, preparations, reactions and mechanisms.

**CLO-5 :** To understand the Nitrogen Containing compounds- nomenclature, structure, basicity, preparations, reactions and mechanisms.

**Text books :**

1. Organic Chemistry, Paula Y. Bruice, 2nd Edition, Prentice-Hall, International Edition (1998)
2. Organic Chemistry”, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
3. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5<sup>th</sup> Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
4. Organic Chemistry, L.G. Wade Jr., 5th Edition (2001) Prentie Hall International INC. USA.
5. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, , Oxford Univ. Press, Oxford (2001).
6. Physical Chemistry, P. C. Rakshit, 5th Edition (1985), 4th Reprint (1997), Sarat Book House, Calcutta.
7. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, and M. S. Pathania, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.

**Reference books :**

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
3. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
4. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).

**Online links for study & reference materials:**

6. <http://www.freebookcentre.net/Chemistry/Organic-Chemistry-Books.html>
7. <https://chem.ucr.edu/curricular-materials/textbook>
8. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
9. <https://chemistry.com.pk/free-download-chemistry-books/>
10. <https://bookboon.com> › chemistry-ebooks

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**Course Code: STUGC/C06**  
**Course Credit Hour: 4hr**

**Course Name: Physical Chemistry-I**  
**Total Contact Hour: 60hr**

**Course Objective:**

- Application based learning of the subject. Discussion on the improvement of technology by increasing the heat efficiency. To study the reactions and their kinetics awareness. To acquire general idea about the heat flow, work done, enthalpy. Concept of system and types. Brief knowledge of laws of thermodynamics, kinetics, electrochemical cells and thermochemistry.

**Course Description**

- Better understanding of the heat changes, internal energy, enthalpy and heat capacity. Mathematical relations of different physical quantity. Entropy changes and heat efficiency concept better learning. Reactions, their dependence and kinetics. Electrochemical cells and thermochemistry basic knowledge.

**Course Contents: L-4 T-0 P-2**

**Unit 1: First Law of Thermodynamics I: Basic Concepts**

Thermodynamic processes, Reversible and irreversible processes, Nature of heat and work, Internal energy, units, First law of thermodynamics, Enthalpy, Molar heat capacity, Joule-Thomson effect, Joule-Thomson coefficient of real (van der Waal) gases, Adiabatic expansion of an ideal gas.

**Unit 2: Second law of Thermodynamics:**

The spontaneous processes, Entropy, Physical concept of entropy, the second law of Thermodynamics, Numerical definition of entropy, Units of entropy, Standard entropy, The Carnot cycle, Derivation of entropy from Carnot cycle, Net work done in one cycle, Entropy change for an ideal gas. Free energy and its concept, Work function ( $\Delta G$ ) Gibbs and Helmholtz free energies and their relationship, Variation of free energy with temperature and pressure.

**Unit 3: Thermochemistry:**

Introduction, Definition, Units of energy changes, Enthalpy of a reaction, Exothermic and Endothermic reactions, Thermochemical equations, Enthalpy of reaction, Kirchhoff's equation, Different types of enthalpy of reaction, Energy changes during transitions or phase changes, Hess's law. Application of Hess's law.

**Unit 4: Electrochemical Cells:**

Reactions in reversible cells, free energy and *emf* of reversible cell. Single electrode potential (Nernst equation), its measurement and sign convention. Standard electrode potential. *Emf* of reversible cell from electrode potentials. Types of reversible activities, pH, and equilibrium constant. Potentiometric titration. Concentration cells with and without transference. Liquid junction potential and its elimination.

**Unit 5: Chemical Kinetics:**

Order and molecularity of chemical reactions, pseudo order. Kinetic law for second order reactions, determination of the rate constant and order of reaction from kinetic data. Effect of temperature on rate of reaction: collision theory of rates of bimolecular reactions and its comparison with Arrhenius equation.

**Course Learning Outcomes (CLOs) :**

**CLO-1:** To state and apply the laws of thermodynamics; joule Thomson effect and adiabatic expansion of ideal gases.

**CLO-2:** To design practical engines by using thermodynamic cycles; predict chemical equilibrium and spontaneity of reactions by using thermodynamic principles. To be able to describe the stability of metal complexes by the use of formation constants and to calculate thermodynamic parameters from them.

**CLO-3:** To study the use of simple models for predictive understanding of physical phenomena associated to chemical thermodynamics and kinetics

**CLO-4:** Students can learn depth concepts about electrochemistry, *emf*, concentration cells and potentiometric titrations

**CLO-5:** The use of simple models for predictive understanding of physical phenomena associated to chemical thermodynamics and kinetics. To study the limitations and uses of models for the solution of applied problems involving chemical thermodynamic and kinetics

**Text books :**

1. Paul L Houston, Chemical Kinetics and Reaction Dynamics, Dover Publications Inc.; Illustrated edition (29 December 2006) ISBN-13: 978-0486453347
2. Physical Chemistry, P. C. Rakshit, 5th Edition (1985), 4th Reprint (1997), Sarat Book House, Calcutta.
3. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, and M. S. Pathania, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.

4. Physical Chemistry, K. J. Laidler and J. M. Meiser, 3rd Edition, Houghton Mifflin Comp., New York, International Edition (1999).

**Reference books :**

1. Physical Chemistry - P.W. Atkins, ELBS fourth edition.
2. Physical Chemistry – R.A. Alberty, R.I. Bilby, John Wiley – 1995
3. Essentials of Physical chemistry - Bahl and Tuli, S. Chand-2012
4. An Introduction To Electrochemistry, by Samuel Glasstone, East-West Press (Pvt.) Ltd. (1 January 2006) ISBN-13 : 978-8176710138

**Online links for study & reference materials:**

1. <https://courses.lumenlearning.com>
2. <https://www.siyavula.com>
3. <https://www.britannica.com/science/chemical-equilibrium>
4. <https://courses.lumenlearning.com>
5. <https://www2.estrellamountain.edu>
6. [https://application.wiley-vch.de/books/sample/3527330747\\_c01.pdf](https://application.wiley-vch.de/books/sample/3527330747_c01.pdf)
7. <http://library.umac.mo/ebooks/b28113640.pdf>

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**Course Code : STUGC-304**

**Course Credit Hour : 4hr**

**Course Name : Environmental Chemistry**

**Total Contact Hour : 60hr**

**Course Objective:**

- Environmental science is the foundation of the increased environmental understanding today and chemistry plays a major role in this. The properties and reactions of substances in the environment can profoundly influence the world we live in. These substances may be natural or man-made, and there is increasing interest in the interface between man-made systems and the natural environment. Understanding of the chemical basis of environmental science is developed in this course via studies in the areas of water, soil, earth and atmosphere. The objectives of this course are to (1) teach the students basic knowledge of environmental chemistry, such as chemistry of atmosphere, hydrosphere, pedosphere and biosphere; (2) teach the student how to apply basic theories and methods of chemistry to study the environmental issues caused by chemical substances (pollutants); (3) provide the students with broad and strong knowledge base for solving related problems.

**Course Description:**

- During this course students will study the chemistry of air, water, and toxic organic compounds as well as how anthropogenic activities affect this chemistry on planet Earth. Specifically, they will examine the sources, reactions, transport,

effects, and fates of chemical species found in air and water as well as the effects of technology thereon. This course is divided into 4 major parts that reflects the most pressing issues in Environmental Chemistry today: (1) Atmospheric Chemistry and Air Pollution (2) Water Chemistry and Water Pollution (3) Soil Chemistry and soil pollution and (4) Pedospheric Chemistry. All students who take this course are expected to demonstrate a mastery of all topics through successful completion of quizzes, problem sets, and exams as well as the pollutant assignment.

### **Course Contents : L-4 T-0 P-2**

#### **Unit: 1. Atmospheric Chemistry**

Atmospheric structure, Atmospheric composition, Air pollution, Particles and Clouds, Climate, Stratospheric ozone depletion, Water in the atmosphere-Acid rain.

#### **Unit: 2. Hydrospheric Chemistry**

Water chemistry basics, Colloids, Adsorption and reaction at surfaces, Oxidation and reduction, Dispersions, Dissolution and precipitation, Endocrine disruptors in water

#### **Unit: 3. Pedospheric Chemistry**

Soil Structure and Components, Soil properties, Heavy metals in soil, Agricultural chemicals in soil.

#### **Unit: 4. Biospheric Chemistry**

Bioaccumulation of pollutants, Chemical contaminants and ecotoxicology, Transport and transformation of typical pollutants in the environment.

### **Course Learning Outcomes(CLOs) :**

Environmental chemistry is the study of the distribution and interactions of matter (chemicals) in the environment, which includes both the outdoors and the indoors. Students learn the basic principles of environmental chemistry. After completion of the course, they will be able to

**CLO-1:** Understand the interconnections between different sectors of the environment (soil, water, atmosphere) and the effect of human activities on the natural chemical processes.

**CLO-2:** Develop skills in recognizing chemically based environmental problems, an awareness of the possible effects of chemicals on the environment and a capacity to interpret environmental data and to apply diverse chemical principles in the explanation of environmental phenomena.

