दिल्ली विश्वविद्यालय

UNIVERSITY OF DELHI

Bachelor of Science in Analytical Chemistry
or
Bachelor of Science (Hons.) Analytical Chemistry with Dissertation/ Academic Projects/ Entrepreneurship
or
Bachelor of Science (Hons.) Analytical Chemistry with Dissertation/ Academic Projects/ Entrepreneurship (Discipline-1 Major)
or
Bachelor of Science (Hons.) Analytical Chemistry with Discipline-1(Major) & Discipline-2 (Minor)

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Syllabus for Semester I and II is complete and finalized,

Syllabus for Semester III to VI is subject to minor changes,

Syllabus for Semester VII and VIII is yet to be decided.

The syllabus for undergraduate programme in Analytical Chemistry has been drafted in accordance with the recommendations of the Undergraduate Curriculum Framework-2022. The preamble, definitions and abbreviations, features and important aspects of UGCF have been incorporated in this document as mentioned in UGCF 2022. In step with the evolving trends and developments in higher education globally, UGCF-2022 distinctly integrates the objectives and underlying philosophy of National Education Policy (NEP) 2020 in its attributes. The salient features such as holistic development, academic flexibility, life-long learning, multidisciplinary education, multilingualism, intra- and inter- university mobility, apprenticeship, research, innovation, entrepreneurship, social outreach, and the like, aim to enrich the learning experience, creativity, innovation, and skill development of the youth of our nation.

-Drafting Committee

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Preamble

The Undergraduate Curriculum Framework-2022 underlines the historical perspective, philosophical basis, and contemporary realities of higher education as enshrined in the National Education Policy (NEP) 2020 and endeavours to synchronize these cornerstones while charting the road ahead for the state of higher education.

The University of Delhi, a premier institute of teaching, learning, and research in higher education, acclaimed nationally and internationally, has nurtured the quest for reaching the peak in every sphere of education, in its true sense, in the process of its contribution to the nation-building. Being a Central University, mandated to act as the torchbearer in expanding the horizons of human resource development through expansion of higher education, it has always paid adequate premium towards constructive and meaningful innovation as a regular feature in its undergraduate curriculum development over the years. A reflection of such sustained and continued endeavour is amply exemplified in the successive revision of undergraduate curricular framework over the decades and especially in the last two decades, keeping pace with the emerging trends in higher education in the new millennium globally and its critical importance in enriching the youth of our nation, well equipped with the prevailing priorities of skill development through innovative and practical oriented teaching-learning more than anything else. To actualize the noble objective, as succinctly brought out in the National Education Policy 2020, the University has endeavoured to explore the possibility of further restructuring and refinement of its undergraduate curriculum framework in line with the objective and underlying philosophy of the NEP 2020 to capture the imagination of the youth of our nation which depicts the contemporary realities of our demographic advantage globally. The resultant outcome of this comprehensive exercise undertaken by the university is the Undergraduate Curriculum Framework-2022 (UGCF-2022) which not only underlines the heart and soul of the NEP 2020 in letter and spirit but also goes on to create a teaching-learning framework at the undergraduate level to attract the young minds towards research, innovation, apprenticeship, social outreach, entrepreneurship and similar such areas of human knowledge and endeavour while imbibing the truly charged academic environ of the university and its constituent colleges.

1. UGCF-2022: Definitions and Abbreviations

(a) Academic credit – An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work per week.

(b) Courses of study – Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, *viz.* Discipline Specific Core courses (DSCs), Discipline Specific Electives (DSEs), Skill Enhancement Courses (SECs) and Generic Electives (GEs). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the College/ University.

(i) Discipline Specific Core (DSC): Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/her programme of study. In Bachelor of Science (Analytical Chemistry), DSCs are the core credit courses of Analytical Chemistry, Chemistry, Physics and Mathematics; which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020. A student will study three Core Courses each, in Semesters I to VI and one core course each in semesters VII and VIII.

(ii) Discipline Specific Elective (DSE): The Discipline Specific Electives (DSEs) are a pool of credit courses of *Analytical Chemistry*, *Chemistry, Physics* and *Mathematics* from which a student will choose to study based on his/her interest. A student of Bachelor of Science in Analytical Chemistry gets an option of choosing one DSE course in each of the semesters III to VI from a pool of DSEs courses as specified for Odd and Even Semesters (Table-4). The student has an option of choosing a maximum of six DSE courses of analytical chemistry / Chemistry in semesters VII and VIII, not a combination of both.

(iii) Generic Elective (GE): Generic Electives is a pool of courses offered by various disciplines of study, which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student. In semesters I, II, V and VI, a student has to compulsorily study one GE course from a pool of courses offered by the institution. However, in semesters III and IV a student has an option of choosing between a DSE course in chemistry / Physics / Mathematics and a GE course of any discipline offered by the

Institution. Similarly, in semester VII and VIII a student can exercise an option of choosing a maximum of two Generic elective courses out of a combination of three DSE and GE courses.

(iv) Ability Enhancement course (AEC), Skill Enhancement Course (SEC) & Value Addition Course (VAC): These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose. A student who desires to make Academic Project/Entrepreneurship as Minor has to pick the appropriate combination of courses of GE, SEC, VAC, & Internship/Apprenticeship/Project/ Community (IAPC) which shall be offered in the form of various modules as specified in the scheme of studies.

• **AEC courses** are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/II semester) and the second year (III/IV semester), respectively. The AEC pool consists of credit courses in languages listed in the Eighth Schedule of the Constitution of India, as updated from time to time.

• **SEC** are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction. Some of these courses may be offered to students of chemistry while the rest can be open to students of all other disciplines. A student will study one Skill Enhancement Course of 2 credits each (following 1T+ 1P/ 0T+2P credit system) in all the semesters from I to VI. It is to be noted that in the semesters III, IV, V and VI; students can choose either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).

• **VAC courses** are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural & constitutional values; promote critical thinking, Indian Knowledge Systems, scientific temperament, communication skills, creative writing, presentation skills, sports & physical education and team work which will help in all round development of students.

2. Features of UGCF-2022

The Undergraduate Curriculum Framework- 2022 (UGCF) is meant to bring about systemic change in the higher education system in the University and align itself with the NEP 2020. The objectives of the NEP 2020 have been reflected in the following features of UGCF:

a) Holistic Development

Holistic development of the students shall be nurtured through imparting life skills in initial years. These life skill courses shall include courses on 'Environment and Sustainable Development Studies', 'Communication Skills', 'Ethics and Culture', 'Science and Society', 'Computational Skills', 'IT & Data Analytics', and similar such skills which shall make the students better equipped to deal with the life's challenges.

b) Academic Flexibility

Flexibility to the students to determine their learning trajectories and pursuance of programmes of study has been well ingrained in the UGCF. The Framework allows students to opt for one, two, or more discipline(s) of study as a core discipline(s) depending on his/her choice. He/she has been provided the option of focusing on studying allied courses of his/her selected discipline(s) (DSEs) or diversifying in other areas of study of other disciplines. Students have also been provided with the flexibility to study SECs or opt for Internships or Apprenticeship or Projects or Research or Community Outreach at an appropriate stage. In the fourth year, students are provided flexibility to opt for writing a dissertation (on major, minor, or combination of the two) or opt for Academic Projects or Entrepreneurship depending upon their choice and their future outlook, post completion of their formal education.

c) Multiple Exits/ Re-entry/ Academic Bank of Credit (ABC)/ Academic Outreach

Given the extent of plurality of the Indian society and the diverse background to which students belong, multiple exits and provision of re-entry have been provided at various stages of the undergraduate programme to accommodate their requirement and facilitate them to complete their studies depending upon their priorities of life. The earning and accumulation of credits in the Academic Bank of Credit (ABC), and the flexibility to redeem the requisite credit for award of appropriate Certificate / Diploma/ Degree, as the per the norms laid down by the UGC and the University, shall be made available to the students to provide the opportunity for lifelong learning as well as for availing academic outreach beyond the superstructure of the programme

of study in another University / Institution at the national /international level depending upon individual choice of the student(s).

d) Multidisciplinary Education

UGCF has incorporated multidisciplinary education by embedding within the framework. In Bachelor of Science Analytical Chemistry, a student can study DSC, DSE, and SEC courses of Chemistry/Analytical chemistry, Physics and Mathematics. More importantly a student can choose to study Generic Elective courses in all the disciplines offered by the college/University.

The framework does not maintain/support hierarchy among fields of study/disciplines and silos between different areas of learning. As long as a student fulfils the pre-requisites of a course of study, he/she shall be able to study it. Modules or systems of study shall be meaningfully laid down so as to guide the students in choosing the track/academic paths for the desired outcome.

e) **Multilingualism**

One of the significant hallmarks of the framework is a provision of pursuing multilingualism while studying any other discipline as core subject(s), which has no bearing with any language and linguistics. I and II semesters of the programme provides an opportunity to the students to study languages which are enshrined under the eighth schedule of the Constitution of India, thereby allowing the students for their holistic development, including the ability to acquire proficiency in a language beyond their mother tongue.

f) **Research and Innovation**

The framework provides a mandatory programme on research methodologies as one of the discipline specific electives (DSE) courses at the VI & VII semester for students who opt for writing dissertation on major/ minor or interdisciplinary at VII and VIII semesters. Dissertation/ Academic Project/Entrepreneurship in four-year undergraduate course shall commence from VII semester and conclude in VIII semester. Detailed outcomes of each track chosen out of these three options shall be notified at the end of VII and VIII semesters shall be done accordingly.

Further, provision for internship/apprenticeship/project/community outreach right from the III semester up to VI semester provides ample opportunity to the students to explore areas of knowledge/activity beyond the four walls of the classroom and reach out to the world outside

without any dilution of the academic feature of the course of study, he/she is pursuing. This also acts a precursor for the students to take up academic project or entrepreneurship at a later stage in VII & VIII semester. Such an initiative will help in skill development and laying a strong foundation for research and thus contribute towards overall national development through the development of skilled manpower and innovation.

g) Intra- and Inter-University Mobility

Intra and inter University mobility of students is another element of critical importance which has been ingrained in the framework. A student, by virtue of such mobility, will be able to make lateral movement within the University as well as from the University to any other Institution and vice-versa. Such an attribute allows a student maximum flexibility in terms of pursuance of education with special reference to higher education and enables him/ her to achieve goal of life, the way he/she perceived it.

Based on the aforementioned features of UGCF-2022, the University expects maximum involvement of the student fraternity in utilizing the benefits of such a flexible yet rigorous curriculum framework at the undergraduate level and reaping the benefits of it through enrichment of their skills in their area of interest which will eventually help them in gaining employment, entrepreneurship, start-ups and various other ways of a dignified life and living as a global citizen with comparable skills and innovative ideas befitting to the contemporary global demands. The university expects the youthful nation to reap the maximum benefits out of the UGCF-2022 in developing skilled manpower to harness the youthful energy at one hand and expand the permeation of the skilled workforce globally, taking the demographic advantage on the other hand.

3. Introduction to Undergraduate Degree course in Analytical Chemistry

As per the recommendations of UGCF 2022, the undergraduate degree course in Analytical Chemistry is a six/ eight semester course spread over three/ four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the DSCs of Analytical Chemistry / Chemistry, Physics and Mathematics, a student can opt courses from the syllabus comprising of DSEs, GEs, SECs, AECs and VACs. Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/ her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/ her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

4. Programme Duration and Exit Options

The minimum credit to be earned by a student per semester is 18 credits and the maximum is 26 credits. ***However, students are advised to earn 22 credits per semester***. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits have to be secured for the purpose of award of ***Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Analytical Chemistry are listed in Table 1***.