**CLO-3** Demonstrate knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.

**CLO-4:** Describe causes and effects of environmental pollution by industry and discuss some mitigation strategies.

**CLO-5:** Discuss local and global environmental issues based on the knowledge gained throughout the course.

**Text books :**

1. Pani, B. (2017), Textbook of Environmental Chemistry, I.K. International Publishing House.
2. De, A. K. (2012), Environmental Chemistry, New Age International Pvt, Ltd, New Delhi.
3. Khopkar, S.M. (2010), Environmental Pollution Analysis, New Age International Publisher.
4. Michael Baird, Colin, Cann, Environmental Chemistry, W. H. Freeman and Company, 5<sup>th</sup> edition, ASIN : B00HQ22RPG
5. W. Hawker, D. W. Conell, M. Warne, P. D. Vowles: Basic Concepts of Environmental Chemistry, Lewis Publishers, ISBN-13 : 978-0873719988
6. P. Schwarzenbach, P. M. Gschwend, D. M. Imboden: Environmental Organic Chemistry, J. Wiley and Sons, 3<sup>rd</sup> edition, ISBN: 978-1-118-76723-8.
7. G. Howard: Aquatic Environmental Chemistry, Oxford Science Publ., 5<sup>th</sup> edition ISBN-13 : 978-0198502838

**Reference books :**

1. Baird, et al ENVIRONMENTAL CHEMISTRY by, W. H. Freeman and Company, New York, 4th Edition. ISBN-13: 9781429201469, ISBN-10: 1429201460.
2. Friedland, R. Relyea and D. Courard-Hauri, ENVIRONMENTAL SCIENCE FOUNDATIONS AND APPLICATIONS, W. H. Freeman and Company, 2<sup>nd</sup> edition, ISBN-13: 9781429240291, ISBN-10: 0429240296.

**Online links for study & reference materials:**

1. <https://climate.ncsu.edu/edu/Structure>
2. [https://www.researchgate.net/publication/265849316\\_Effects\\_of\\_Heavy\\_Metals\\_on\\_Soil\\_Plants\\_Human\\_Health\\_and\\_Aquatic\\_Life](https://www.researchgate.net/publication/265849316_Effects_of_Heavy_Metals_on_Soil_Plants_Human_Health_and_Aquatic_Life)
3. <http://www.pollutionissues.com/A-Bo/Bioaccumulation.html>
4. [https://nptel.ac.in/content/syllabus\\_pdf/104103020.pdf](https://nptel.ac.in/content/syllabus_pdf/104103020.pdf)

**Course Code : STUGC/SEC1**  
**Course Credit Hour : 4hr**

**Course Name: Intellectual Property Rights**  
**Total Contact Hour : 60hr**

**Course Objective :**

- To introduce fundamental aspects of Intellectual property Rights to students who are going to play a major role in development and management of innovative projects in industries. To disseminate knowledge on patents, patent regime in

India and abroad and registration aspects. To disseminate knowledge on trademarks and registration aspects. To disseminate knowledge on Design, Geographical Indication (GI), Plant Variety and Layout Design Protection and their registration aspects To aware about current trends in IPR and Govt. steps in fostering IPR.

### **Course Description :**

- This course is an intensive study of the core subjects of intellectual property law: patents, copyrights, trade secrets, and trademarks. It examines the fundamental principles of these bodies of law, their underlying policies, and how the laws inter-relate. Course will provide. comprehensive knowledge to the students regarding Indian position of the Patent Law (1970), Historical development, Procedure for granting a patent, Infringement
- Comprehensive knowledge to the students regarding Indian position of the Copyright Law, 1957, Historical background and Development of Copyright Law, Infringement. comprehensive knowledge to the students regarding Indian position of the Trademark Act, 1999, Historical development of the concept of trademark and trademark law, Registration of trademark, Infringement of trademark, geographical indications and for industrial designs too.

### **Course Contents : L-4 T-0 P-2**

#### **Unit I: Introduction to Intellectual Property**

Historical Perspective, Different Types of IP, Importance of protecting IP.

#### **Unit II: Copyrights**

Introduction, How to obtain, Differences from Patents.

#### **Unit III: Trade Marks**

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.

#### **Unit IV: Patents**

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

#### **Unit V: Geographical Indications**

Definition, rules for registration, prevention of illegal exploitation, importance to India.

#### **Unit VI: Industrial Designs**

Definition, How to obtain, features, International design registration.

### **Course Learning Outcomes(CLOs) :**

**CLO 1:** The students once they complete their academic projects, shall get an adequate knowledge on patent and copyright for their innovative research works

**CLO 2:** During their research career, information in patent documents provide useful insight on novelty of their idea from state-of-the art search. This provides further way for developing their idea or innovations

**CLO 3:** Pave the way for the students to catch up Intellectual Property (IP) as a career option

- a. R&D IP Counsel
- b. Government Jobs – Patent Examiner
- c. Private Jobs
- d. Patent agent and Trademark agent
- e. Entrepreneur

### **Text Books :**

1. N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001), 6<sup>th</sup> Edition, ISBN No: 978-9381849309
2. Manjula Guru & M.B. Rao, Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications (2003), 1<sup>st</sup> Edition, ISBN-10 : 0761997385 ISBN-13 : 978-0761997382
3. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001), 1<sup>st</sup> Edition, ISBN-10 : 0074638602 ISBN-13 : 978-0074638606

### **Reference Books:**

4. Arthur Raphael Miller, Micheal H.Davis; Intellectual Property: Patents,Trademarks and Copyright in a Nutshell, West Group Publishers (2000), 3<sup>rd</sup> Edition, ISBN-10 : 0314235191; ISBN-13 : 978-0314235190
5. Jayashree Watal, Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford, 1<sup>st</sup> Edition, ISBN-10 : 0195661702 ISBN-13 : 978-0195661705

### **Online links for study & reference materials :**

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1. <http://cipam.gov.in/>
2. (<https://www.wipo.int/about-ip/en/>)
3. (<http://www.ipindia.nic.in/>)
4. <http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf>



**Course Code : STUGC/C08**  
**Course Credit Hour : 4hr**

**Course Name : Inorganic Chemistry-I**  
**Total Contact Hour : 60hr**

**Course Objective :**

- To understand the concept of acid and bases, related theories and strengths. To make the students understand that solutions which have water as a solvent are called aqueous solutions and those with solvent other than water are called non-aqueous solutions. To understand the concepts of metal ligand bonding in transition complex compounds. To understand the nomenclature, classification, properties and preparations of coordination compounds. In order to study transition metals to understand the trends in properties and reactivity of the d-block elements. To explain and differentiate the physical and chemical properties of lanthanides and actinides. To Identify and define various types of nuclear changes or processes including fission, fusion and decay reactions.

**Course Description :**

- This course provides an overview of fundamental topics in inorganic chemistry. Acid base concept, their strength, non-aqueous solvents their characteristics, metal ligand bonding, nomenclature, classification, properties and preparations of coordination compounds. In order to study transition metals to understand the trends in properties and reactivity of the d-block elements lanthanides and actinides their properties and differentiation. Nuclear chemistry to understand the nuclear fission, fusion, radioactivity half-life and application.

**Course Contents : L-4 T-0 P-2**

**Unit 1:**

**Acids and bases:** Bronsted-Lowry, Lux-Flood, Solvent System and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases. HSAB theory and applications

**Unit 2:**

**Non-aqueous solvents:** Physical properties of a solvent for functioning as an effective reaction medium, types of solvents and their general characteristics. Liq.  $\text{NH}_3$  as a non-aqueous solvent

**Unit 3:**

**Coordination compounds:** Nomenclature, Werner's theory. Isomerism. Sidgwick's EAN concept and Valence Bond Theory. Stereochemistry of coordination compounds with coordination no. 4, 5 and 6.

**Unit 4:**

**Lanthanides:** Comparative study of lanthanide elements with respect to electronic configuration atomic and ionic radii, oxidation state and complex formation, lanthanide contraction. Separation of lanthanides. Application of lanthanide complexes.

**Unit 5:**

**Nuclear Chemistry:** Nucleus and its classification, nuclear forces, nuclear binding energy, stability of nucleus. Radioactivity: Radioactive elements, general characteristics of radioactive decay, decay kinetics (decay constant, half life, mean life period), units of radioactivity.

**Course Learning Outcomes (CLOs) :**

After completion of the course student will be

**CLO-1 :** Able to state the acid base theory as well factors affecting their relative strength.

**CLO-2:** Familiar with the basic knowledge of the non-aqueous solutions and applications of non-aqueous solvents in analytical chemistry.

**CLO-3 :** Recognize the bonding in transition compounds by VBT and CFST theories. 2. Able to predict the geometry of coordination compounds and type of hybridization.

**CLO-4 :** Able to understand the various uses of lanthanides elements in flash light powders, in dyeing cotton and in lasers

**CLO-5 :** Able to define radioactive compound and their general properties as half -life, decay constant.

**Text books :**

1. *Recent Aspects in Inorganic Chemistry*, R.C. Agarwal, Kitab Mahal
2. *Inorganic Chemistry*, J.E. Huheey, E.A. Keiter and R.L. Keiter.
3. *Basic Inorganic Chemistry*, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
4. *Physical Chemistry for the Chemical and Biological Sciences*, Raymond Chang; University Science Book, California (2000).
5. *New Trends in Green Chemistry*, V.K. Ahluwalia, M. Kidwai, Anamaya Publication, New Delhi (2004)
6. *Physical Chemistry for the Chemical and Biological Sciences*, Raymond Chang; University Science Book, California (2000).
7. *New Trends in Green Chemistry*, V.K. Ahluwalia, M. Kidwai, Anamaya Publication, New Delhi (2004)
8. *Green Chemistry: Environmentally Benign Reactions*, V. K. Ahluwalia, 2007
9. *Modern Molecular Photochemistry*, N. J. Turro, University Science Books, Sausalito California (1991).
10. *Green Chemistry: An Introductory Text*, Mike Lancaster, RSC Paperback, Edn. (2002)

**Reference books :**

1. R.C. Agarwal , *Recent Aspects in Inorganic Chemistry*, Kitab Mahal, 1<sup>st</sup> edition, ISBN-13 : 978-8122500349

2. J.E. Huheey, E.A. Keiter and R.L. Keiter, Inorganic Chemistry, pearson, 4<sup>th</sup> edition ISBN-10 : 006042995X; ISBN-13 : 978-0060429959 .
3. F. A Cotton, G. Wilkinson, and Paul L. Gaus, Basic Inorganic Chemistry, Wiley, 3rd Edition, ISBN: 978-0-471-50532-7
4. Raymond Chang , Physical Chemistry for the Chemical and Biological Sciences, University Science Book, California (2000), 3<sup>rd</sup> Edition, ISBN 978-1-891389-06-1
5. ASIM K. DAS, FUNDAMENTAL CONCEPTS OF INORGANIC CHEMISTRY, CBS PUBLISHERS & DISTRIBUTORS PVT LTD , 3<sup>rd</sup> Edition, ISBN-13 : 978-9389565973
6. J.D. Lee Concise Inorganic Chemistry, wiley, 4<sup>th</sup> Edition, ISBN-13 : 978-8126564200

#### Online links for study & reference materials:

1. [http://www2.hkedcity.net/sch\\_files/a/scg/scg-chem/visitor\\_cabinet/5325/d-block.pdf](http://www2.hkedcity.net/sch_files/a/scg/scg-chem/visitor_cabinet/5325/d-block.pdf)
2. [http://www.vandemataramcollege.com/app/webroot/files/notes/Chemistry\\_of\\_Lanthanides\\_and\\_Actinides-TY\\_Bsc.pdf](http://www.vandemataramcollege.com/app/webroot/files/notes/Chemistry_of_Lanthanides_and_Actinides-TY_Bsc.pdf)
3. [https://edurev.in/studytube/Non-Aqueous-Solvents--Part-1--Acids-and-Bases--Ino/28aefa4a-3eed-4cd8-9c40-93b893191011\\_t](https://edurev.in/studytube/Non-Aqueous-Solvents--Part-1--Acids-and-Bases--Ino/28aefa4a-3eed-4cd8-9c40-93b893191011_t)
4. <https://www.elsevier.com/books/non-aqueous-solvents-in-inorganic-chemistry/holliday/978-0-08-011335-7>
5. [https://www.fkit.unizg.hr/\\_download/repository/PDF\\_chemistry\\_of\\_transition\\_element.pdf](https://www.fkit.unizg.hr/_download/repository/PDF_chemistry_of_transition_element.pdf)
6. [https://www.alchemyst.co.uk/pdf/Inorganic/lanthanides\\_and\\_actinides.pdf](https://www.alchemyst.co.uk/pdf/Inorganic/lanthanides_and_actinides.pdf)

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**Course Code :** STUGC/ C0

**Course Name :** Organic Chemistry-II

**Course Credit Hour :** 4hr

**Total Contact Hour :** 60hr

#### Course Objective :

- On completion of this course, the students will be able to understand the basic of organic molecules, structure, bonding, reactivity and reaction mechanisms. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

#### Course Description :

- Write a brief summary indicating how this will be conducted specifying the key topics of the whole course. Alkyl halides-SN1, SN2, SNi, E1, E2, Ecb

mechanisms. Grignard reagents, primary, secondary and tertiary alcohols, Active methylene compounds preparation and applications, Conjugated and isolated dienes, resonance stabilization, Natural pigments- General structural features, occurrence, biological importance and applications.

### **Course Contents : L-4 T-0 P-2**

#### **Unit 1:**

**Alkyl Halides:** Nucleophilic substitution: SN1, SN2, SNi mechanisms; Eliminations reactions: E1 and E2, Ecb mechanisms, Elimination versus substitution reactions; energy profile diagrams-transition states (general considerations). Grignard reagents: Preparation and synthetic applications.

#### **Unit 2:**

**Alcohols:** Comparative study of substitution, dehydration, oxidation, and esterification of primary, secondary and tertiary alcohols.

#### **Unit 3:**

**Active methylene compounds:** Preparation and synthetic applications of ethyl acetoacetate and diethyl malonate, Tautomerism

#### **Unit 4: Dienes**

Conjugated and isolated dienes, resonance stabilization, 1,2-versus 1,4-addition, Diels-Alder reaction.

#### **Unit 5: Natural pigments**

General structural features, occurrence, biological importance and applications of carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll).

### **Course Learning Outcomes (CLOs) :**

**CLO-1 :** To learn the Alkyl halides reactivity -SN1, SN2, SNi, E1, E2, Ecb mechanisms.

**CLO-2 :** To learn the Grignard reagents-types, preparations , reactions and applications

**CLO-3 :** primary, secondary and tertiary alcohols,

**CLO-4 :** To learn the Active methylene compounds preparation and applications, Conjugated and isolated dienes, resonance stabilization.

**CLO-5 :** To understanding the Natural pigments- General structural features, occurrence, biological importance and applications.

### **Text books :**

1. Organic Chemistry”, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.

2. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5<sup>th</sup> Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
3. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, and E. Wothers, , Oxford Univ. Press, Oxford (2001).

#### **Reference books :**

1. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
2. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
3. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
4. University Press.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).

#### **Online links for study & reference materials :**

6. <http://www.freebookcentre.net/Chemistry/Organic-Chemistry-Books.html> 7.

7. <https://chem.ucr.edu/curricular-materials/textbook>

8. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>

9. <https://bookboon.com> › chemistry-ebooks

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**Course Code : BPHY402**  
**Course Credit Hour : 4hr**

**Course Name : Green Chemistry**  
**Total Contact Hour : 60hr**

#### **Course Objective :**

- Today's society is moving towards becoming more and more environmentally conscious. There is rising concern of environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills 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.
- The primary goal of this course is to make students aware of how chemical processes can be designed, developed and run in a sustainable way. Green chemistry has been defined as “the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. No one person can be an expert in all areas of green chemistry but this course should provide a base of knowledge and understanding of resources and directions of innovations in green chemistry and green engineering for future awareness. Ultimately, the current

green chemistry community of scholars hopes that the term “green chemistry” becomes obsolete because ALL chemistry will be approached with the 12 principles in mind.

- Innovations and applications of green chemistry in education has helped companies not only gain 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.

### **Course Description :**

- Understand the twelve principles of green chemistry and will build the basic understanding of toxicity, hazard and risk of chemical substances. Understand stoichiometric calculations and relate them to green chemistry metrics. They will learn about atom economy and how it is different from percentage yield. Learn to design safer chemical, products and processes that are less toxic, than current alternatives. Importance led reactions in various green solvents. 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.
- We will learn about the principles of green chemistry and chemical engineering and their modern application in both academia and industry. Green chemistry metrics will be defined to help quantify improved processes. Students learn the basic principles of green chemistry. They will study green process metrics. They learn alternative solvent media and energy sources for chemical processes. They learn about renewable feedstocks for the chemical industry, present and under development. They review the principles of catalysis, photochemistry and other interesting processes from the viewpoint of green chemistry. They perform laboratory experiments in which they apply some of the concepts previously learnt (stoichiometry, green solvent, reagents ...) and they put into practice some of the principles of green chemistry. Case studies will be used to illustrate the use of alternative feedstocks, reagents, and reaction media, recent developments in environmentally benign catalysis and synthetic methods, and broader considerations of energy utilization.

### **Course Contents : L-4 T-0 P-2**

#### **Unit I Introduction to Green Chemistry**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry.

#### **Unit II Principles of Green Chemistry and Designing a Chemical synthesis**

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/byproducts; maximum incorporation of the materials used in the process into the final products (Atom

Economy); prevention/minimization of hazardous/toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

### **Unit III Examples of Green Synthesis/Reactions**

**1** Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, citral, ibuprofen, paracetamol, furfural.

**2** Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols).

### **Unit IV Future Trends in Green Chemistry**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

### **Course Learning Outcomes (CLOs) :**

After finishing the course student will be able to:

**CLO-1:** To understand the principles of green chemistry and end-of-pipe method

**CLO-2:** To understand and can plan green solutions for industrial production of Petroleum and petrochemicals, Surfactants, Organic and inorganic chemicals

**CLO-3:** To provide green solutions for chemical energy storage, Energy carriers and alternative fuels including electrofuels and hydrogen

**CLO-4:** To present examples of successful green technologies

### **Text books :**

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. A.S. Matlack: Introduction to Green Chemistry, Marcel Deckkar, (2001).
3. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).

4. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).
5. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers, 1<sup>st</sup> Edition, ISBN 978-94-015-7102-9
6. Dr. Indu Tucker Sidhwani, Rakesh K. Sharma **An Introductory Text on Green Chemistry**, 1<sup>st</sup> edition, ISBN-10 : 812655407X
7. R. A. Sheldon, Isabella Arends, Ulf Hanefeld , Green Chemistry and Catalysis, Wiley, 1<sup>st</sup> Edition, ISBN:9783527611010, 3527611010

#### **Reference books :**

1. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998). ISBN: 9780198506980
2. Lancaster, M.(2016),Green Chemistry An Introductory Text.2nd Edition, RSC Publishing.
3. Cann ,M. C. ; Connely, M. E.(2000), Real-World cases in Green Chemistry, American Chemical Society, Washington.
4. Matlack, A.S.(2001),Introduction to Green Chemistry, Marcel Dekker.
5. Alhuwalia, V. K.; Kidwai, M.R.(2005),New Trends in Green chemistry, Anamalaya Publishers.

#### **Online links for study & reference materials :**

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<https://www.acs.org/content/dam/acsorg/greenchemistry/education/summerschool/Kirchhoff%20Green%20Chemistry%20Principles%20and%20Practice2.pdf>

<https://oregonstate.edu/instruct/ch390/lessons/media/lesson1.pdf>

[faculty.swosu.edu/tim.hubin/share/Microwave%20Synthesis.pdf](https://faculty.swosu.edu/tim.hubin/share/Microwave%20Synthesis.pdf)

[https://oatao.univ-toulouse.fr/10066/1/Lesage\\_10066.pdf](https://oatao.univ-toulouse.fr/10066/1/Lesage_10066.pdf)

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**Course Code : STUGC/SEC2**

**Course Credit Hour : 3 hr**

**Course Name : Food Chemistry**

**Total Contact Hour : 40hr**

#### **Course Objective :**

This skill based course provides:

- Students the basic knowledge in Food Chemistry and modern trends in the industry. The practical training to the students in the food analysis. General knowledge of the biology and chemistry. Elementary idea of basic food groups, their functions and sources. Application based learning of the subject.