Table 1: Qualification Type and Credit Requirements

S.No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award
1.	*Undergraduate Certificate in Analytical Chemistry*	After successful completion of Semester II	44

2.	*Undergraduate Diploma in Analytical Chemistry*	After successful completion of Semester IV	88
3.	*Bachelor of Science in Analytical Chemistry*	After successful completion of Semester VI	132
4.	*Bachelor of Science (Hons.) in Analytical Chemistry with Dissertation/Academic Projects/Entrepreneurship*	After successful completion of Semester VIII	176
5.	*Bachelor of Science (Hons.) in Analytical Chemistry with Dissertation/Academic Projects/Entrepreneurship Discipline-1(Major)*	After successful completion of Semester VIII and credit requirements for Major	176
6.	*Bachelor of Science (Hons.) in Analytical Chemistry with Dissertation/Academic Projects/Entrepreneurship Discpline-1 (Major) & Discipline-2 (Minor)*	After successful completion of Semester VIII and credit requirements for Major and Minor	176

Major Discipline

A student pursuing four-year undergraduate programme in Analytical Chemistry shall be awarded B.Sc. (Hons.) degree with Major in Analytical Chemistry on completion of VIII Semester, if he/she secures in Analytical Chemistry/Chemistry at least 50% of the total credits *i.e.*, at least 88 credits in Analytical Chemistry/ Chemistry out of the total of 176 credits.

Minor Discipline

A student of B.Sc. (Hons.) Analytical Chemistry may be awarded Minor in a discipline (Analytical Chemistry /Chemistry, Physics/ Mathematics) on completion of VIII Semester, if he/she earns minimum 28 credits from six DSCs and one DSE of that discipline.

5. Programme Objectives

The undergraduate degree course in Chemistry aims to provide:

i. In-depth knowledge in chemistry through understanding of key chemical concepts, principles, theories and their manifestations.
ii. Competence and skill in solving both theoretical and applied chemistry problems.
iii. A conducive learning environment that ensures holistic cognitive development of students.
iv. Exposure to the latest advances in chemistry, allied disciplines and research.
v. Development of critical and analytical thinking, scientific reasoning, problem solving skills, communication skills and teamwork.
vi. Moral and ethical awareness, leadership qualities, innovation and life-long learning.
vii. Multicultural competence and multilinguism.
viii. Knowledge and skills to undertake higher studies/research in chemistry and related interdisciplinary areas thereby enabling students' employment/entrepreneurship.
ix. Sufficient subject matter competence and also enable students to prepare for various competitive examinations.

6. Program Outcomes

The programme learning outcomes of the undergraduate degree course in Analytical Chemistry are as follows:

• **In-depth knowledge:** The student will acquire theoretical knowledge and understanding of the fundamental concepts, principles and processes in the main and allied branches of chemistry/ Analytical Chemistry, Physics and Mathematics. The core papers will provide in-depth understanding of the subject. A wide choice of elective courses offered to the student will provide specialized understanding rooted in the core and interdisciplinary areas.

• **Hands-on/ Laboratory Skills:** Comprehensive hands-on/ laboratory exercises will impart analytical, computational and instrumentation skills. The students will be able to demonstrate mature skills for the collating, evaluation, analysis and presentation of information, ideas, concepts and quantitative and/or qualitative data.

• **Research skills:** The course provides an opportunity to students to hone their research and innovation skills through internship/ apprenticeship/ project/ community outreach/ dissertation/Academic Project/ Entrepreneurship. It will enable the students to demonstrate mature skills in literature survey, information management skills, data analysis and research ethics.

• **Role of Analytical Chemistry:** The students will develop awareness and appreciation for the significant role played by Analytical Chemistry/Chemistry, Physics and Mathematics in current societal and global issues, including areas such as sustainable development and green chemistry. They will be able to address and contribute to such issues through the skills and knowledge acquired during the programme.

• **Communication and IT Skills:** Various DSCs, DSEs, SECs, GEs and AECs have been designed to enhance student's ability to write methodical, logical and precise reports. The courses will, in addition, guide the student to communicate effectively through oral/poster presentations, writing laboratory/ project reports and dissertations. Several IT based papers in DSCs, DSEs, SECs and AECs will enable students to develop expertise in general and subject specific computational skills.

• **Lateral Thinking:** The programme will develop the ability to apply the underlying concepts and principles of Analytical chemistry/ Chemistry, Physics and Mathematics and allied fields beyond the classrooms to real life applications, innovation and creativity.

• **Competence and Job Opportunities:** The skills acquired during the programme will provide varied opportunities for students' career progression. They will be able to join analytical, chemical, pharmaceutical, biochemical, material testing, fast moving consumer goods (FMCG) and other industries/laboratories, academics, innovation and research at different exit points.

7. Programme Structure

The detailed framework of undergraduate degree programme in Chemistry is provided **in Table -2.**

Table 2
Structure of Undergraduate Programme in Analytical Chemistry under UGCF-2022

Semester	Core (DSC) (4)	Discipline Elective (DSE) (4)	Generic Elective (GE) (4)	Ability Enhancement Course (AEC) (2)	Skill Enhancement Course (SEC) (2)	Internship/ Apprenticeship/ Project/Community Outreach (IAPC) (2)	Value Addition Course (VAC) (2)	Total Credits
I	AC1 **(2T+2P)** CHEM1 **(2T+2P)** PHYS1 **(2T+2P)**	N/A	Choose one from a pool of courses **GE-1** **(2T+2P)/(3T+1P)**	Choose one **AEC** from a pool of courses	Choose one **SEC** from a pool of courses **(1T+1P)/ (0T+2P)**	N/A	Choose from a pool of courses	**22**
II	AC2 **(2T+2P)** CHEM2 **(2T+2P)** MATH1 **(4T+0P)**	N/A	Choose one from a pool of courses **GE-2** **(2T+2P) /(3T+1P)**	Choose one **AEC** from a pool of courses	Choose one **SEC** from a pool of courses **(1T+1P)/ (0T+2P)**	N/A	Choose from a pool of courses	**22**
Students on exit shall be awarded *Undergraduate Certificate in Analytical Chemistry* after securing the requisite 44 credits on completion of semester II								**Total = 44**
III	AC3 **(2T+2P)** CHEM3 **(2T+2P)** MATH2 **(4T+0P)**	*Choose from a pool of courses **DSE-1** **(2T+2P)/(3T+1P)** OR **GE-3** **(2T+2P)/ (4T+0P) /(3T+1P)**		Choose one **AEC** from a pool of courses	Choose one **SEC** **(1T+1P)/ (0T+2P)** OR **IAPC****		Choose from a pool of courses	**22**
IV	AC4 **(2T+2P)** CHEM4 **(2T+2P)** PHYS2 **(2T+2P)**	*Choose from a pool of courses **DSE-2** **(2T+2P) /(3T+1P)** OR **GE-4** **(2T+2P)/(4T+0P) /(3T+1P)**		Choose one **AEC** from a pool of courses	Choose one **SEC** **(1T+1P)/ (0T+2P)** OR **IAPC****		Choose from a pool of courses	**22**
Students on exit shall be awarded *Undergraduate Diploma in Analytical Chemistry* after securing the requisite 88 credits on completion of Semester IV								**Total = 88**
V	AC5 **(2T+2P)** CHEM5 **(2T+2P)**	Choose one from a pool	Choose one form a pool of	N/A	Choose one **SEC** **(1T+1P)/ (0T+2P)** OR		NA	**22**

	PHYS2 **(2T+2P)**	of courses **DSE-3 (2T+2P) /(3T+1P)**	courses **GE-5 (2T+2P)/ (4T+0P) /(3T+1P)**		**IAPC****		
VI	AC6 **(2T+2P)** CHEM6 **(2T+2P)** MATH3 **(4T+0P)**	Choose one from a pool of courses **DSE-4** *** **(2T+2P) /(3T+1P)**	Choose one form a pool of courses **GE-6 (2T+2P)/ (4T+0P) /(3T+1P)**	N/A	Choose one **SEC (1T+1P)/ (0T+2P)** OR **IAPC****	NA	**22**
Students on exit shall be awarded *Bachelor of Science in Analytical Chemistry* after securing the requisite 132 credits on completion of Semester VI							**Total = 132**
VII	DSC-19 AC7 / CHEM7/PHY4/ MATH4	Choose three DSE (4)*** courses **OR** Choose two DSE (4) and one GE (4) courses **OR** Choose one DSE (4) course and two GE (4) courses ****	N/A	N/A	N/A	Dissertation on Major (6) **OR** Dissertation on Minor (6) **OR** Academic project/ Entrepreneurship (6)	**22**
VIII	DSC-20 AC8 / CHEM8/PHY5/ MATH5	Choose three DSE (4) courses **OR** Choose two DSE (4) and one GE (4) courses **OR** Choose one DSE (4) course and two GE (4) courses ****	N/A	N/A	N/A	Dissertation on Major (6) **OR** Dissertation on Minor (6) **OR** Academic project/ Entrepreneurship (6)	**22**
Students on exit shall be awarded Bachelor of Science (Hons.) Analytical Chemistry with Dissertation/ Academic Projects/ Entrepreneurship or Bachelor of Science (Hons.) Analytical Chemistry with Dissertation/ Academic Projects/ Entrepreneurship (Discipline-1 Major) or Bachelor of Science (Hons.) Analytical Chemistry with Discipline-1(Major) & Discipline-2 (Minor) after securing the requisite 176 credits on completion of Semester VIII							**Total = 176**

*There shall be choice in Semester III and IV to either choose a DSE (from a pool of Analytical Chemistry/Chemistry, Physics and Mathematics DSE courses) or a GE (from a pool of GE courses or a DSE course from other discipline which will be considered as a GE course).
**There shall be choice in III and IV Semesters to choose either one 'SEC' or in the alternative 'Internship/Apprenticeship/Project/Community Outreach (IAPC)' in each Semester for two credits each.

***Research Methodology'** shall be offered as one of the DSE courses in VI and VII. If a student wishes to pursue four years Honours Degree with dissertation on major / minor, he/she shall compulsorily opt for a Research Methodology course in either VI Semester or VII.

****The following choices will be available in VII and VIII semesters:

(i) to choose three DSEs of 4 credits each **OR**

(ii) to choose two DSEs and one GE of 4 credits each **OR**

(iii) to choose one DSE and two GEs of 4 credits each.

Note: ***Wherever there is a practical there will be no tutorial and vice-versa. The size of the group for practical papers is recommended to be 12-15 students for Analytical Chemistry/ Chemistry practicals.***

7.1 Semester-wise Distribution of Discipline Specific Core (DSC) Courses

A student will study three Discipline Specific Core Courses each, in Semesters I to VI and one core course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters is listed in **Table-3**.

Table 3: **Semester-wise Distribution of Discipline Specific Core (DSC) Courses**

Discipline Specific Core Courses (4)			
Semester	**Course Code**	**Course Title**	**Credits:T=Theory P= Practical/ Tutorials**
I	**DSC1-AC1: Analytical Chemistry-1**	Basic Principles and Laboratory Operations	T=2; P=2
I	**DSC2-C1 Chemistry-1**	Fundamentals of organic chemistry, stereochemistry and Hydrocarbons	T=2; P=2
I	**DSC3-Physics-1**	-	T=2; P=2
II	**DSC4-AC2: Analytical Chemistry-2**	Separation Methods -I	T=2; P=2
II	**DSC5-C2 Chemistry-2**	Periodic Properties and Chemical bonding	T=2; P=2
II	**DSC6-Maths-1**	-	T=3; Tutorial=1
III	**DSC7-AC3: Analytical Chemistry-3**	Quantitative Methods of Analysis	T=2; P=2
III	**DSC8-C3 Chemistry-3**	Chemical Energetics and Equilibria	T=2; P=2
III	**DSC9-Maths-2**	-	T=3; Tutorial=1
IV	**DSC10-AC4: Analytical Chemistry-4**	Separation Methods -II	T=2; P=2
IV	**DSC11-C4 Chemistry-4**	Functional Group Organic Chemistry-I	T=2; P=2
IV	**DSC12-Physics-2**	-	T=2; P=2
V	**DSC13-AC5: Analytical Chemistry-5**	Instrumental Methods of Analysis-I	T=2; P=2
V	**DSC14-C5 Chemistry-5**	Coordination Chemistry and Organometallics	T=2; P=2
V	**DSC15-Physics-3**	-	T=2; P=2
VI	**DSC16-AC6: Analytical Chemistry-6**	Instrumental Methods of Analysis-II	T=2; P=2
VI	**DSC17-C5 Chemistry-6**	Quantum Chemistry and Spectroscopy	T=2; P=2
VI	**DSC18-Maths-3**	-	T=3; Tutorial=1

7.2 Details of Discipline Specific Elective (DSE) Courses

The DSE courses will be offered to students from the three branches of Analytical Chemistry/ Chemistry, Physics and Mathematics in III, IV, V, and VI semesters as listed below in **Table-4**. The DSE courses are distributed in **Pool A** (***Pool of Odd Semesters***) and Pool B (***Pool of Even Semesters***) to be offered to students in odd semesters, respectively as specified in Table-

4. A student studying in semester III and V will have an option of choosing any DSE course of his/her choice as offered by the respective College from Pool A. Similarly, a student studying in semester IV and VI will have an option of choosing any DSE course of his/her choice as offered by the respective College from Pool B. It is to be noted that the college will offer at least one DSE course from each of the discipline Analytical Chemistry/Chemistry, Physics and Mathematics OR a GE course from a pool of GE courses offered by all the disciplines in the College. A DSE course if chosen from other disciplines except Analytical chemistry, Physics and Mathematics, such a course will be considered as GE course. In the semesters VII and VIII a student will have the option to choose DSE courses from ***any one*** of the discipline Analytical Chemistry/Chemistry, Physics and Mathematics and not a combination of these Disciplines.