## **Course Description :**

- Students will learn to apply and incorporate the principles of food science in practical, real- world situations and problems. Students will be able to apply the principles of food science to control and assure the quality of food products.

## **Course Contents : L-3 T-0 P-2**

### **UNIT I: Introduction: Food Science (6 h)**

**Food:** Introduction to different food groups and importance of food chemistry, Source, functions of food – food groups – food guide – basic five food groups, balance diet – food in relation to health. **Water:** Water in foods and its properties, Importance of water in relation to food content. **Milk:** Composition and effectiveness as a diet. Dairy and dairy product.

### **UNIT 2: Constituents of Foods: Properties and Significance (10 h)**

**Carbohydrates:** Classification, Structure, Properties, Artificial sweetening agents. Principles involved in the analysis of carbohydrates.

**Proteins:** amino acids – peptides– proteins, Metabolism, Sources and physico-chemical and functional properties.

**Fats and Oils:** Nomenclature and classification. Emulsions and emulsifiers, rancidity of fats – chemistry of fat and oil processing – function and storage of fats. Analysis of oils and fats –iodine number, RM value, acid number and saponification values – principles.

### **UNIT 3: Additional Food Constituents: (10 h)**

**Minerals and Vitamins:** Sources, functions, bioavailability and deficiency of the following minerals (calcium, phosphorous, magnesium, iron, copper, iodine, fluorine, sodium and potassium (elementary treatment). Vitamins - classification, sources, functions and deficiencies of fat- soluble vitamins – A, D, E and K, Water-soluble vitamins – C, thiamin, niacin, riboflavin, Bcomplex, - B6, Folic acid and B12.

**Fibers:** Importance in diet.

**Enzymes:** Nomenclature, classification, Enzymes used in food processing.

### **UNIT 4: Foods and Food Additives: (6 h)**

**Food additives:** Artificial sweeteners– Food flavours Antioxidants. Acidulants, Woodsmoke, Formaldehyde, Spices, Alkalies, Food colours –Emulsifying agents and Edible foaming agents, Preservatives -leavening agents. Baking powder –Yeast, Stabilizers and Thickeners.

**Sequesterants** – uses and abuses of these substances in food beverages.

## **UNIT 5: Food Adulteration and Food Safety (4 h)**

**Adulterants:** Common adulterants in different foods – milk and milk products, vegetable oils, and fats, spices and condiments, cereals, pulses, sweetening agents and beverages. Contamination with toxic chemicals, Microbial growth,

**Quality control:** Specifications and standards: PFA, FPO, FDA, drug license, WHO standards, ISI specifications, packing and label requirements, essential commodities act, consumer protection act. AGMARK.

**Packaging of foods** – classification of package, materials used for packing, laws related to packaging and nutrition labelling.

### **Course Learning Outcomes (CLOs) :**

**CLO-1:** To know the chemistry underlying the properties and reactions of various food components, food groups, importance of balanced diet, properties of water and milk. To know the chemistry underlying the properties and reactions of various food components.

**CLO-2:** Students will be able to compare and contrast the structure and functions of the oligo and polysaccharides, proteins, fats and oils.

**CLO-3:** To understand the various sources, functions, bioavailability and deficiency of the minerals, vitamins, fibers and enzymes.

**CLO-4:** Ability to explain the benefits and limitations (scientific and ethical) of food additives and processing aids currently used by the food processing industry and those additives which may be permitted to be used in the future.

**CLO-5:** To know the major chemical reactions that limit shelf life of foods. Common adulterants used, how to preserve the quality and packaging of food materials.

### **Text books :**

1. Swaminathan M. Advanced Text Book on Food and Nutrition , volume I and II Printing and Publishing CO., Ltd., Bangalore. 1993.
2. Swaminathan M. Text Book on Food chemistry, Printing and Publishing CO., Ltd., Bangalore. 1993.
3. Norman N. Potter, Food science, CBS publishers and distributors, New Delhi. 1994.
5. Owen R Fennema, Food Chemistry, Marcel Decker Inc., New York. 1996.
6. Srilakshmi B., Food Science, New age International Pvt. Ltd. Publishers, III ed. 2003.
7. Siva Sankar B., Food Processing and Preservation. Prentice – Hall of India Pvt. Ltd., New Delhi. 2002.
8. Ramakrishnan S., Prasannam K.G and Rajan R –Principles. Text book of medical biochemistry. Orient Longman Ltd. III ed. 2001.
9. Shakuntala Manay N. and ShadaksharaswamyM. FOODS: Facts and Principles. New age International Pvt. Ltd. Publishers, II ed. 2002

### **Reference books :**

1. Food Microbiology by Frazier, Tata McGraw-Hill Education. 18<sup>th</sup> edition ISBN: 9781259062513, 9781259062513
2. Lillian Hoagland Meyer, Food Chemistry, CBS publishers and distributors, New Delhi. 1994. ISBN: 9788123911496
3. Louis J. Ronsivalli and Ernest R. Viera, Elementary Food Science, 3<sup>rd</sup> edition
4. Dennis R. Heldman and Richard W. Hartel, Principles of food Processing (1996)

#### **Online links for study & reference materials :**

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1. <https://www.frontiersin.org/journals/all/sections/food-chemistry>
2. <https://www.toppr.com/guides/chemistry/biomolecule/carbohydrates/>
3. [http://www.cuchd.in/elibrary/resource\\_library/University%20Institutes%20of%20Sciences/Fundamentals%20of%20Biochemistry/Chap-10.pdf](http://www.cuchd.in/elibrary/resource_library/University%20Institutes%20of%20Sciences/Fundamentals%20of%20Biochemistry/Chap-10.pdf)
4. <https://revisionworld.com/gcse-revision/applied-science/aqa-additional-applied-science/unit-2-exam-topics/food-science/food-tests/fat-tests>
5. <https://www.webmd.com/diet/guide/types-fat-in-foods>
6. <https://www.healthlinkbc.ca/health-topics/ta3868>
7. <https://www.uofmhealth.org/health-library/ta3912>
8. <http://www.leadthecompetition.in/GK/functions-of-minerals-in-human-body.html>
9. <http://www.foodadditivesworld.com/flavorings.html>
10. <https://books.google.co.in/books?id=XcSp015g4X0C&pg=PA278&lpg=PA278&dq=sequestrants+in+food&source=bl&ots=y1nGrfKbaL&sig=Y1ikfJ7K9jZpGW R15RPsfqjOMGc&hl=en&sa=X&ved=2ahUKEwj6r-m52fbeAhUKfn0KHVF-DGMQ6AEwC3oECAsQAQ#v=onepage&q=sequestrants%20in%20food&f=false>
11. <https://www.worldofchemicals.com/Chemicals/Sequestrants/id-73.html?lst=trt>

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**Course Code: GE-4**

**Course Name : Fuel Chemistry and Batteries**

**Course Credit Hour : 3hr**

**Total Contact Hour : 60hr**

#### **Course Objective:**

- To acquire knowledge of applied chemistry materials and about fuels and batteries. To describe the electrochemistry associated with several common batteries. To distinguish the operation of a fuel cell from that of a battery.

#### **Course Description:**

- The course will cover important technologies in energy conversion and storage in detail, including lithium-ion batteries and fuel cells. To recognize biofuels as alternative energy source. To study the fractional distillation of petroleum and different byproducts.

### **Course Contents : L-4 T-0 P-2**

#### **UNIT –I : Review of energy sources (renewable and non-renewable): (12h)**

Classification of fuels and their calorific value. Coal: Uses of Coal (fuel and non-fuel) in various industries, its composition, carbonization of coal - coal gas, producer gas and water gas – composition and uses – fractionation of coal tar – uses of coal tar-based chemicals, requisites of a good metallurgical coke, coal gasification (Hydro gasification and catalytic gasification) coal liquefaction and solvent refining.

#### **UNIT-II Petroleum and petrol chemical industry: (6h)**

Composition of crude petroleum, refining and different types of petroleum products and their applications.

#### **UNIT-III Fractional distillation (10 h)**

Principle and process, cracking (Thermal and catalytic cracking). Reforming petroleum and non-petroleum fuels (LPG, CNG, LNG, biogas), fuels derived from biomass, fuel from waste, synthetic fuels (gaseous and liquids), clear fuels,

Petro-chemicals : vinyl acetate, propylene oxide , isoprene , butadiene, toluene and its derivative xylene.

#### **UNIT-IV Lubricants: (10 h)**

Classification of lubricants, lubricating oils(conducting and non-conducting) , solid and semi solid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

#### **UNIT-V Batteries: (7 h)**

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

### **Course Learning Outcomes (CLOs) :**

**CLO-1:** To discuss different types of fossil fuels and their calorific value.

**CLO-2:** To study the composition of crude petroleum, refining and different types of petroleum products and their applications. To understand and analyze the combustion mechanisms of various fuels.

**CLO-3:** To study the fractional distillation and other derived petrochemicals.

**CLO-4:** To learn the classification of lubricants and their properties.

**CLO-5:** To acquire detailed knowledge of batteries and their working.

**Text books :**

1. Engineering Chemistry by P.C. Jain & M. Jain, Dhanpatrai Publishing Company, New Delhi (2010)
2. Engineering Chemistry by Shashi Chawla, Dhanpatrai & Company (P) Ltd. Delhi (2011)
3. Engineering Chemistry by Shikha Agarwal, Cambridge University Press, Delhi (2015)

**Reference books :**

1. Engineering Chemistry by Rama Devi, Venkata Ramana Reddy and Rath, Cengage learning, New Delhi. (2016)
2. Engineering Chemistry by Thirumala Chary and Laxminarayana, Scitech Publishers, Chennai (2016).
3. Dell, Ronald M Rand, David A J, 'Understanding Batteries', Royal Society of Chemistry, (2001).
4. M. Aulice Scibioh and B. Viswanathan 'Fuel Cells – principles and applications', University Press, India (2006).

**Online links for study & reference materials :**

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1. [CY8151 – unit 4 - Fuels introduction - Padeepz](#)
  2. [CY8151 – unit 5 - Batteries & fuel cells - Padeepz](#)
  3. [CY8151 – unit 5 - Fuel cells - Padeepz](#)
  4. [Batteries and Fuel Cells | Chemistry for Majors \(lumenlearning.com\)](#)
  5. [3 Fuel Chemistry.pdf - FUEL CHEMISTRY LEARNING OUTCOMES](#)  
[\u25e6Classify fossil fuels\(CO1 \u25e6Discuss the different steps in petroleum processing and | Course Hero](#)
- 

**Course Code :** STUGC/C0

**Course Name :** Advance Organic Chemistry

**Course Credit Hour :** 4hr

**Total Contact Hour :** 60hr

**Course Objective :**

- Familiarization about classes of organic compounds and their methods of preparation. Basic uses of reaction mechanisms. On completion of this course, the students will be able to understand the various Methods of Determining Reaction Mechanism and Molecular Rearrangements.

**Course Description :**

- Write a brief summary indicating how this will be conducted specifying the key topics of the whole course the various methods of determining reaction mechanism, Principles and reactions of photochemistry, Synthesis and chemistry of heterocyclic compounds, organosulphur compounds synthesis and reactions, Molecular Rearrangements reactions with mechanisms.

**Course Contents : L-4 T-0 P-2**

**Unit-1: Methods of Determining Reaction Mechanism:** Guidelines for proposing a reasonable mechanism, product studies, bonds broken and formed, inter and intramolecular migration of groups, crossover experiments, exchange with solvents, importance of byproducts, reactive intermediates. Isotopic substitution in a molecule, primary and secondary kinetic isotope effects - their importance in mechanistic studies.

**Unit -2: Photochemistry:** Principles of photochemistry, Photochemical reactions of carbonyl compounds and olefins.

**Unit -3: Heterocyclic Compounds:** Synthesis and chemistry of indole, quinoline and isoquinoline.

**Unit -4: Organosulphur and Organophosphorus Compounds:** Introduction to organosulphur compounds, methods of synthesis and reactions of thiols, thioether and aliphatic sulphonic acids. Introduction to organophosphorus compounds, phosphate esters and phosphorus ylides, general methods of preparation and reaction. Wittig reaction.

**Unit -5: Molecular Rearrangements Involving Electron Deficient Atoms:** Pinacol-pinacolone, Beckmann, Hofmann and Wolff rearrangements, Baeyer-Villiger oxidation.

**Course Learning Outcomes (CLOs) :**

**CLO-1 :** To learn the different types and methods of determining reaction mechanism,

**CLO-2 :** To learn the Principles and reactions of photochemistry.

**CLO-3 :** To learn the Structures, resonance, Synthesis and chemistry of heterocyclic compounds.

**CLO-4 :** To learn the various organo-sulphur compounds synthesis and reactions.

**CLO-5 :** To learn the different types of Molecular Rearrangements reactions with mechanisms.

**Text books :**

1. “*Organic Chemistry*”, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
2. “*A Guide Book to Mechanism in Organic Chemistry*”, P. Sykes, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. “*Organic Chemistry*”, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
4. “*Organic Chemistry*”, S. M. Mukherji, S. P. Singh, and R. P. Kapoor, 1st Edition (1985), 5<sup>th</sup> Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.

**Reference books :**

1. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc (2009).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.
3. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
4. Morrison R. T. and Boyd R. N. *Organic Chemistry*, Sixth Edition Prentice Hall India, 2003.

**Online links for study & reference materials :**

5. <http://www.freebookcentre.net/Chemistry/Organic-Chemistry-Books.html>  
<https://chem.ucr.edu/curricular-materials/textbook>
6. <https://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/intro1.htm>
7. <https://chemistry.com.pk/free-download-chemistry-books/>  
[https://bookboon.com › chemistry-ebooks](https://bookboon.com/chemistry-ebooks)

**Course Code : STUGC/ CO**

**Course Name : Polymer Chemistry**

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**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- The primary objective of this paper is to help the student to know about the synthesis, properties and applications of polymers. To study the fundamental concepts of polymer chemistry. To study the structure of monomers, functionality, and classification of polymers basis of source, composition, conditions, molecular weight, geometry, and Nomenclature of polymers.
- To study the various methods and techniques of polymerization reactions, their chemistry, mechanism, structures, properties and applications. To study the structure of polymers, Molecular weight and their types, polymer dispersity, degree of polymerization, chain length and polymerization techniques. To study the molecular structure, properties and applications are depending on structure. If structure changes (modify) properties and applications also changes.

**Course Description :**

- The course provides an introduction to polymer chemistry based on synthesis mechanisms associated with chain-growth and step-growth polymerization. Basic knowledge is provided with regards to polymerization kinetics, network formation, and gelation. Industrial polymerization processes are considered in light of the form and properties of the product. Polymer structure/conformation and transitions from liquid (melt) to solid (polymer crystal or glass) states are discussed using equilibrium thermodynamics, kinetics and free volume considerations.
- By the end of this course, students will be able to: Know about history of polymeric materials and their classification, Learn about different mechanisms of polymerization and polymerization techniques, Evaluate kinetic chain length of polymers based on their mechanism, Differentiate between polymers and copolymers, Learn about different methods of finding out average molecular weight of polymers, Differentiate between glass transition temperature ( $T_g$ ) and crystalline melting point ( $T_m$ ), Determine  $T_g$  and  $T_m$ , Know about solid and solution properties of polymers, 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.

**Course Contents : L-4 T-0 P-2****UNIT 1 : INTRODUCTION TO POLYMER**

- 1.1 Monomers, Oligomers, Polymers and their characteristics
- 1.2 Classification of polymers : Natural synthetic, linear, cross linked and network; plastics, elastomers, fibres, Homopolymers and Co-polymers
- 1.3 Bonding in polymers : Primary and secondary bond forces in polymers ; cohesive energy and decomposition of polymers.
- 1.4 Determination of Molecular mass of polymers: Number Average molecular mass ( $M_n$ ) and Weight average molecular mass ( $M_w$ ) of polymers and determination by (i) viscosity (ii) Light scattering method (iii) Gel Permeation Chromatography (iv) osmometry and ultracentrifuging.



Self study: Molecular weight determination of high polymers by different methods.

## **UNIT 2 : KINETICS AND MECHANISM FOR POLYMERIZATION**

2.1 Chain growth polymerization : Cationic, anionic, free radical polymerization, Stereo regular polymers : Ziegler Natta polymers.

2.2 Polycondensation-non catalysed, acid catalysed polymerization, molecular weight distribution Step growth polymers

Self study: Degrees of polymerization

## **UNIT 3 : TECHNIQUES OF POLYMERIZATION AND POLYMER DEGRADATION**

3.1 Bulk, Solution, Emulsion, Suspension, Melt polycondensation, solution polycondensation interfacial and gas phase polymerization

3.2 Types of Polymer Degradation, Thermal degradation, mechanical degradation, photodegradation, Photo stabilizers.

Self study: Solid and gas phase polymerisation

## **UNIT 4 : INDUSTRIAL POLYMERS: (10 hours)**

4.1 Raw material, preparation, fibre forming polymers, elastomeric material.

4.2 Thermoplastics : Polyethylene, Polypropylene, polystyrene, Polyacrylonitrile, Poly Vinyl Chloride, Poly tetrafluoro ethylene, nylon and polyester.

4.3 Thermosetting Plastics : Phenol formaldehyde and epoxide resin.

4.4 Elastomers : Natural rubber and synthetic rubber - Buna - N, Buna-S and neoprene. Conducting Polymers : Elementary ideas ; examples : poly sulphur nitriles, poly phenylene, poly pyrrole and poly acetylene.

Self study: Poly methylmethacrylate, polyimides, polyamides, polyurethanes, polyureas, polyethylene and polypropylene glycols

## **UNIT 5 : INTRODUCTION TO POLYMER PROCESSING : (5 hours)**

5.1 Compounding: Polymer Additives: Fillers, Plasticizers antioxidants and thermal stabilizers fire retardants and colourants.

5.2 Processing Techniques: Calendaring, die casting, compression moulding, injection moulding, blow moulding, extrusion moulding and reinforcing.

Self study: Film casting, Thermofforming, Foaming.

### **Course Learning Outcomes (CLOs) :**

**CLO 1:** Will understand the basic concepts, operation and applications of various techniques used for molecular weights of polymers Differentiate kind of polymers and their properties,

**CLO 2:** Understand the concept of synthesis of homo polymers, co -polymers, ter-polymers, block co-polymers.

**CLO 2:** Understand different techniques of polymerization of polymers, Concept of Molecular Weight and distribution.

**CLO 3:** understand various structure of polymers and their effect on different properties of polymers.

**CLO 4:** have deep understanding of the various analytical techniques used for identification and characterization of polymeric materials. Process of polymer degradation.

**CLO 5:** understand the processing techniques for various polymers additives,

**Text books :**

1. F. N. Billmeyer, Textbook of Polymer Science, Wiley Interscience, 1971, 2<sup>nd</sup> edition, ISBN-10 : 0471072990; ISBN-13 : 978-0471072997
2. A. Kumar and S. K. Gupta, Fundamentals and Polymer Science and Engineering, Tata McGraw-Hill, 1978.1<sup>st</sup> Edition, ISBN: 0-8247-0867-9
3. Seymour's Polymer Chemistry, Marcel Dekker Inc,3<sup>rd</sup> Edition, ISBN-10 : 0824787196; ISBN-13 : 978-0824787196
4. G. Odian: Principles of Polymerization, John Wiley, 1<sup>st</sup> Edition ISBN:9780471274001
5. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995. 2. G.S. Misra, Introductory Polymer Chemistry, New Age International (Pvt) Limited, 1996.
6. 1.F. N. Billmeyer, Textbook of Polymer Science, Wiley Interscience, 1971.