Table 4: Details of Discipline Specific Elective (DSE) Courses

Discipline Specific Electives (4)		
Course Code	**Course Title**	Credits:T=Theory P= Practical/ Tutorials
Pool A (Odd Semesters)		
DSE-AC1	Analytical Biochemistry	T=2; P=2
DSE-AC3	Polymer	T=2; P=2
DSE-AC5	Industrial Chemicals and Environment	T=2; P=2
DSE-C1	Functional group organic chemistry-II	T=2; P=2
DSE-C3	Phase equilibria and solutions	T=2; P=2
DSE-C5	Main group chemistry	T=2; P=2
DSE-RM	Research methodology for Chemists*	T=3; P=1
Pool B (Even Semesters)		
DSE-AC2	Green Chemistry	T=2; P=2
DSE-AC4	Food Chemistry, Nutrition and Additives	T=2; P=2
DSE-AC6	Application of Computers in Chemistry	T=3; P=1
DSE-C2	Conductance, Electrochemistry and Chemical Kinetics	T=2; P=2
DSE-C4	Novel Inorganic Solids	T=3; P=1
DSE-C6	Active Methylene compounds, Polynuclear Hydrocarbons and Heterocyclic chemistry	T=2; P=2
DSE-RM	Research Methodology for Chemists*	T=3; P=1

*__Research Methodology for Chemists__ shall be offered as one of the DSE courses in VI and VII. If a student wishes to pursue four years Honours Degree with dissertation on major / minor, he/she shall compulsorily opt for a Research Methodology course in either VI Semester or VII.

7.3 Details of Skill Enhancement Courses (SECs)

To enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses will be offered to students as listed in **Table-5**. The SEC courses will be offered to students from all the three disciplines *viz*., Chemistry, Physics and Mathematics in each of the semesters; I, II, III, IV, V, and VI as listed below in Table 5. The SEC courses are also distributed in **Pool A** (***Pool for Odd Semesters***) and **Pool B** (***Pool for Even Semesters***), to be offered to students in odd and even semesters, respectively. A student studying in semester I, III and V will have an option of choosing any SEC course of his/her choice as offered by the respective college from Pool A. Similarly, a student studying in semester II, IV and VI will have an option of choosing any SEC course of his/her choice as floated by the college from Pool B. It is to be noted that the college will offer at least one SEC course from each of the three disciplines *i.e.* Chemistry, Physics and Mathematics in each semester.

There shall be a choice in Semesters III, IV, V and VI to either choose an SEC course from a pool of SEC courses offered by parent departments OR to choose Internship /Apprenticeship /Project / Community Outreach (IAPC).

Table-5: Details of Skill Enhancement Courses[#$]

SEC Courses (2)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS T=Theory Credits P=Practical Credits**
Pool for Odd Semesters		
Analytical Chemistry (SEC-1)	Chemistry Lab Standard Operations and Safety Measures	T=0 P=2
Analytical Chemistry (SEC-3)	Chemistry of Cosmetics & Toiletries	T=0 P=2
Analytical Chemistry (SEC-5)	Cheminformatics	T=0 P=2
Analytical Chemistry (SEC-7)	Intellectual Property Rights and Academic Ethics	T=1 P=1

Analytical Chemistry (SEC-9)	Essential Food Nutrients	T=1 P=1
Pool for Even Semesters		
Analytical Chemistry (SEC-2)	Chemistry: IT Skills and Data Analysis	T=0 P=2
Analytical Chemistry (SEC-4)	Chemical Aspects of Forensic Science	T=1 P=1
Analytical Chemistry (SEC-6)	Green Methods in Chemistry	T=0 P=2
Analytical Chemistry (SEC-8)	Lab Testing and Quality Assurance	T=1 P=1
Analytical Chemistry (SEC-10)	Food Flavours and Colourants	T=1 P=1

 # SEC Papers will also offered by the Department of Physics and Mathematics.

$It is to be ensured that while choosing DSEs or SECs a student should not opt for a paper where the course content is similar to the paper previously studied by the student in any semester.

7.4 Details of Generic Elective (GE) Courses

Generic Elective courses provide multidisciplinary or interdisciplinary education to students. Various GE courses will be offered which may be opted by students as listed below in Table 6. Colleges will offer the GE papers as per Table 6, in which GE papers are distributed into **Pool A** (***Pool for Odd Semesters***) and **Pool B** (***Pool for Even Semesters***).

Table-6: Details of Generic Elective (GE) Courses#

GE COURSES (4)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
Pool A: (Pool for Odd Semesters)		
GE-01	Medicines in Daily Life	T=2 P=2
GE-03	Energy and the Environment	T=3 P=1
GE-05	Bioinorganic Chemistry	T=2 P=2
GE-07	States of Matter	T=2 P=2
GE-09	To be Decided	T=2 P=2

GE-11	To be Decided	T=2 P=2
Pool B: (Pool for Even Semesters)		
GE-02	Chemistry: Statistical Methods and Data Analysis	T=2 P=2
GE-04	Chemistry and Society	T=2 P=2
GE-06	Role of Metals in Medicine	T=2 P=2
GE-08	Fragrances and Flavours: A Industry's Perspective	T=2 P=2
GE-10	To be decided	
GE-12	To be decided	

 # Note: Department of Physics and Mathematics will also offer GE Papers.

7.5 Details of Ability Enhancement Courses (AECs)

A student has to study one AEC course each in the first four semesters of the programme. The AEC courses include environmental studies and language courses. The pool of courses is offered by the University / College.

7.6 Details of Value Addition Courses (VACs)

A pool of value-added courses will be provided by the University.

8. Teaching-Learning Process

The undergraduate programme in Analytical Chemistry is designed to provide students with a sound theoretical background, practical training in all aspects of Analytical chemistry and research. It will help them develop an appreciation of the importance of analytical chemistry in different contexts. The programme includes foundational as well as in-depth courses that span the traditional sub-disciplines of chemistry. Along with the DSCs there are DSEs, GEs, SECs, AECs and VACs which address the need of the hour.

These courses will be delivered through the conventional chalk and talk method, laboratory work, projects, case studies, field work, seminars, hands-on training/workshops in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles

and ICT enabled teaching-learning tools (PowerPoint presentations, audio visual resources, e-resources, models, soft-wares, simulations, virtual labs etc). Students will be encouraged to carry out short term projects and participate in industrial and institutional visits and outreach programmes.

They will be introduced to scientific reasoning and discovery, innovative problem-solving methodologies, online quizzes, surveys, critical analysis etc. to develop convergent and divergent thinking abilities. The laboratory training complements the theoretical principles learned in the classroom and includes synthesis of molecules, measurement of chemical properties and phenomena, hands-on experience with modern instruments, computational data analysis, modelling and laboratory safety procedures.

Different pedagogies such as experiential learning, participative learning, project-based learning, inquiry-based learning and ICT pedagogy integration instruction (blended and flipped learning) will be adopted wherever possible.

Students will be encouraged to work in groups to develop their interpersonal skills like communication and teamwork. Students' diligent and active participation/ engagement in industrial visits/ internships/ Academic Projects/ Dissertations will lay a strong foundation for a successful career in academics, industry, research, entrepreneurship and community outreach.

9. Assessment Methods

The primary objective of the assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening the core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination of the University of Delhi.

i. **Internal Assessment or Continuous Evaluation**: During a semester, students' mastery of the various learning outcomes as described in the syllabus will be assessed through class tests, assignments, group assignments, laboratory record files, project reports, quizzes, MCQs, presentations etc. Each theory paper will have 25% marks for internal assessment. The component of internal assessment for each practical paper will be 50 % marks. The critical analysis of internal assessment/ continuous evaluation outcomes will provide opportunities to improve the teaching-learning process by

focusing on the areas that need conceptual strengthening, laboratory exposure or design of new experiments, and research.

ii. **End of Semester University Examinations**: The summative end-semester university examinations will be conducted for both theory and practical courses. Besides internal assessment, each theory paper will have 75% marks and each practical paper will be of 50% marks for end of semester examination of the university.

10. Scheme of Examination

The total marks for a four-credit course is 100 and for a two credit course is 50. The distribution of 100 marks for each of DSC (2T+2P, 4T+0P), DSE (2T+2P) and GE (2T+2P) courses having four credits is shown in Table 7. Further, the distribution of 50 marks for each of SEC course in 0T+2P /1T+1P and VAC course in 2T+0P format is given in Table 7.

Table 7: Distribution of total marks for each of DSC/ DSE/ SEC/ GE/ VAC courses in different credit formats.

Types of Paper	**Credit Format of Papers**	**Theory Component**	**Practical Component**
Discipline Specific Core (DSCs)	**4T + 0P**	Theory: 100 Marks 1. Internal assessment: 25 Marks: a) Class Test: 10 Marks b) Assignment/ presentation/ Quiz/ group discussion: 10 Marks c) Attendance: 05 Marks 2. End Semester Theory Examination: 75 Marks	**NA**
	2T +2P	Theory: 50 Marks 1. Internal assessment: 12 Marks: a) Class Test: 05 b) Assignment/ presentation/ Quiz/ group discussion: 05 c) Attendance: 02 2. End Semester Theory Examination: 38 Marks	Practical: 50 Marks 1. Internal assessment: 25 Marks: a) Continuous Evaluation: 15 b) Record File: 10 2. End Semester Examination: 25 Marks a) Experiment: 20 b) Viva-Voce: 05
Discipline Specific Electives (DSEs)	**2T + 2P**	Theory: 50 Marks 1. Internal assessment: 12 Marks: a) Class Test: 05 b) Assignment/ presentation/ Quiz/ group discussion: 05 c) Attendance: 02 2. End Semester Theory Examination: 38 Marks	Practical: 50 Marks 1. Internal assessment: 25 Marks: a) Continuous Evaluation: 15 b) Record File: 10 2. End Semester Examination: 25 Marks a) Experiment: 20 b) Viva-Voce: 05

	3T+1P	Theory: 75 Marks 1. Internal assessment: 25 Marks: a) Class Test: 10 b) Assignment/ presentation/ Quiz/ group discussion: 10 c) Attendance: 05 2. End Semester Theory Examination: 50 Marks	Practical: 25 Marks 1. Internal assessment: 12.5 Marks: a) Continuous Evaluation: 7.5 b) Record File: 05 2. End Semester Examination: 12.5 Marks a) Experiment: 10 b) Viva-Voce: 2.5
Skill Enhancement Courses (SECs)	**0T+ 2P**	NA	Practical: 50 Marks 1.Continuous Evaluation: 25 Marks: a) Performance Assessment: 15 b) Marks Record File: 10 2. Examination: 25 Marks a) Experiment: 20 b) Viva Voce: 05
	1T + 1P	Theory: 25 Marks 1. Internal assessment: 06 Marks: a) Class Test: 2.5 b) Assignment/presentation/Quiz/ group discussion: 2.5 c) Attendance: 1 2. End Semester Examination: 19 Marks	Practical: 25 Marks 1. Continuous Evaluation: 12.5 Marks: a) Performance Assessment: 7.5 b) Record File: 5 2. Examination: 12.5 Marks: a) Experiment: 10 b) Viva Voce: 2.5
GE	**2 T + 2 P**	Theory: 50 Marks 1. Internal assessment: 12 Marks a) Class Test: 05 b) Assignment/presentation/Quiz/ group discussion: 05 Attendance: 02 2. End Semester Examination: 38 Marks	Practical: 50 Marks 1. Continuous Evaluation: 25 Marks a) Performance Assessment: b) Record File: 10 2. Examination: 25 Marks: a) Experiment: 20 b) Viva Voce: 05
	3T+1P	Theory: 75 Marks 1. Internal assessment: 25 Marks: a) Class Test: 10 b) Assignment/ presentation/ Quiz/ group discussion: 10 c) Attendance: 05 End Semester Theory Examination: 50 Marks	Practical: 25 Marks 1. Internal assessment: 12.5 Marks: a) Continuous Evaluation: 7.5 b) Record File: 05 2. End Semester Examination: 12.5 Marks a) Experiment: 10 b) Viva-Voce: 2.5
VAC * Performance Assessment: Performance thro	**2 T + 0 P**	Theory: 50 Marks 1. Internal assessment: 12 Marks: a) Class Test: 05 b) Assignment/presentation/Quiz/ group discussion: 05 c) Attendance: 02	NA

		2. End Semester Examination: 38 Marks	

Note: Duration of end-semester theory and practical examinations of different credit courses will be as per University of Delhi regulations/ordinances.