**Reference books :**

1. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995, 2<sup>nd</sup> Edition, ISBN: 9780852263075, 9780852263075
2. G.S. Misra, Introductory Polymer Chemistry, New Age International (Pvt) Limited, 1996,1<sup>st</sup> edition, ISBN:8122404715 9788122404715
3. Fred j devis, Polymer chemistry, oxford university press, 1<sup>st</sup> Edition, ISBN 0 19 850309 1
4. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill.
5. R.W. Lenz: Organic Chemistry of Synthetic High Polymers.
6. Reference Books • Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
7. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
8. Carraher,C. E. Jr. (2013), Seymour's Polymer Chemistry, Marcel Dekker, Inc.
9. Odian, G. (2004), Principles of Polymerization, John Wiley.
4. Billmeyer, F.W. (1984),Text Book of Polymer Science, John Wiley.
5. Ghosh, P. (2001),Polymer Science & Technology, Tata McGraw-Hill.
10. Lenz, R.W. (1967),Organic Chemistry of Synthetic High Polymers, Interscience (Wiley).

**Online links for study & reference materials :**

1. <https://www.britannica.com/science/polymerization#:~:text=Polymerization%2C%20any%20process%20in%20which,three%2C%20or%20more%20different%20compounds.>
1. <https://byjus.com/jee/polymerization/>
2. [https://chem.libretexts.org/Bookshelves/General\\_Chemistry/Map%3A\\_General\\_Chemistry\\_\(Petrucci\\_et\\_al.\)/27%3A\\_Reactions\\_of\\_Organic\\_Compounds/27.08%3A\\_Polymers\\_and\\_Polymerization\\_Reactions](https://chem.libretexts.org/Bookshelves/General_Chemistry/Map%3A_General_Chemistry_(Petrucci_et_al.)/27%3A_Reactions_of_Organic_Compounds/27.08%3A_Polymers_and_Polymerization_Reactions)

3. <https://www.corrosionpedia.com/definition/903/polymerization>
4. <https://royalsocietypublishing.org/doi/pdf/10.1098/rspa.1939.0059>
5. <https://www.nap.edu/read/2307/chapter/5>

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**Course Code :STUGC/C**  
**Course Credit Hour : 4hr**

**Course Name : Industrial Chemistry-I**  
**Total Contact Hour : 60hr**

**Course Objective :**

- After completion of the course, the learner shall be able to understand about the industrial processes of various types of the chemical and derivatives preparation in industrial scale and challenges. Have sound knowledge of pharmaceuticals, cosmetics, perfumes and pesticides. Become well equipped to design, carry out, record and analyze the industrial preparations. Understand the ethical, historic, philosophical, and environmental dimensions of problems and issues facing industrial chemists. Become skilled in problem solving, critical thinking and analytical reasoning. Identify and solve chemical problems and explore new innovative areas of research. Know the proper procedures and regulations for safe handling and use of chemicals and can follow the proper procedures.

**Course Description :**

- This course briefs about the industrial scale preparations of various types of Cosmetics and Perfumes, oils. Heterogeneous catalysis and their industrial applications. Battery Industry, Alloys-classification, properties and industrial applications.

**Course Contents : L-4 T-0 P-2**

**Unit-1:**

**Cosmetics and Perfumes:** A general study including 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).

Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil,  $\alpha$ -phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

**Unit-2:**

**Catalysis Industry:** General principles and properties of catalysts, homogenous catalysis and heterogeneous catalysis and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts in industry.

**Unit-3:**

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

**Unit-4:**

**Alloys:** Classification of alloys, Ferrous and Non-Ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

**Course Learning Outcomes (CLOs) :**

**CLO-1 :** To understand the industrial scale preparations of various types of Cosmetics and Perfumes, oils with process flowcharts.

**CLO-2 :** To understand the concept and advantages of heterogeneous catalysis and their industrial applications. Catalyst deactivation process and regeneration.

**CLO-3 :** To understand the industrial scale preparations of various types of battery Industry

**CLO-4 :** To understand the concept and advantages of alloys-classification, properties and industrial applications.

**Text books :**

1. Vermani, O. P.; Narula, A. K. (2004), Industrial Chemistry, Galgotia Publications Pvt. Ltd.,
2. New Delhi.
3. Bhatia, S. C. (2004), Chemical Process Industries, Vol. I & II, CBS Publishers, New Delhi.
4. Barel, A.O.; Paye, M.; Maibach, H.I.(2014), Handbook of Cosmetic Science and
5. Technology, CRC Press.
9. Gupta, P.K.; Gupta, S.K.(2011),Pharmaceutics and Cosmetics, Pragati Prakashan
10. Butler, H. (2000),Poucher's Perfumes, Cosmetic and Soap, Springer

**Reference books :**

1. Stocchi, E.(1990), Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. 2. Felder, R. M.; Rousseau, R. W. (2015), Elementary Principles of Chemical Processes, Wiley

3. Publishers, New Delhi.
4. Kingery, W. D.;Bowen, H. K.;Uhlmann, D. R. (1976), Introduction to Ceramics, Wiley
5. Publishers, New Delhi.
6. Kent, J. A. (ed) (1997), Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
7. Jain, P. C.; Jain, M. (2013), Engineering Chemistry, Dhanpat Rai & Sons, Delhi.

**Online links for study & reference materials :**

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1. <https://bookboon.com> › chemistry-ebooks
2. [https://www.researchgate.net/publication/257417805\\_Industrial\\_Chemistry](https://www.researchgate.net/publication/257417805_Industrial_Chemistry)
3. <https://chemistry.com.pk/free-download-chemistry-books/>
4. <https://www.kopykitab.com/Industrial-Chemistry-1-by-Dr-G-S-Gugale-Dr-A-V-Nagawade-Dr-R-A-Pawar-Dr-K-M-Gadave>
5. <https://www.internetchemistry.com/chemistry/industrial-chemistry.php>

**Course Code : STUGC/ DSE 2**

**Course Name : Forensic Chemistry**

**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- To give the students the importance of forensic chemistry and an exposure to find, analyse and find a suitable method to detect the crime. (Readings, discussion, video examples). Participation in this course will be familiarize the student with the methodologies involved in analyzing forensic samples. Provide a background in statistical analysis of data. Allow students to assess forensic methodologies utilized in the popular media

**Course Description :**

- Application based learning of the subject. Students will learn to apply and incorporate the forensic principles and analysis. To familiarize the student with the methodologies involved in analyzing forensic samples. To determine the accuracy and reproducibility of methods studied in this course.

**Course Contents : L-4 T-0 P-2**

**UNIT 1: JUSTICE AND SCIENCE**

A brief history of forensic Science, Science and law, Evidence, Modern Practice of forensic Science, Methodology, Role of forensic scientist, Forensic chemistry, Theory of forensic analysis, identification, Comparative analysis: Classification and Individualization.

**UNIT 2: FINGERPRINTS**

Fingerprints as a means of identification, Fingerprint patterns, Fingerprint classification, Development of latent fingerprints, Composition of latent fingerprint residues, Physical methods, Chemical methods: Powder dusting, Ninhydrin reaction, Silver nitrate reaction,

iodine fuming, superglue fuming, phenolphthalein reaction, combination/special illumination, systematic approaches.

### **UNIT 3: FORENSIC TOXICOLOGY**

Drugs and poison as biological evidence, Application of forensic toxicology, Drug and Poison classes, Non-medicinal agents, Analytical Method in forensic toxicology, Chemical examination, Presumptive drug analysis, Chemical color tests, Microcrystalline tests, Microscopic analysis, Instrumental examination and IR spectroscopy, Thin layer chromatography, ink analysis, Soil analysis.

### **UNIT 4: ARSON, FIRE AND EXPLOSIVES.**

Chemistry of fire or explosion, Behavior of fire, Origin and Cause Analysis, Accelerants, Fatal fire investigation, Collection of fire Debris evidence, Analysis of fire debris evidence, Explosives.

### **UNIT 5: TRACE EVIDENCE**

Instruments of Microanalysis and Sample types, Basic Microscopy, Scanning Electron Microscopy, Microscopic Evidence and its Analysis: Glass, Hairs and furs, Fibers, Paint, Soils, Gunshot Residue.

### **Course Learning Outcomes (CLOs) :**

**CLO-1:** To introduce the modern practices of forensic science, methodology and role of forensic scientist. To determine the accuracy and reproducibility of methods studied in this course.

**CLO-2:** To understand the different types of fingerprint techniques and their usage. To learn the strengths and weaknesses of the methods studied in this course

**CLO-3:** Understand how spectroscopic and analytical methods are used to analyze forensic samples like drugs, poisons and soil.

**CLO-4:** To study the fire patterns, their causes and behaviour analysis as a tool in forensic study.

**CLO-5:** To understand the importance of microscopic evidence and how its analysis are done.

### **Text books :**

1. *Forensic Chemistry*, Suzanne Bell, © 2006, Pearson-Prentice Hall. ISBN 0-13-147835-4.
2. *Forensic Chemistry*, David Collins, Brigham Young University, Idaho.

3. Introduction to Forensic Chemistry by Kelly M. Elkins ISBN 9781498763103 published October 18, 2018 by CRC Press

**Reference books :**

1. *Forensic Chemistry*, Suzanne Bell, © 2006, Pearson-Prentice Hall. ISBN 0-13-147835-4.
2. *Criminalistics: An Introduction to Forensic Science* by Richard Saferstein (Author)
3. Trejos, T., Koch, S., & Mehlretter, A. (2020). Scientific foundations and current state of trace evidence – A review. *Forensic Chemistry* 18. doi:10.1016/j.forc.2020.100223.