Minimum Acceptable Level of Academic Standards

The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or a qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of assessment process of the student's performance is indicated in **Table - 8**.

TABLE 8: Letter Grades and Grade Points

Letter Grade	Grade point
O (outstanding)	10
A+ (Excellent)	9
A (Very good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
AB (Absent)	0

Computation of the grade cut offs on a 10-point grading system The results for all the Undergraduate courses under the UGCF-2022 shall be based on a 10 point grading system with Letter Grades as per the formula prescribed in amendment to Ordinance IX clause 12(3) dated 08th May, 2017 of the University of Delhi in the computation of the grade cut offs as shown in **Table 9**.

Table 9: The computation of the grade cut offs on a 10 point grading system with Letter Grades

Letter Grade	Numerical Grade	Formula	Computation of Grade Cut off
O (Outstanding)	**10**	**m>** $\bar{X}$ +2.5σ	the value of $\bar{X}$ + 2.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.5 σ or90% whichever is lower
A+ (Excellent)	**9**	$\bar{X}$ - 2.0 σ ≤ m < $\bar{X}$ - 2.5 σ	the value of $\bar{X}$ + 2.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.0 σ or80% whichever is lower

A (Very Good)	**8**	$\bar{X}$ + 1.5 σ ≤ m < $\bar{X}$ + 2.0 σ	the value of $\bar{X}$ + 1.5 σ a to be taken into account form grade computation will be Actual $\bar{X}$ + 1.5 σ 70% whichever is lower
B+ (Good)	**7**	$\bar{X}$ + 1.0 σ ≤ m < $\bar{X}$ + 1.5 σ	the value of $\bar{X}$ + 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 1.0 σ or 60% whichever is lower
B (Above average)	**6**	$\bar{X}$ ≤ m < $\bar{X}$ + 1.0 σ	the value of $\bar{X}$ a to be taken into account for grade computation will be Actual $\bar{X}$ or 50% whichever is lower
C (Average)	**5**	$\bar{X}$ - 0.5 σ ≤ m < $\bar{X}$	the value of $\bar{X}$ - 0.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 0.5 σ or 40% whichever is lower
D (Pass)	**4**	$\bar{X}$ - σ ≤ m < $\bar{X}$ - 0.5 σ	the value of $\bar{X}$ - 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 1.0 σ or 30% whichever is lower

- m is the marks obtained by a student in a particular paper in that semester.
- $\bar{X}$ is the average of marks obtained by all the students appeared in that particular paper in that Semester.
- σ is the standard deviation.

11.1. Discipline Specific Courses (DSC)

SEMESTER 1

11.1.1. Course Code: DSC1: ANALYTICAL CHEMISTRY1 (AC1)
Course Title: Basic Principles and Laboratory Operations

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this course is to make students aware about the SI Units, concentration terms, various analytical methods, and safe usage of chemicals and its waste.

Learning Outcomes:

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

- Understand about SI units
- Learn use of analytical equipments

- Know types of errors in chemical analysis
- Handle statistical tests of data
- Know safety with chemicals and waste.

Unit 1: Basic Concepts

A. SI Units

· Definitions of the Seven Base Units
· Derived units
· Conversion between units
· Significant figures

B. Chemical concentrations

· Mole, molar mass (calculations in grams and moles)
· Solutions and their concentrations
· Molar concentration
· Analytical molarity
· Equilibrium molarity of a particular species
· Percent concentration
· Parts per million/billion (ppm, ppb)
· Volume ratios for dilution procedures
· p-functions.

(Lectures: 5)

Unit 2: Introduction to Analytical Chemistry and Analytical Methods

General steps in chemical analysis
Introduction to methods of detecting analytes

a) Physical
b) Electromagnetic radiations
c) Electric charge.

(Lectures: 5)

Unit 3: Errors in Chemical Analysis

- Types of errors
- Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty
- The Gaussian distribution
- Mean and standard deviation
- Confidence intervals
- Statistical tests of data (F test, t test, Q test for bad data)
- Method of least squares
- Calibration curve
- Safety with chemicals and waste

(Lectures: 20)

PRACTICALS (Credits: 02, Laboratory Periods-60)

1. Description, Use and Calibration of Common Laboratory Apparatus I: Glassware: Volumetric flasks, Burettes, Pipettes, Weighing bottles, Drying ovens.
2. Description, Use and Calibration of Common Laboratory Apparatus II: Different types of Funnels, Chromatographic columns, Chromatographic jars, Desiccators, Filter crucibles, Rubber policeman.
3. Preparing Solutions: Standard solutions (acids and bases), primary standards and secondary standards, and to find out their concentration by any suitable methods.
4. Determination of strength of given strong acid using strong base volumetrically
5. Estimation of sodium carbonate by titrating with hydrochloric acid.
6. Use and maintenance of pH meter. Determination of pH of given dilute solutions of shampoos, soaps, fruit juices and different soft drinks.
7. Determination of cell constant of a conductometric cell using standard KCl solutions.
8. To check the conductivity of various water samples (*Collect at least four samples*).

REFERENCES:

- Higson, S. P.J. (2003), Analytical Chemistry, Oxford University Press.
- Skoog, D.A.; West, D.M. (2003), Fundamentals of Analytical Chemistry, Brooks/Cole.
- Christian, G.D.(2004), Analytical Chemistry, 6th Edition, John Wiley & Sons, New York.
- Fifield, F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
- Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

Additional References

- Day. R. A.; Underwood, A. L. (1991), Quantitative Analysis, Prentice Hall of India.
- Gordus, A. A. (1985), Schaum's Outline of Analytical Chemistry, Tala McGraw-Hill.
- Dean J. A. (1997), Analytical Chemistry Handbook, McGraw Hill.
- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Teaching Learning Process:

- Conventional chalk and board teaching
- Visit chemical industries/ Drug industries to get information about the various instruments used in industries
- ICT enabled classes
- Power point presentations
- Interactive sessions
- To get recent information through the internet.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: SI Units, Concentrations terms, Analytical methods, Laboratory operations, Electromagnetic radiation, Statistical methods, Errors.

11.1.2. Course Code: DSC2: CHEMISTRY-1 (C1)

Course Title: Fundamentals of Organic Chemistry, Stereochemistry and Hydrocarbons

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The course is infused with the recapitulation of fundamentals of organic chemistry and visualizing the organic molecules in a three-dimensional space. To establish the applications of these concepts deferent class of mechanism included. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

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

- Understand and explain the differential behaviour of organic compounds based on fundamental concepts learnt.
- Understand the stereochemistry of aliphatic and aromatic hydrocarbons
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, and electrophilic substitution.
- Understand the mechanism of reactions of hydrocarbons

Unit I: Fundamentals of Organic Chemistry

Introduction to carbon compounds, an overview of Fundamentals (Electronic displacement-Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect). Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbene.

Acidity and basicity in carbon compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivative.

(Lectures: 05)

Unit II: Stereochemistry

Types of projection formulas of carbon compound - Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: the concept of chirality (upto two carbon atoms). Configurational Isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; cis-trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

(Lectures:07)

Unit III: Aliphatic Hydrocarbons

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

Alkanes: Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent. Reactions: Free radical substitution: Halogenation.

Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), the addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration - demercuration, Hydroboration oxidation.

Alkynes: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides and acidity of alkynes, the addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$. Hydration to form carbonyl compounds

(Lectures:12)

Unit IV: Aromatic Hydrocarbons

Aromaticity: benzenoids and Hückel's rule. Structure and aromatic character of benzene.

Preparation: methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonic acid. Reactions: electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side-chain oxidation of alkylbenzenes.

(Lectures: 06)

PRACTICALS (Credits: 02; Laboratory Periods: 60)

1. Purification of organic compounds by crystallization using the following solvents:

   a. Water
   b. Alcohol
   c. Water + Alcohol

2. Determination of the melting points of organic compounds using Kjeldahl method and electrically heated melting point apparatus.
3. To study the effect of impurities on the melting point.
4. To identify the organic compounds using mixed melting point experiment. (*Identify at least two organic compounds*).

5. Determination of boiling point of liquid organic compounds using both distillation and capillary method.
6. Detection of extra elements present in an organic compounds (*Up to two extra elements*).
7. Organic Preparations:
   a. Bromination of acetanilide/ phenol
   b. Nitration of nitrobenzene and bromobenzene

REFERENCES:

Theory:

- Sykes, P.(2005), A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Eliel, E. L. (2000), Stereochemistry of Carbon Compounds, Tata McGraw Hill.
- Morrison, R. N.; Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 7th Edition.
- Bahl, A; Bahl, B. S. (2012), Advanced Organic Chemistry, S. Chand.

Practical:

- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Pearson.
- Mann, F.G.; Saunders, B.C.(2009), Practical Organic Chemistry, Pearson Education.
- Dhingra, S; Ahluwalia V.K., (2017), Advanced Experimental Organic Chemistry, Manakin Press.

Teaching Learning Process:

- Conventional chalk and board teaching
- Class interactions and discussions
- Power point presentation on important topics.
- Teaching Learning process is largely student focused

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory Examination Presentations by Individual Student/ Group of Students

Keywords: Chirality, Aromaticity, Alkanes, Alkenes, Alkynes.

SEMESTER II

11.1.4. Course Code: DSC4: ANALYTICAL CHEMISTRY2 (AC2)
Course Title: SEPARATION METHODS-I

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: To acquire basic knowledge of the analytical chemistry of important techniques that will provide the basis for their industrial production methods. To provide an adequate mastery of analytical methods used for the determination of commercial/domestic raw materials and finished product quality.

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

• Become familiar with fundamental concepts of partition coefficients and their role in achieving separations across different types of chromatography.

• Develop the core skills to parse existing chromatographic protocols and identify the key factors influencing a chromatography experiment.

• Understand the underlying assumptions of the most common chromatographic separation techniques and approaches to method validation.

• Understand the concept of solubility and their application in separation using distribution law.

Unit 1: Chromatography

Classification of chromatographic methods: Principles of differential migration, description of chromatographic process, distribution coefficients, modes of chromatography. the chromatography (elution time and volume) capacity factor, column efficiency and resolution, sample preparation.

(Lectures: 08)

Unit 2: Techniques of paper chromatography

Experimental modifications, various modes of developments, nature of paper, detections of spots, retardation factors, factors that affect reproducibility of R_f values (due to paper, solvent system, sample, development procedures), selection of solvent, quantitative analysis, applications.

(Lectures:06)

Unit 3: Thin layer chromatography

Stationary phase, adsorbents, liquid phase support, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, R_f values (effect of adsorbent, solvent, solute, development process), quantitative analysis, applications.

(Lectures: 05)

Unit 4: Solvent Extraction

Distribution law, determination of distribution ratio, batch extraction, continuous extraction, discontinuous extraction, counter-current extraction.

(Lectures: 05)

Unit 5: Dialysis and membrane filtration

General laboratory methods, filters-nitrocellulose, fiberglass and polycarbonates.

(Lectures: 06)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Separation and identification of amino acids present in the given mixture by **radial** and **ascending** paper Chromatography (*Perform both*).
2. Separation of ortho-nitrophenol & para-nitrophenol and *o*- and *p*-amino phenol by thin layer chromatography (TLC) and calculation of their R_f values.
3. Separation of constituents of leaf pigments by thin layer chromatography and paper chromatography (*radial & ascending both*).
4. Separation of a mixture of compounds by solvent extraction.
5. Separation of a mixture of naphthalene, benzoic acid and 2-naphthol.
6. Separation of a mixture of 1,4-dimethoxybenzene, 2-chloro benzoic acid and *p*-cresol.
7. Analysis of soil samples (*at least three soil samples to be collected for analysis*) collected from college nursery, sports ground Delhi villages/ Yamuna River bank.

   (**a**) Determination of pH of soil samples.

   (**b**) Determination of total soluble salts.

   (**c**) Determination of carbonate and bicarbonate.

   (**d**) Determination of calcium, magnesium and iron.

   (**e**) Determination of conductance of the soil samples.
8. Industrial visit to STP plant.

REFERENCES:

- Fifield,F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
- Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.
- Harris, D. C. (2007), Quantitative Chemical Analysis, 6th Edition, Freeman

- 4. Mikes, O. (2000), Laboratory Handbook of Chromatographic methods, D.Van Nostrand Company Inc.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Solvent extraction, TLC, Chromatography.

11.1.5. Course Code: DSC5: CHEMISTRY-2 (C2)
Course Title: PERIODIC PROPERTIES AND CHEMICAL BONDING
Total Credits:4 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The course discusses the periodicity in properties with reference to the s, p and d block, which is necessary in understanding their group chemistry. It provides basic knowledge about ionic, covalent and metallic bonding underlining the fact that chemical bonding is best regarded as a continuum between the three cases. It provides an overview of hydrogen bonding and van der Waal forces which influence the melting points, boiling points, solubility and energetics of dissolution of compounds.

Learning Outcomes:

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

- Understand periodicity in ionization enthalpy, electron gain enthalpy, electronegativity and enthalpy of atomization.
- Understand variability in oxidation state, colour, metallic character, magnetic and catalytic properties and ability to form complexes
- Understand the concept of lattice energy using Born-Landé expression.
- Draw Born Haber Cycle and analyse reaction energies.
- Draw the plausible structures and geometries of molecules using VSEPR theory.
- Understand and draw MO diagrams (homo- & hetero-nuclear diatomic molecules).
- Understand the importance and applications of hydrogen and van der Wall bonding.

Unit I: Periodic Properties

Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy, inert pair effect.

General group trends of s, p and d block elements with special reference to Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, Enthalpy of Atomization, oxidation state, colour, metallic character, magnetic and catalytic properties, ability to form complexes

(Lectures: 12)

UNIT II: Bonding in coordination compounds

Ionic Bonding: General characteristics of ionic bonding, Lattice Enthalpy and Solvation Enthalpy and their relation to stability and solubility of ionic compounds, Born-Lande equation for calculation of Lattice Enthalpy (no derivation), Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.
Covalent Bonding: Valence Bond Approach, Hybridization and VSEPR Theory with suitable examples, Concept of resonance and resonating structures in various inorganic and organic compounds, Molecular Orbital Approach: Rules for the LCAO method, bonding, nonbonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^{+}.
Metallic Bonding, Hydrogen Bonding, van der Waals Forces

(Lectures: 18)

PRACTICALS (Credits: 02; Laboratory Periods: 60)

1. Preparation of standard solutions of different normality and molarity of Mohr's salt and oxalic acid.
2. Estimation of free alkali present in different soaps and detergents (*At least two samples to be taken*).
3. Estimation of oxalic acid by titrating it with $KMnO_4$ (*Provide at least two unknown solutions*).
4. Estimation of Mohr's salt by titrating it with $KMnO_4$ (*Provide a tleast two unknown solutions*).
5. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
6. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal and external indicators.
7. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
8. Chromatographic separation of mixture of metal ions Cu^{2+}, Cd^{2+} and Ni^{2+}, Co^{2+}.

REFERENCES:

Theory:

- Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education
- Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), Inorganic Chemistry 2nd Ed., Oxford University Press.
- Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Inorganic Chemistry, 5th Edition, W. H. Freeman and Company.

- Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India
- Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
- Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.
- Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition, Pearson.

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, Ionic Bonding, Dipole Moment, VSEPR Theory, Covalent Bonding, Metallic Bonding, van der Wall Forces.

SEMESTER III

11.1.7. Course Code: DSC 7: ANALYTICAL CHEMISTRY3 (AC3)

Course Title: Quantitative Methods of Analysis

Total Credits: 04 (Credits: Theory-02, Practical-02)

(Total Lectures: Theory- 30, Practical-60)

Objectives: The main objective of this course is to make students acquire knowledge about the basic principles underlying gravimetric and volumetric analysis, different types of titration curves, equilibria principles and environmental analysis

Learning Outcomes:

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

- Know the concept of volumetric and gravimetric analysis and deducing the conversion factor for determination
- Understand the various titration curves
- Stability of complexes
- Know and analyze various pollutants present in environment.

Unit 1: Gravimetric Analysis

Requisites of precipitation, Nucleation, precipitation, and growth of precipitates; Particle size and filterability of precipitates; Factors influencing precipitation, Co-precipitation, post-precipitation. Super saturation, digestion, precipitation from homogeneous solution, washing of precipitate and ignition of precipitate, Brief idea about method of filtration and drying of precipitate, Use of reagents used in gravimetry (8-hydroxy quinoline (oxine) and dimethyl glyoxime (DMG)

(Lectures: 09)

Unit 2: Basic principles underlying titrimetric analysis.

- **Acid-base:** 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_a and K_b values. Neutralisation-titration curve, theory of indicators, choice of indicators.
- **Theory of redox indicator**s: Principle and detection of equivalence point by visual & potentiometric methods
- **Precipitation titrations** Argentometric titrations, indicators for precipitation titrations involving silver nitrate- Volhard's method., Mohr's method, Adsorption indicators.
- **Complexometric titrations:** Stability of complexes, titration involving EDTA: . direct, back, displacement and indirect determinations,. Metal ion indicators and characteristics. Application-determination of hardness of water
- Problems based on titrimetric analysis.

(Lectures: 12)

Unit 3: Introduction to Environmental Analysis

- Environmental analysis of water: colour, odour, taste, conductivity, dissolved solids, hardness, DO, COD, BOD, chlorides, sulphates, nitrates and phosphates
- Environmental analysis of air: Sampling, particulate matter, gaseous pollutants-SOx, NOx, COx, and organic pollutants
- Environmental analysis of industrial effluents-estimation of toxic metals Hg, Cd, Pb, As, radiochemical wastes

(Lectures: 09)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Determination of the pK_a of a weak acid by potentiometric and pH metric titrations.

2. Determination of the strength of the given ferric chloride solution by titrating it against EDTA.
3. Estimation of chloride in water by precipitation method.
4. Estimation of amount of nickel present in given solution as *bis*(dimethylglyoximato)nickel(II) /Aluminium as oxinate.
5. Draw the absorbance curve of bromophenol blue using a colorimeter.
6. Determination of the composition of the Fe^{3+}-salicylic acid complex in solution by Job's method (*Plot curve using excel also*).
7. Determination of the formula of the chelate formed between iron (III) and Tiron.
8. Determination of dissolved oxygen (DO) /biological oxygen demand (BOD),/chemical oxygen demand (COD) (*Use at least two water samples from different sources*)

REFERENCES:

- Willard, Merritt, Dean, Settle (2004), Instrumental Methods of Analysis, CBS Publishers & Distributors.
- Skoog, D.A.; West, D.M.; Holler, F.J.; Crouch, S.R. (2014), Fundamentals of Analytical Chemistry, Cengage Learning.
- Harris, D.C. (2015),Quantitative Chemical Analysis, W.H.Freeman & Company.
- Mendham, J., Denney, R.C., Barnes, J.D.; Thomas, M.J.K. (2000); Vogel's Quantitative Chemical Analysis, Prentice Hall.
- Manahan, S.E. (2017)Environmental Chemistry, CRC Press
- De, A.K. (2012)Environmental Chemistry, New Age International Pvt. Lt

Teaching Learning Process:

- Conventional chalk and board teaching
- Visit chemical industries to get information about the technologies and environmental pollution from industrial effluents.
- ICT enabled classes.
- Power point presentations.
- Interactive sessions, Debate.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Gravimetric analysis, Volumetric analysis, Centrifugation methods, Environmental analysis, Industrial effluents, Wastewater analysis.

11.1.8. Course Code: DSC8: CHEMISTRY-3 (C3)
Course Title: CHEMICAL ENERGETICS AND EQUILIBRIA
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this paper is to develop basic understanding of the chemical energetics, laws of thermodynamics and ionic equilibrium. It provides basic understanding of the behaviour of electrolytes and their solutions. The students will also learn about the properties of ideal and real gases and deviation from ideal behaviour.

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

- Understand the laws of thermodynamics, thermochemistry and equilibria.
- Understand concept of pH and its effect on the various physical and chemical properties of the compounds.
- Use the concepts learnt to predict feasibility of chemical reactions and to study the behaviour of reactions in equilibrium.

Unit 1: Chemical Energetics

Review of Intensive and extensive variables; state and path functions; isolated, closed and open systems, concept of heat, Q, work, W, internal energy, U, and enthalpy, H.

First law

Concept of heat, Q, work, W, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, Joule Thompson Porous Plug experiment, Nature of Joule Thompson coefficient, calculations of Q, W, ΔU and ΔH for reversible, irreversible and free expansion of ideal gases under isothermal conditions.

Thermochemistry

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of hydration, enthalpy of formation and enthalpy of combustion and its applications, bond dissociation energy and bond enthalpy; effect of temperature (Kirchhoff's equations) on enthalpy of reactions.

Second Law

Concept of entropy; statement of the second law of thermodynamics. Calculation of entropy change for reversible processes and irreversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity (for ideal gases), Gibbs-Helmholtz equation.

Third Law

Statement of third law, unattainability of absolute zero, calculation of absolute entropy of molecules, concept of residual entropy, calculation of absolute entropy of solid, liquid and gases.

(Lectures: 14)

Unit 2: Chemical Equilibrium

Criteria of thermodynamic equilibrium, chemical equilibrium in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their qualitative dependence on T, P and concentration (Le Chatelier's principle). Free energy of mixing and spontaneity.

(Lectures: 04)

Unit 3: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, Henderson-Hasselbach equation. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

(Lectures: 12)

PRACTICALS (Credits :02, Laboratory Periods: 60)

Chemical Energetics:

1. Determination of heat capacity of calorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of the enthalpy of ionization of ethanoic acid.
4. Determination of basicity of a dibasic acid by thermochemical method.
5. Determination of integral enthalpy of solution of salts (KNO_3 or NH_4Cl).
6. Determination of enthalpy of hydration of copper sulphate.

Ionic equilibria:

7. Preparation of buffer solutions: (i) Sodium acetate-acetic acid or (ii) Ammonium chloride-ammonium acetate. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
8. Study the effect of addition of HCl/NaOH on pH of the buffer solutions (acetic acid, and sodium acetate).
9. pH metric titration of (i) strong acid with strong base, (ii) weak acid with strong base

REFERENCES:

Theory:

- Castellan, G. W. (2004), Physical Chemistry, Narosa.
- Kapoor, K. L. (2015), A Textbook of Physical Chemistry, Vol 1, 6th Edition, McGraw Hill Education.
- Kapoor, K. L. (2015), A Textbook of Physical Chemistry, Vol 2, 6thEdition, McGraw Hill Education.
- Puri, B. R., Sharma, L. R. and Pathania M. S. (2020), Principles of Physical

Chemistry, Vishal Publishing Co.

Practical:

- Khosla, B. D.; Garg, V. C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co.
- Kapoor, K. L. (2019), A Textbook of Physical Chemistry, Vol 7, 1st Edition, McGraw Hill Education.
- Batra, S. K., Kapoor, V and Gulati, S. (2017) 1st Edition, Experiments in Physical Chemistry, Book Age series.