**Online links for study & reference materials :**

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1. [www.onlinelibrary.wiley.com/doi/book/10.1002/9781118897768](http://www.onlinelibrary.wiley.com/doi/book/10.1002/9781118897768)
  2. <https://bibleandbookcenter.com/read/forensic-chemistry/>
  3. [https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiPn5aV\\_5\\_tAhXQT30KHZXvCPMQFjALegQIFBAC&url=https%3A%2F%2Fsciencemonk.com%2Fforensictoxicology%2F&usg=AOvVaw3OvIJ52ayAvNfMGp11DPGj](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiPn5aV_5_tAhXQT30KHZXvCPMQFjALegQIFBAC&url=https%3A%2F%2Fsciencemonk.com%2Fforensictoxicology%2F&usg=AOvVaw3OvIJ52ayAvNfMGp11DPGj)
  4. *Applications - Forensic and Toxicology - Markes International* [www.markes.com](http://www.markes.com)  
› Mass Spec application notes (google.com)
  5. [https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiA36Lu\\_5\\_tAhXQT30KHZXvCPMQFjAAegQIAhAC&url=https%3A%2F%2Fwww.ncjrs.gov%2Fpdffiles1%2Fnij%2Fgrants%2F225085.pdf&usg=AOvVaw3VwUP1DpB2jpxNzTFid8yY](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiA36Lu_5_tAhXQT30KHZXvCPMQFjAAegQIAhAC&url=https%3A%2F%2Fwww.ncjrs.gov%2Fpdffiles1%2Fnij%2Fgrants%2F225085.pdf&usg=AOvVaw3VwUP1DpB2jpxNzTFid8yY)
  6. [https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiA36Lu\\_5\\_tAhXQT30KHZXvCPMQFjABegQIARAC&url=https%3A%2F%2Fwww.ncjrs.gov%2Fpdffiles1%2Fnij%2F181584.pdf&usg=AOvVaw2OTidxhmvH5bHMmX7ZtIxx](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiA36Lu_5_tAhXQT30KHZXvCPMQFjABegQIARAC&url=https%3A%2F%2Fwww.ncjrs.gov%2Fpdffiles1%2Fnij%2F181584.pdf&usg=AOvVaw2OTidxhmvH5bHMmX7ZtIxx)
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**Course Code: STUGC/C13  
Approach-II**

**Course Name : Physical Chemistry- A Molecular**

**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- General knowledge of the spectroscopic and quantum chemistry. Elementary idea of atomic structures, degeneracy, eigen functions and quantum numbers. Provides a description of the physical properties of nature at the scale of atoms and subatomic particles. The gain basic knowledge of molecular statistics

#### **Course Description:**

- Students will learn to apply and incorporate spectroscopy for the analysis of chemical structures and characterization of chemical species. Basic knowledge of atomic structures and quantum mechanics.

#### **Course Contents : L-4 T-0 P-2**

**Unit 1: Quantum Mechanics and Atomic Structure:** A review of the black body radiation and the old quantum theory. The wave nature of electron. The Uncertainty Principle. Schrödinger's wave mechanics. Eigenfunctions and normalizations. Quantum mechanical operators. Expectation value of a physical quantity. Orthogonality of wave functions. The particle in a one-dimensional box problem and its solutions. Particle in a three-dimensional box. Degeneracy. The hydrogen atom problem. Atomic orbitals. Orbital quantum numbers and their physical significance. Electron spin. Helium atom and Pauli Principle. The variational principle.

**Unit 2: Molecular Spectroscopy:** Emission and absorption spectra. Transition probabilities and selection rules. Pure rotational spectra. Diatomic molecules. Rigid rotor model. Linear triatomic molecules. Vibrational-rotational spectra. Diatomic molecules. Harmonic oscillator-rigid rotor approximation. Anharmonicity effect. Normal modes of vibration. Infrared spectra of linear and bent AB<sub>2</sub> molecules. Characteristic group frequencies. Electronic spectra of diatomic molecules. Vibrational structure. Franck-Condon principle.

**Unit 3: Molecular Statistics:** The Boltzmann distribution. Maxwell distribution law for distribution of molecular speeds. The Maxwell-Boltzmann distribution law for the distribution of molecular energies. The partition functions. Thermodynamic quantities from partition functions. The Sackur-Tetrode equation for molar entropy of monoatomic gases. Rotational and vibrational partition functions. The characteristic temperature. The calculation of Gibbs free energy changes and equilibrium constant in terms of partition functions.

**Unit 4: Transport Phenomena:** General transport equation. Viscosity and diffusion.

#### **Course Learning Outcomes (CLOs) :**

**CLO-1:** To study about the wave nature of electron, schrodingers wave mechanics and orthogonality.



**CLO-2:** Application based learning of the subject. To gain elementary knowledge of vibrational, electronic, rotational spectroscopy.

**CLO-3:** To have the idea of anharmonicity, Franck-condon principle and different modes of vibration. Maxwell-Boltzmann distribution can be used to determine the distribution of the kinetic energy of for a set of molecules.

**CLO-4:** To learn the effect of temperature and pressure on transport phenomenon. Better understanding of viscosity and diffusion phenomenon.

**Text books:**

1. "Physical Chemistry", K. J. Laidler and J. M. Meiser, 3rd Edition (International Edition, 1999), Houghton Mifflin Co., New York.
2. "Physical Chemistry", I. N. Levine, 4th Edition (International Edition, 1995), McGraw-Hill Inc., New York.
3. "Physical Chemistry - A Molecular Approach", D. A. McQuarrie and J. D. Simon, South Asian Edition (1998), University Science Books, Sausalito CA, by Viva Books, New Delhi.

**Reference books :**

1. Physical Chemistry, P. Atkins and J. De Paul, 8<sup>th</sup> Edition (2006), International Student Edition, Oxford University Press.
2. Essentials of Physical chemistry - Bahl and Tuli, S. Chand- 2012
3. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, and M. S. Pathania, 37th Edition (1998), Shoban Lal Nagin Chand & Co., Jalandhar.

**Online links for study & reference materials :**

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1. <https://chemistry.stackexchange.com/questions/40018/orthogonal-wavefunctions>
  2. [Maxwell Boltzmann Distribution Derivation - Equation Derivation and Important FAQs \(vedantu.com\)](#)
  3. [http://kkrk.chem.elte.hu/molim/lectures/Electronic\\_vibrational\\_line\\_shape\\_Part2.pdf](http://kkrk.chem.elte.hu/molim/lectures/Electronic_vibrational_line_shape_Part2.pdf)
  4. [http://kkrk.chem.elte.hu/molim/lectures/Electronic\\_vibrational\\_line\\_shape\\_Part2.pdf](http://kkrk.chem.elte.hu/molim/lectures/Electronic_vibrational_line_shape_Part2.pdf)
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**Course Code : STUGC/C**

**Course Name : Organic Chemistry-III**

**Course Credit Hour : 4hr**

**Total Contact Hour : 60hr**

**Course Objective :**

- After completion of the course, the learner shall be able to understand organic compounds and derivatives preparations and reactions with mechanisms. Isolation of industrially important organic molecules.

**Course Description :**

- This course summary shall indicate the specific key topics of the Carboxylic acids, general preparation, acidity and reactions, Cycloalkanes, general synthesis, Bayer's strain theory and its limitations, Five membered heterocycles & Condensed five membered heterocycles synthesis and reactions, classification, structure and synthesis of citral, geraniol and a-terpineol.

**Course Contents : L-4 T-0 P-2****Unit-1: Carboxylic Acids and their Derivatives**

Carboxylic acids, general preparation and reactions. Comparative acidity of carboxylic and sulphonic acids. Benzoic, phthalic and cinnamic acid. General chemistry of acid chlorides, acid anhydrides, amides and esters

**Unit-2: Alicyclic Compounds**

Cycloalkanes, general synthesis, Bayer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. Cyclohexane - chair and boat conformations, axial and equatorial bonds, conformation of mono substituted cyclohexanes.

**Unit-3: Heterocyclic Chemistry:**

Five membered heterocycles – Furan, Pyrrole and Thiophene, Condensed five membered heterocycles – Benzofuran, Indole and Benzothiophene, Pyridine, rings with more than one heteroatom 1, 2 –Azoles and 1, 3-Azoles, Purines and Pyrimidines.

**Unit-4: Terpens**

Occurrence, classification, structure and synthesis of citral, geraniol and a-terpineol.

**Course Learning Outcomes(CLOs) :**

**CLO-1 :** To understand the carboxylic acids, general preparation and reactions. Comparative acidity of carboxylic and sulphonic acids. Benzoic, phthalic and cinnamic acid. General chemistry of acid chlorides, acid anhydrides, amides and esters.

**CLO-2 :** To learn cycloalkanes, general synthesis, Bayer's strain theory and its limitations. Cyclohexane - chair and boat conformations, axial and equatorial bonds, conformation of mono substituted cyclohexanes.

**CLO-3 :** To understand the synthesis and reactions of five membered heterocycles compounds and Condensed five membered heterocycles. Chemistry of 1, 2 –Azoles and 1, 3-Azoles, Purines and Pyrimidines.

**CLO-4 :** To learn the about terpenoids, Occurrence, classification, structure and synthesis of citral, geraniol and a-terpineol.

**Text books :**

1. “*Organic Chemistry*”, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
2. “*Organic Chemistry*”, S. M. Mukherji , S. P. Singh, and R. P. Kapoor, 1st Edition (1985), 5<sup>th</sup> Reprint (1999), New Age International (P) Ltd. Publishers, New Delhi.