Additional Resources:

- Mahan, B. H.(2013), University Chemistry, Narosa.
- Barrow, G. M. (2006), Physical Chemistry, 5th Edition, McGraw Hill.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Chemical Thermodynamics, First law, Second law, Third law, Spontaneity of reaction, Equilibrium, buffers.

SEMESTER IV

11.1.10. Course Code: DSC 10: ANALYTICAL CHEMISTRY4 (AC4)

Course Title: SEPARATION METHODS-II

Total Credits: 04 (Credits: Theory-02, Practical-02)

(Total Lectures: Theory- 30, Practical-60)

Objectives: Objective of this course is to learn the separation techniques and its application.

Learning Outcomes:

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

• Various types of separation techniques and their applications

• Electrophoretic techniques

Unit 1: Column Chromatography

A. General: columns, matrix materials, stationary phase, column packing, application of sample, column development and sample elution, detectors and fraction collectors, applications.

B. High performance liquid chromatography: Principle, column, matrices and stationary phases, column packing, mobile phase and pumps, application of sample, detectors, applications. **C. Adsorption chromatography:** Principle, adsorbents, solvents, nature of solute, operating parameters, retention volumes and times, applications.

D. Liquid-liquid partition, chromatography: Principle, normal phase chromatography, reversed phase liquid chromatography, applications.

E. Ion-exchange chromatography: Principle, ion exchangers, ion- exchange equilibria, ion-exchange resin selectivity, column operations (column development, detection of solute bands), factors affecting retention volumes, applications.

F. Gel chromatography: Principle, types of gels, separation by gel chromatography, applications.

(Lectures: 20)

Unit 2: Electrophoretic Techniques:

A. Principle, apparatus, support media (paper, cellulose acetate membranes, gels)

B. SDS-PAGE, native gels, gradient gels, isoelectric focusing, 2D-PAGE, continuous flow electrophoresis, detection, estimation and recovery of proteins in gels.

C. Western Blotting, Electrophoresis of Nucleic Acids, Capillary Electrophoresis.

D. Isoelectric Focusing.

(Lectures: 10)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Determination of the residual chlorine in city water supply using colorimetry (*Take at least two samples*).
2. Determination of adsorption isotherm of acetic acid on activated charcoal and determination of the adsorption constant (k).
3. Determination of the capacity of at least two anion exchange resins *e.g.* Amberlite type II (Dimethyl-2-hydroxyethylbenzyl ammonium-based and Amberlite type I trialkyl ammonium-based, DOWEX type II, etc.
4. Determination of the capacity of at least two cation exchange resins *e.g.* DOWEX-50 (sulphonic acid based), sodium polystyrene sulfonate, Amberlite-sulphonic acid based, *etc*).
5. To remove the hardness of the water by using ion exchange resins.
6. To separate Ni (II) and Zn (II) by ion exchange resins and quantify it by complexometric titration.
7. Determination of the solubility of $CaSO_4$ by ion exchange and complexometric titrations.

8. Separation of compounds using adsorption column chromatography.
(**a**) Separation of the mixture of *o*-nitro phenol and *p*-nitro phenol.
(**b**) Separation of the mixture of dyes (methylene blue and methyl orange).
(**c**) Separation of the mixture of *o*-nitro aniline and *p*-nitro aniline.
9. Determination of the void volume of a gel column.
10. Visit to Water Purification Plants.

REFERENCES:

- Mikes, O. (2000), Laboratory Handbook of Chromatographic methods, D. Van Nostrand Company Inc.
- Fifield,F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
- Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K.; (2000), Vogel's Quantitative Chemical Analysis, Prentice Hall.
- Wilson, K.; Walker, J. (2000),Principles and Techniques of Practical Biochemistry, Cambridge University Press. Additional Resources:
- Holme, D.J.; Peck, H. (1998),Analytical Biochemistry, Prentice Hall.
- Freifelder, D. (1983),Physical Biochemistry, W.H.Freeman & Company.
- Plummer, D.T.(2001),Introduction to Practical Biochemistry, McGraw-Hill.

Additional Resources:

- Holme, D.J.; Peck, H. (1998),Analytical Biochemistry, Prentice Hall.
- Freifelder, D. (1983), Physical Biochemistry, W.H.Freeman & Company.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Column Chromatography, Electrophoretic Techniques

11.1.11. Course Code: DSC11: CHEMISTRY-4 (C4)
Course Title: Functional Group Organic Chemistry-I
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: To establish the concept, structure, methods of preparation and reactions for the following classes of compounds: alkyl and aryl halides, alcohols, phenols and ethers, aldehydes and ketones are described. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning Outcomes:

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

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reaction mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, and electrophilic substitution.

Unit I: Alkyl and Aryl Halides

A) Alkyl halides (upto 5 carbons):

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

Preparation: starting from alcohols (1º, 2º & 3º) and alkenes with mechanisms.

Reactions: Nucleophilic substitution reactions with mechanism and their types (SN^1, SN^2 and SNi), Competition with elimination reactions (elimination vs substitution), nucleophilic substitution reactions with specific examples from hydrolysis, nitrite and & nitro formation, nitrile & isonitrile formation and Williamson's ether synthesis.

Grignard reagent and its synthetic applications

B) Aryl halides:

Structure and resonance
Preparation: Methods of preparation of chloro, bromo & iodo-benzene from benzene (electrophilic substitution), from phenols (nucleophilic substitution reaction) and from aniline (Sandmeyer and Gattermann reactions).
Reaction: Nucleophilic aromatic substitution by OH group (Bimolecular Displacement Mechanism), Effect of nitro substituent on the reactivity of haloarenes, Reaction with strong bases $NaNH_2/NH_3$(elimination-addition mechanism involving benzyne intermediate), relative reactivity and strength of CX bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(Lectures: 14)

Unit II: Alcohols, Phenols, Ethers (Aliphatic and Aromatic)

A) Alcohols (upto 5 Carbon):

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

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

Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic $K_2Cr_2O_7$ and conc. HNO_3), Oppeneauer Oxidation.

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

C) **Phenols**: acidity of phenols and factors affecting their acidity.

Preparation: Methods of preparation from cumene, diazonium salts and benzene sulphonic acid.

Reactions: Directive influence of OH group and Electrophilic substitution reactions, viz. nitration, halogenation, sulphonation, Reimer-Tiemann reaction, Gattermann–Koch reaction, Houben-Hoesch condensation, reaction due to OH group: Schotten-Baumann reaction

D) **Ethers** (Aliphatic & Aromatic):

Williamson's ether synthesis, Cleavage of ethers with HI

E) **Aldehydes and ketones (Aliphatic and Aromatic):**

Preparation: from acid chlorides and from nitriles.

Reactions: Nucleophilic addition, nucleophilic addition – elimination reaction including reaction with

HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's reaction,

Wittig reaction, Benzoin condensation, Clemmensen reduction, Wolff Kishner reduction, Meerwein-PondorffVerley reduction.

(Lectures: 16)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

Systematic qualitative identification and derivative preparation of organic compounds. following functional groups containing compounds should be provided: alcohols, phenols, carbonyl compounds and carboxylic acids (mono- and dicarboxylic both). (*Provide few organic compounds containing at least one extra element*)

REFERENCES:

Theory:

- Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), Organic Chemistry, 7 th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. (2002), Organic Chemistry (Volume 1), 6 th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K. International.
- Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2017), Organic Chemistry, 12th Edition, Wiley

Practical:

- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's Textbook

of Practical Organic Chemistry, Pearson.
- Mann, F.G.; Saunders, B.C.(2009), Practical Organic Chemistry, Pearson Education.
- Dhingra,S; Ahluwalia V.K., (2017), Advanced Experimental Organic Chemistry, Manakin Press.

Teaching Learning Process:

- Conventional chalk and board teaching
- Class interactions and discussions
- Power point presentation on important topics.
- Teaching Learning process is largely student focused

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory Examination Presentations by Individual Student/ Group of Students

Keywords: Aryl halides, Alcohols, Phenols, Ethers and Epoxides, Aldehydes and Ketones.

SEMESTER V

11.1.13. Course Code: DSC 13: ANALYTICAL CHEMISTRY-5 (AC5)
Course Title: INSTRUMENTAL METHODS OF ANALYSIS-I
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: This course is to make students understand the following concepts:

• Spectroscopic methods of analysis
• Principles of UV and Visible spectrophotometry and its applications
• Various components of UV and Visible spectrophotometry
• Single and double beam instruments
• IR spectroscopy and its applications

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

- Different types of spectroscopic methods of analysis.
- The instrumentation and the applications of the UV- Visible and IR spectrometry.

Unit 1: Basic Concepts of Spectroscopy

An introduction to spectroscopic methods of analysis: Electromagnetic radiation, frequency, wavelength, Planck's equation, Electromagnetic spectrum, mathematical description of wave, superposition of waves, optical interferences, interaction of radiation with the matter, emission of radiation, absorption of radiation, scattering, line broadening.

(Lectures: 04)

Unit 2: UV- Visible Spectrophotometry:

A. Lambert-Beer's law

B. Principles, Electronic transitions, Instrumentation, Single/double beam instrument

C. Industrial/Research Applications: Effect of solvent and conjugation on λ_{max}, Effect of cis-trans geometrical isomerism (e.g. stilbene, cinnamic acid, maleic and fumaric acid), calculation λ_{max} of different compounds (homo- and heteroannular dienes, unsaturated carbonyl compounds) (Woodward-Fieser Rule and Schott's Rule) and calculation of stoichiometric ratios of metal-ligand complex using Job's method.

(Lectures: 12)

Unit 3: IR Spectrophotometry:

A. Principle, Modes of vibrations, Bands (Fundamental, overtones, etc)

B. Instrumentation: FT-IR, sample handling, special cautions during scanning.

C. Applications: Identification of the functional groups (mention the use of fingerprint region and functional group region) and simple organic molecules, Factors affecting the absorption frequency.

(Lectures: 10)

Unit 4: Raman spectroscopy:

Introduction, basic principle, instrumentation, the difference between Raman and IR, Applications of Raman spectroscopy.

(Lectures: 04)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Comparison of UV spectra of $K_2Cr_2O_7$ in aqueous and acidified medium (UV range 180-250 nm).
2. Determination of the pK_a of an indicator (methyl orange) using a spectrophotometer.
3. To find the stability constant and reaction stoichiometry of the complex formed between iron and 1,10-phenanthroline.
4. Identification of the structure of organic compounds using IR- spectroscopy (IR spectra should be provided).
5. Partial reduction of m-dinitrobenze to m-nitro aniline and its characterization using IR spectroscopy.

6. Synthesis of benzoic acid from benzamide and its characterization using IR spectrum.
7. Isolation of DNA from onion and its characterization using UV spectroscopy.
8. Extraction of carotene and xanthophyl from plants and recording its IR spectra.
9. Discuss the IR spectra of alcohols, carbonyl compounds, carboxylic acids and esters. (*Provide IR spectra*).
10. Oxidation of benzaldehyde to benzoic acid and compare the IR spectra of product with starting material.
11. Visit to Central Instrument Facility Centre- Delhi University and prepare a report.

REFERENCES:

- Kemp, W. (1991), Organic Spectroscopy, Palgrave Macmillan.
- Pavia, D.L., et al. (2015) Introduction to Spectroscopy, Cengage Learning India Private Limited.
- Banwell, C.N. (2006), Fundamentals of Molecular Spectroscopy,Tata McGraw-Hill Education.
- Kalsi, P.S. (2002) Spectroscopy of Organic Compounds, New Age International Publishers.
- Smith, B.C. (1998), Infrared Spectral Interpretations: A Systematic Approach, CRC Press.
- Plummer, D.T.(2001), Introduction to Practical Biochemistry, McGraw-Hill.
- B D Khosla, et al. (2018) Senior Practical Physical Chemistry, R Chand & Co.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: UV-Vis Spectroscopy, IR-Spectroscopy and Raman Spectroscopy

11.1.14. Course Code: DSC14: CHEMISTRY-5 (C5)
Course Title: COORDINATION CHEMISTRY AND ORGANOMETALLICS

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The course introduces the students to basics of coordination chemistry and organometallics which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc. Nomenclature, isomerism,

bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system. In organometallic chemistry, the students are introduced to classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

Learning Outcomes:

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

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
- Learn how IR data can be used to understand extent of back bonding in metal carbonyls

Unit I: Introduction to Coordination compounds

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

(Lectures: 06)

UNIT II: Bonding in coordination compounds

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion

(Lectures: 14)

UNIT III: Organometallic chemistry

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO

diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

(Lectures: 10)

PRACTICALS: (Credits: 02; Laboratory Periods: 60)

1. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
4. Preparation of the following inorganic compounds and their characterization using appropriate analytical techniques:
   (i) Tetraamminecopper(II) sulphate
   (ii) Potassium trioxalatoferrate(III) trihydrate
   (iii) Chrome alum
   (iv) Cuprous chloride
   (v) Manganese(III)phosphate ($MnPO_4.H_2O$)
   (vi) Potash alum
   (vii) Acetylacetonate complex of Cu^{2+} and Fe^{3+}
   (viii) Tetraamminecarbonatocobalt(III)nitrate

REFERENCES:

Theory:

- Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education
- Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), Inorganic Chemistry 2nd Ed., Oxford University Press.
- Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Inorganic Chemistry, 5th Edition, W. H. Freeman and Company.
- Cotton, F.A.; Wilkinson, G.; Gaus, P.L. Basic Inorganic Chemistry, 3rd Edition, Wiley India.
- Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
- Greenwood, N.N.; Earnshaw, A. (1997), Chemistry of the Elements, 2nd Edition, Elsevier.