**Reference books :**

1. “*Organic Chemistry – Structure and Reactivity*”, Seyhan N. Ege, AITBS publishers, Delhi (1998).
2. “*Organic Chemistry*”, Paula Y. Bruice, 2nd Edition , Prentice-Hall Internattional Inc, New Jersey, International Edition (1998).

**Online links for study & reference materials**

<http://www.freebookcentre.net/Chemistry/Organic-Chemistry-Books.html>

<https://chem.ucr.edu/curricular-materials/textbook>

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**Course Code :STUGC/DSE**

**Course Credit Hour : 4hr**

**Course Name : Industrial Chemistry-II**

**Total Contact Hour : 60hr**

**Course Objective :**

- After completion of the course, the learner shall be able to understand the industrial preparation process of various commercials pesticides, glass, ceramic materials, paints, dyes.

**Course Description :**

- This course summary shall indicate the specific key topics of the pesticides, Synthesis, applications and residual toxicity. The ammonia and ammonium salts, urea, Superphosphate, bio-fertilizers. Definition and manufacture of glasses, optical glass and coloured glass, Cement. Primary constituents of a paint, binders and solvents for paints, detergents.

## **Course Contents : L-4 T-0 P-2**

### **Unit-I:**

**Pesticides & Fertilizers:** Classification of pesticides, Synthesis, applications and residual toxicity of aldrin, parathion, malathion, DDT, paraquat, 2,4-Dichlorophenoxyacetic acid, Zineb, Bordeaux mixture. Industrial manufacturing process of ammonia and ammonium salts, urea, Superphosphate, biofertilizers.

### **Unit-2:**

**Glass and Ceramics:** Definition and manufacture of glasses, optical glass and coloured glass. Clay and feldspar, glazing and vitrification, glazed porcelain, enamel. Portland cement: composition and setting of cement, white cement.

### **Unit-3:**

**Paints, Varnishes and Synthetic Dyes:** Primary constituents of a paint, binders and solvents for paints. Oil based paints, latex paints, baked-on paints (alkyd resins). Constituents of varnishes. Formulation of paints and varnishes.

### **Unit-4:**

**Detergents:** Production of toilet and washing soaps, detergent powder, liquid soaps.

## **Course Learning Outcomes (CLOs) :**

**CLO-1 :** To learn the various types of fertilizers-preparations, applications. pesticides, Synthesis, applications and residual toxicity.

**CLO-2 :** To learn the various types of glass manufacturing of glasses, troubleshooting. Classification of cements-preparation, applications.

**CLO-3 :** To learn the various types of primary constituents of a paint, binders and solvents for paints colours and applications

**CLO-4 :** To learn the various types of detergents, effect of composition, preparation, process.

### **Text books :**

1. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).

2. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
3. Richard Turton, Wallace B Whiting, Richard C Bailie Analysis, Synthesis and Design of Chemical Processes, 2020, Addison Wesley, ISBN-13: 9780134177403
4. Vermani, O. P.; Narula, A. K. (2004), Industrial Chemistry, Galgotia Publications Pvt. Ltd., New Delhi.
5. Bhatia, S. C. (2004), Chemical Process Industries, Vol. I & II, CBS Publishers, New Delhi.
6. Jain, P. C.; Jain, M. (2013), Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
7. Gopalan, R. Venkappayya, D.; Nagarajan, S. (2004), Engineering Chemistry, Vikas Publications.
8. Sharma, B. K. (1997), Engineering Chemistry, Goel Publishing House, Meerut

#### Reference books :

1. George T. A. (1977). Shreve's Chemical Process Industries. 5th edn. McGraw-Hill International Edition. Chemical Engineering Series. Singapore.
2. Chang R. and Tikkanen W. (1988). The Top Fifty Industrial Chemicals. Random House, New York.
3. Price R.F. and Regester M.M. (2000), WEFA Industrial Monitor, 2000-2001, John Wiley & Sons Inc., New York. Chang R. (1991). Chemistry, 4th Edition, McGraw-Hill Inc. New York.
4. Shukla S. D and Pandey G. N, (1978). A Textbook of Chemical Technology. Vol.1 (Inorganic/Organic). Vikas publishing House PVT Ltd. New Delhi.
5. Stephenson R.M. (1966). Introduction to the Chemical Process Industries, Reinhold Publishing Corporation, New York.
6. Groggins P.H. (1958). Unit Processes in Organic Synthesis, 5th Edition, McGraw-Hill Book Company, New Delhi.
7. Das R.K. (1988) Industrial Chemistry: Metallurgy, Kalyani Publishers, New Delhi. Gerhartz, W. (Editor), (1987). Ullmann's Encyclopaedia of Industrial Chemistry Vol A8, 5th Edition, VCH Verlagsgesellschaft mbH, Weinheim.

#### Online links for study & reference materials :

<https://bookauthority.org/books/best-industrial-chemistry-books>

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**Course Code :** STUGC/ DSE 4

**Course Credit Hour :** 4hr

**Course Name :** Drug Synthesis

**Total Contact Hour :** 60hr

#### Course Objective :

- General structural features of agents belonging to the therapeutic class. Relevant physicochemical properties. Relevant chemical reactions/synthetic pathways for selected drugs. Structural influences on mechanism of pharmacologic action

(structure-activity relationship). Structural influences on pharmacologic/toxicological/therapeutic profiles.

### Course Description :

- The course gives an introduction to the most common synthetic methods that are applied in industrial and laboratory drug synthesis. The course deals with Structure, stereochemistry, Mode of action, Structure activity relationships, synthesis of drugs and with the molecular mechanism of drug action.

### Course Contents : L-4 T-0 P-2

**1. Antibacterials:** Penicillines, Cephalosporins, Tetracyclines, Aminoglycosides, Chloramphenicol, Macrolides, Lincomycins, Polypeptides antibiotics, Polyene antibiotics. Sulfonamides and Sulfones fluoroquinolones, Trimethoprim and other unclassified antibiotics. Antimycobacterials: Sulfanilamides, p-Aminosalicylic acid derivatives, Thioamides, Thiourea, derivatives, Thiosemicarbazones, Isoniazid, Kanamycin sulfate, Capreomycin, Rifampin, Pyrazinamide, Anthionamide, Clofazimine, Cyclosporin, Dapsone, Sulfazem. Commercial synthetic/semi-synthetic routes to : 6-amino penicillanic acid, ampicillin, amoxycillin, production of penicillin, 7-amino cephalosporanic acid, cephalexin, ceftizoxime, cefaclor, cephalothin, Tetracyclins: doxycycline, nalidixic acid, sulfadiazine, Norflaxacin, Ciprofloxacin, O-flaxacin, Amifloxacin, Difloxacin, Chloramphenicol, Nitrofurantoin, Sulfamethoxazole, Acetylsulfamethoxazole, Trimethoprim.

**2. Antimalarials:** Cinchona alkaloids, 4-Aminoquinolines, 8-Aminoquinolines, 9-Aminoacridines, Biguanides, Pyrimidines and Sulfones, Mefloquine, Sulfonamides. Commercial synthetic routes to: Chloroquine, pamaquine, primaquine, proguanil, Amodiaquine, Mefloquine, Pyrimethamine, Sotonaquine.

**3. Antiamoebic and antiprotozoal drugs:** Emetine hydrochloride, 8-Hydroxyquinoline, Iodochlorohydroxyquinol, Metronidazole, Diloxanide furoate, Bilamical hydrochloride, Hydroxystilbamidine isothionate, Pentamidine isothionate, Nifurtimox, Suramin sodium, Carbarsone, Glycobiarsol, Melarsoprol, Sodium stibogluconate, Dimercaprol, Diethylcyclohexylamine citrate, Centarsone, Acetarsone, Antimony potassium tartarate, Bismuth sodium thioglycollate, Sulphonamide, Stibiophen. Bismuth sodium thioglycollamate, Furazolidone.

**4. Anthelmintics:** Introduction, Tetrachloroethylene, Piperazines, Gentian violet, Pyrvinium pamoate, Thiabendazole, Mabendazole, baphenium hydroxynaphthoate, Dichlophen, Niclosamide, Levamisole hydrochloride, Tetramisole, Niridazole, Biothional, Antimony potassium tartarate, Stibiophen, Sodium Stibiocaptate.

**5. Antifungal drugs:** Fatty acids and their derivatives (Propionic acid, zinc propionate, sodium caprylate, zinc caprylate, undecylenic acid, Zinc undecylenate, Triacetin), Salicylanilids, Salicylic acid, Tolnaftate, pchloromethoxylenol, Acrisocrin, Fluconazole, Itraconazole, Haloprogin, Clotrimazole, Econazole, Miconazole, Ketoconazole, Flucytosine, Griseofulvin, Polyene antibiotics (Nystatin, Amphoetericin-B),

Chlorophenesin, Dithranol. Commercial synthetic routes to: Miconazole, Clotrimazole, Econazole, Fluconazole, Griseofulvin, Ketoconazole, Naftidine, Tolnaftate, Flucytosin.

**Course Learning Outcomes(CLOs) :**

After completion of the course student will be able to understand/explain

**CLO-1 :** Recognize the drug structure and predict its pharmacologic action.

**CLO-2 :** Relevant chemical reactions/synthetic pathways for selected drugs

**CLO-3 :** Knowledge of the connection between the structural features of the drugs and their physico-chemical characteristics, mechanism of action and use.

**CLO-4:** Application the gained knowledge about the drugs. Counseling and giving information to patients about the drug action.

**Text books :**

- Pharmaceutical Chemicals in Perspective. B.G. Reuben and H.A. Wittcoff, John Wiley & Sons, New York, 1989.
- W.C. Foye, Principles of Medicinal Chemistry, Lea & Febiger, Philadelphia, U.S.A.
- Strategies of Organic Drug Synthesis and Design, D. Lendnicer, John Wiley and Sons, New York, 1998.
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