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
- Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Coordination Compounds, Organometallic Chemistry.

SEMESTER VI

11.1.16. Course Code: DSC 16: ANALYTICAL CHEMISTRY-6 (AC6)
Course Title: INSTRUMENTAL METHODS OF ANALYSIS-II
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

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

•Atomic spectroscopy
• NMR spectroscopy and its applications
• ESR spectroscopy

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

- What are the different types of spectroscopic methods of analysis that can be used to analyze the samples.
- The instrumentation and the applications of the NMR and ESR spectroscopy.

Unit 1: Atomic Spectroscopy

A. Basic principle and Bohr theory of hydrogen atom
B. Types
C. Atomizer
D. Atomic absorption and photoelectron spectroscopy
E. Applications of absorption and photoelectron spectroscopy

(Lectures:06)

Unit 2: ^{1}H NMR Spectroscopy

A. Principle
B. Instrumentation and sample handling
C. Spin-spin and spin-lattice relaxation
D. Chemical shift
E. Solvents, Internal and external reference compounds

F. Factors affecting chemical shift (Electronegativity, diamagnetic anisotropy, *etc*.)
G. Spin-spin coupling
H. Coupling constants and its applications in characterization of organic molecules including *cis*- and *trans*-isomers
I. Discussion on Chemical shift equivalent nuclei and Magnetic equivalent nuclei with suitable examples
J. Deuterium exchange, Effect of restricted rotation (*e.g.* DMF) and low temperature NMR.
K. Identification of simple organic compounds including tautomer's using ^{1}H NMR spectral data.

(Lectures:18)

Unit 3: ESR spectroscopy:

Basic principles, Relaxation and line width, zero-field splitting and Kramer's degeneracy, g-factor and factor affecting g-factor, Hyperfine coupling constants splitting in triplet spectra, ESR of simple radicals.

(Lectures:06)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Determination of sodium in ORS using atomic absorption spectroscopy.
2. Determination of copper in drinking water using atomic absorption spectroscopy.
3. Multi-step organic synthesis and characterization of compounds using ^{1}H NMR spectral data (^{1}H NMR spectra of the compounds will be provided to students)
   (**a**) Aniline to *p*-bromoacetanilde
   (**b**) Nitration of bromobenzene
   (**c**) Substitution (S_N2) reaction of 1-iodobutane and 2-naphthol
   (**d**) Synthesis of chalcones, coumarins and xanthenes
4. Separation and identification of organic mixtures containing up to ***two components*** (Use functional group test only).
5. ESR spectra of simple radicals should be discussed in detail with students.

REFERENCES:

- Skoog, D.A. et al (2018) Principles of Instrumental Analysis, Cengage Learning India Private Limited.
- Kemp, W. (1991), Organic Spectroscopy, Palgrave Macmillan.
- Pavia, D.L., et al. (2015) Introduction to Spectroscopy, Cengage Learning India Private Limited.
- Silverstein, R.M. (2014) Spectrometric Identification of Organic Compounds. John Wiley & Sons.
- Kalsi, P.S. (2002) Spectroscopy of Organic Compounds, New Age International Publishers.
- Chang, R. (1971) Basic Principles of Spectroscopy, McGraw-Hill, New York.
- Ahluwalia, V.K.; Dhingra, S. (2000), Comprehensive Practical Organic Chemistry: Qualitative Analysis, Universities Press.
- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

- Mann F.G, and Saunders, B.C. (2009) Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
- Vogel A.I. (2010) Elementary Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: AAS, AES, ^{1}H NMR Spectroscopy and ESR Spectroscopy.

11.1.17. Course Code: DSC17: CHEMISTRY6 (C6)
Course Title: QUANTUM CHEMISTRY AND SPECTROSCOPY
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this course is to introduce the students to the concepts and methodology of quantum mechanics, its applications to spectroscopy and establish the relation between structure determination and spectra.

Learning Outcomes:

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

- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.

- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.
- Explain Lambert-Beer's law, quantum efficiency and photochemical processes.

Unit 1: Quantum Chemistry

Postulates of quantum mechanics, quantum mechanical operators.

Free particle. Particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy.

Schrodinger equation and its application to free particle and particle in a 1D box

Qualitative treatment of H and H like atoms. Setting up of Schrodinger equation for many electron atoms.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

(Lectures: 12)

Unit 2: Spectroscopy

Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter.

Types of spectroscopy. Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

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

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived from vibrational spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronic spectra of polyenes. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts.

(Lectures: 12)

Unit 3: Photochemistry

Laws of photochemistry. Lambert-Beer's law. Fluorescence and phosphorescence. Quantum efficiency and reasons for high and low quantum yields. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions. Photoelectric cells.

(Lectures: 6)

PRACTICALS (Credits:02, Laboratory Periods: 60)

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and K_2Cr2O_7 (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$ (*Use solutions of different pH*)

3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
4. Verify Lambert-Beer's law and determine the concentration of $K_2Cr_2O_7$ in a solution of unknown concentration.
5. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
6. Study the kinetics of iodination of propanone in acidic medium.
7. Determine the dissociation constant of an indicator (phenolphthalein).
8. Study the kinetics of interaction of phenolphthalein with sodium hydroxide.
9. Study the kinetics of interaction of crystal violet with sodium hydroxide.

REFERENCES:

Theory

- Banwell, C.N.; McCash, E.M.(2006), Fundamentals of Molecular Spectroscopy, Tata McGraw- Hill.
- Kapoor, K.L.(2015),A Textbook of Physical Chemistry, McGraw Hill Education, ,Vol 4, 5th Edition, McGraw Hill Education.
- McQuarrie, D.A.(2016),Quantum Chemistry, Viva Books.
- Chandra, A. K.(2001),Introductory Quantum Chemistry, Tata McGraw-Hill.

Practical:

- Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
- Kapoor, K.L. (2019),A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.

Additional Resources:

- Castellan, G. W .(2004),Physical Chemistry, Narosa.
- Petrucci, R. H.(1989),General Chemistry: Principles and Applications, Macmillan Publishing

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Quantisation, Selection rules, Schrodinger equation, Operator, Spectrum, Quantum efficiency.

11.2. DISCIPLINE SPECIFIC ELECTIVES (DSE)

11.2.1. Course Code: ANALYTICAL CHEMISTRY (DSE-AC1)
Course Title: ANALYTICAL BIOCHEMISTRY
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The Objective of the courses to learn about proteins, enzymes, nucleic acids and lipids, using suitable examples, drug receptor interaction and Structure Activity Relation (SAR) studies along genetic code and concept of heredity.

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

- Learn about structures of carbohydrates and Proteins
- Learn about the molecules, macromolecules, polymers and their formations
- Learn about the metabolism of a few biomolecules.
- Know basic principles of drug-receptor interaction and structure activity relationship (SAR).
- Know biochemistry of diseases.

Unit 1: Carbohydrates and Proteins:

Basic understanding of the structures and properties of carbohydrates, biological importance of Carbohydrates.
Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, Haworth projections and conformational structures; Structure elucidation of glucose and fructose (Fischer's proof), Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;
Disaccharides – Structure elucidation of maltose, lactose and sucrose.
Polysaccharides – Elementary treatment of starch, cellulose and glycogen.
Amino Acids, Peptides and Proteins:
α-Amino Acids - Classification and characterization, Zwitterions, pKa values, isoelectric point and electrophoresis;
Proteins: Classification, Primary, secondary and tertiary structures of proteins, test for proteins, isolation, characterization, biological importance; denaturation of proteins.

Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes and cofactors (ATP, NAD, FAD), specificity of enzyme action (including stereospecificity).

(Lectures: 16)

Unit 2: Lipids
Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Classification. Biological importance of triglycerides and phosphoglycerides and

cholesterol; Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones and peptide hormones.

(Lectures:06)

Unit 3: Biochemistry of disease:

A diagnostic approach by blood/ urine analysis. **Blood:** Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anemia.

Urine: Collection and preservation of samples. Formation of urine. Composition and estimation of constituents of normal and pathological urine. Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

(Lectures: 08)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Carbohydrate- qualitative and quantitative both.
2. Proteins-qualitative tests
4. Determination of the iodine number of oil.
5. Determination of the saponification value of an oil.
6. Determination of acid value of fats and oils.
7. Determination of cholesterol using Liebermann- Burchard reaction.
8. Estimation of DNA by diphenylamine reaction
9. Isolation and characterization of DNA from Onion/cauliflower.
10. Determination of amount of protein using Lowry's method/ Biuret method.
11. To study the activity of α-amylase.
12. To study the effect of temperature and pH on the activity of α-amylase.

REFERENCES:

- Devlin, T. M. (2010), Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons.
- Berg, J.M., Tymoczko, J.L.; Stryer, L. (2010), Loose-leaf Version for Biochemistry, W.H.Freeman.
- Lehninger, A.L., Nelson, D.L.;Cox, M. (2004), Principle of Biochemistry, W.H.Freeman.
- Morrison, R. N.; Boyd, R. N. (2016) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. (2015) Organic Chemistry (Volume 1& 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Additional References:

- Swahney, S.K.; Singh, R. (2001), Introductory Practical Biochemistry, Narosa Publishing House.
- Cooper, T.G. (2011),The Tools of Biochemistry, Wiley India Pvt Ltd.
- Wilson, K.; Walker, J. (2000), Principles and Techniques of Practical Biochemistry, Cambridge University Press.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.
- Use of ICT tools to show the structure of carbohydrates and protiens.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Biological importance of carbohydrates, Proteins, isolation, Lipids.

11.2.2. Course Code: ANALYTICAL CHEMISTRY (DSE-AC2) Course Title: Green Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: Our society is becoming more and more environmentally conscious. The concern of environmental pollution, depleting resources, climate change, ozone depletion, heaps of landfills piling up, legislation getting more restrictive with stringent environmental laws, and rising costs of waste disposal are increasing. Sustainable practices have emerged as a response to these concerns. Green chemistry represents the direction in which chemistry should be heading. It is not a new branch of chemistry but the way chemistry should be practiced. Green chemistry innovations and applications in education have not only benefited the environment but have been beneficial to businesses' economic and societal goals, too. Because it is undergraduate students who will be the community's scientists of the future, this is possible.

Learning Outcomes:

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

- Understand the 12 principles of green chemistry and will develop knowledge of toxicity, risk, and hazard of chemical substances.
- learn about atom economy and how it differs from percentage yield. Students will apply stoichiometric calculations to green chemistry applications.
- Learn to design safer chemicals, products and processes that are less toxic, than current alternatives. Hence, they will understand the meaning of inherently safer design for accident prevention and the principle "what you don't have can't harm you"
- Learn about the benefits of utilizing catalysts and biocatalysts, the use of renewable feedstocks that improve energy efficiency and protect the environment, and green solvents for leading reactions.
- Learn about the applications of Green Chemistry.

Unit 1: Introduction to Green Chemistry

What is Green Chemistry? Environmental laws, pollution prevention Act of 1990, Need for Green Chemistry, Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

(Lectures: 03)

Unit 2: Application of Green Chemistry Principles

Principles of Green Chemistry and Designing a Chemical synthesis.

Concept familiarization and application of green chemistry principles using specific examples:

1. Prevention of Waste/ by-products; waste or pollution prevention hierarchy

2. Green metrics to assess greenness of a reaction: Calculation of atom economy of the rearrangement, addition, substitution and elimination reactions; Calculation of E-factor for industrial processes

3. Prevention/ minimization of hazardous/ toxic products

4. Safer Solvent and Auxiliaries: Problems associated with conventional reaction media, Some Common Green solvents: Introduction, Application, Advantages and Disadvantages of green solvents in organic synthesis (taking suitable examples). Special emphasis on the following:

i. Super Critical Fluids (with special reference to carbon dioxide)
ii. Water: Concept of In-water, and on-water reactions (with special reference to synthesis of terpinol and linalool in water, Benzoin condensation, Heck reaction)
iii. Ionic Liquids: Physical Properties and Classification of Ionic Liquids (with special reference to Diels Alder reaction and Coumarin synthesis in ionic liquids)
iv. Biomass derived Solvents: Physicochemical properties, Use of Glycerol and its derivatives (Mizoroki–Heck reaction) and 2-Methyltetrahydrofuran (Suzuki–Miyaura reaction).

5. Design for energy efficiency: Phenomenon of accelerating organic reactions by using the following Green Chemistry tools (taking suitable examples) and its advantages:

i. Mechanochemistry
ii. Ultrasound assisted reactions: Taking examples like Simmons Smith reaction, Diels–Alder reaction,
iii. Microwave assisted reactions: Special emphasis on solvent-free synthesis- copper phthalocyanine and aspirin, In-water reactions-Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction;
iv. Electrocatalysis: Taking examples like adiponitrile synthesis, synthesis of 3-bromothiophene.
v. Visible light induced Reactions: with examples such as, syntheses of caprolactam, vitamin D3, and *cis-trans* isomerization of alkenes

6. Use of renewable starting materials: Illustrate with few examples such as biodiesel, bioethanol, polymers from renewable resources (PLA from corn), Synthesis and properties of 2-Methyltetrahydrofuran, furfural and 5-Aminolevulinic acid (DALA) from levulinic acid

7. Avoidance of unnecessary derivatization – careful use of blocking/protecting groups (taking specific examples like selective oxidation of aldehydic group and synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G

8. Catalysis and green chemistry Introduction to Catalysis (including concept of selectivity, turnover frequency and turnover number), Types of Catalysts: Heterogeneous catalysis and homogeneous catalysis (H-beta and zeolites in organic synthesis), General catalytic cycle for heterogeneous catalysis; Asymmetric catalysis (Monsanto route to L-dopa via asymmetric hydrogenation, synthesis of carbapenhem via Asymmetric reduction); Photocatalysis (with special reference to TiO_2); Biocatalysis (Synthesis of adipic acid/catechol using biocatalyst) and Nanocatalysis (oxazole synthesis using nanocatalyst)

9. Design for degradation: (Illustrate with the help of examples: soaps and detergents, pesticides, polymers)

10. Real Time monitoring of chemical processes using inline, offline and online techniques

11. Inherently safer design/chemistry: Principle and subdivision of ISD, Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol, Asahi Process)

(Lectures: 21)

Unit 3: Real world case studies based on the Presidential green chemistry awards of EPA

- Surfactants for Carbon Dioxide – replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.
- A new generation of environmentally advanced wood preservatives: Getting the chromium and Arsenic out of pressure treated wood.
- An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.
- Healthier Fats and oils by Green Chemistry: Enzymatic Inter esterification for production of No Trans-Fats and Oils.
- Using a naturally occurring protein to stimulate plant growth, improve crop quality, increase yields and suppress disease.

(Lectures: 06)

PRACTICALS (Credits: 02, Laboratory Periods-60)

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

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.
2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, Solubility, Combustion Test, Density, Viscosity, Gel Formation at Low Temperature and IR can be provided).

3. Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
4. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
5. Mechanochemical solvent free, solid–solid synthesis of azomethine using *p*-toluidine and o-vanillin/p-vanillin (various other combinations of primary amine and aldehyde can also be taken).
6. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
8. **Designing and conducting an experiment by utilizing the products and by products obtained in above preparations which become waste otherwise if not used. This is done by critical thinking and literature survey. Some representative examples:**
    - Use of nanoparticles as catalyst for a reaction
    - Benzoin converted into Benzil and Benzil into Benzilic acid by a green method
    - Use of azomethine for complex formation
    - Rearrangement reaction from Benzopinacol to Benzopinacolone
    - Conversion of byproduct of biodiesel to a useful product
    - Spot tests for qualitative inorganic analysis for cations and anions, and qualitative organic analysis for preliminary test and functional group analysis.

REFERENCES:

Theory:

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

Practical:

- Kirchoff, M.; Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC.
- Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi.
- Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B.(2006), Introduction to organic Laboratory Technique-A Microscale approach, 4th Edition, Brrooks-Cole Laboratory Series for Organic chemistry.
- Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. Indu Tucker Sidhwani et al. University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1, February 2015, ISSN: 2395-2334.

- Sidhwani, Tucker I.; Chowdhury, S. Greener alternatives to Qualitative Analysis for Cations without H_2S and other sulfur containing compounds, J. Chem. Educ. 2008, 85, 1099.
- Sidhwani, Tucker I.; Chowdhury, S. et al., DU Journal of Undergraduate Research and Innovation 2016, Volume 2, Issue 2, 70-79.
- Dhingra, S., Angrish, C. Qualitative organic analysis: An efficient, safer, and economical approach to preliminary tests and functional group analysis. Journal of Chemical Education, 2011, 88(5), 649-651. Ranganna, S. (2017). Handbook of analysis and quality control for fruits and vegetable products, 2nd Edn., McGraw Hill Education.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power Point Presentations
- Interactive Sessions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Green Chemistry, 12 Basic Principles of Green Chemistry, Atom Economy, Waster Prevention, Catalyst, Solvent Free synthesis, Green Solvents.

11.2.3. Course Code: ANALYTICAL CHEMISTRY3 (DSE-AC3) Course Title: POLYMERS

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: To acquaint students with knowledge of molecules and macromolecules. To study about molecular weight determination and the solution properties of polymers.

Learning Outcomes:

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

- Learn about the molecules, macromolecules and polymers
- Learn about properties of polymer solutions.
- Learn about the differentiation between molecule and polymer.
- Learn about the properties of polymers.

Unit 1: Introduction to Polymers

Introduction of polymeric materials, classification of polymers, Various structures of copolymers such as linear branched and cross-linked polymers and their types, Molecular forces and chemical bonding in polymers

(Lectures: 04)

Unit 2: Polymerization

Criteria for synthetic polymer formation, Types of polymerizations, Relationships between functionality, extent of reaction and degree of polymerization.

(Lectures: 04)

Unit 3: Molecular Weight of Polymers

Nature and structure of polymers: structure-property relationships, molecular weight of polymers (M_n, M_w), molecular weight distribution, polydispersity, and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, osmometry, light scattering & ultracentrifugation method

(Lectures: 10)

Unit 4: Solution Properties of Polymers

Criteria for polymer solubility, Polymer solution – solubility parameter, properties of dilute solutions and their criteria, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change. Flory- Huggins theory.

(Lectures: 08)

Unit 5: Glass Transition Behaviour of Polymers

Glass transition temperature (T_g), factors affecting the glass transition temperature, WLF equation.

(Lectures:04)

PRACTICALS (Credits: 2, Laboratory periods: 60)

1. Free radical solution polymerization of

   (i) Styrene (St) (ii)Methyl Methacrylate (MMA) (iii) MethylAcrylate (MA).

2. IR , ^{1}H NMR studies of polymers (PSt, PMMA, PMA, PEG, PVOH)

3. Thermal studies of polymers (PSt, PMMA, PMA, PEG, PVOH)

4. To check the solubility of the given polymeric sample in different solvents.

5. Preparation of nylon-6,6

6. Determination of the viscosity-average molecular weight of poly(vinyl alcohol).

7. Determination of the fraction of head-to-head monomer linkages in of poly(vinyl alcohol)

9. Determination of molecular weight by end group analysis.

10. Chemical identification of polymers- (i) Unsaturation (ii) Testing of functional groups (associated with polymers).

11. Determination of hydroxyl number of a polymer using colorimetric method.

12. i) Preparation of urea-formaldehyde resin

ii) Separation of monomers from polymers by solvation-technique.

REFERENCES:

- Harry R. Allcock, Frederick W. Lampe and James E. Mark ((2003) Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall
- Fred W. Billmeyer (1984) Textbook of Polymer Science, 3rd ed. Wiley-Interscience,
- L. H. Sperling (2005) Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
- Malcolm P. Stevens (2005) Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press.
- Gowarikar V.R., (2010) Polymer Science, New Age International Publishers Ltd.
- Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, Tata McGraw Hill.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Degree of polymerization, Glass Transition Temperature, Molecular Weight Distribution, Viscosity Average Molecular Weight.

11.2.4. Course Code: ANALYTICAL CHEMISTRY (DSE-AC4)
Course Title: Food Chemistry, Nutrition and Additives
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The introductory course on food chemistry, nutrition and additives is designed in such a manner that the students develop a basic understanding of the sources, importance, stability, and transformations of food components during handling and processing.

Learning Outcomes:

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

- Build a strong understanding of basic fundamentals of food chemistry • understand how alterations /transformations during processing and handling affect the quality and stability of food
- Learn about the nature and importance of additives in food chemistry

Unit 1: Introduction

Introduction of food chemistry; An overview of the following: alterations during handling or processing (texture, flavour and colour), chemical and biochemical reactions leading to alteration in food quality (browning, oxidation, hydrolysis, protein denaturation), cause and effect relationship pertaining to food handling; Factors governing stability of food (chemical and environmental factors) and role of food chemists.

(Lectures: 03)

Unit 2: Water:

Definition of water in food, Structure of water and ice, Types of water, Sorption phenomenon, Water activity and packaging, Water activity and shelf-life.

(Lectures: 04)

Unit 3: Carbohydrates

Introduction, Sources, Functions, Deficiencies, Structure and importance of Polysaccharides in food chemistry (Agar and Agarose, Pectin, Hemicellulose, Cyclodextrins, Gums, Alginate, Starches, Modified starches), Non Enzymic Browning and its prevention, Caramelisation, Formation of acrylamide in food, Role of carbohydrates as sweeteners in food.

(Lectures: 05)

Unit 3: Vitamins and Minerals

Vitamins: Introduction, Sources, Classification: Water Soluble and Water insoluble Vitamins, Essential Vitamins, Physiological function, deficiencies, Causes of variation and loss in foods, Vitamin like compounds, Effect of food processing. Minerals: Introduction, Sources, Classification: Major minerals and trace elements, Physiological function, Deficiencies, Factors affecting mineral content of food, Fortification and enrichment of foods with minerals, Effect of food processing. (Lectures: 06)

Unit 4: Food additives:

Additives: Introduction, Importance, Classification, Antioxidants, Emulsifiers, Stabilizers, Gelling agents, Gums, Thickeners, Sweeteners, Acidulants, Preservatives, Humectants, Food toxins.

Colouring Agents and Pigments: Introduction, Natural food colourants: Anthocyanins, Carotenoids, Chlorophyll, Caramel, Betalains; Examples of Pigments in common food; Nature-identical colourants: β -Carotene, Canthaxanthin and Riboflavin. Artificial colouring agents; Artificial/synthetic colourants: Azo dyes (e.g. amaranth dye, tatrazine, citrous red, Allura red); Quinoline (e.g. quinoline yellow); Phthalein (e.g. erythrosine); Triarylmethanes

and indigoid (e.g. indigo carmine), FD&C Dyes and Lakes; Properties of certified dyes, Colours exempt from certification.

Food Flavours: Sensation of taste and odour, Chemical Dimension of basic types of taste (Salty, Sweet, Bitter, Sour, Umami taste), other sensations like astringency, coolness, pungency/pungency); Non-Nutritive Sweeteners (aspartame, saccharin, sucralose, Cyclamate) and Nutritive Sweeteners, Molecular mechanism of flavour perception, Biogenesis of fruits and vegetable flavours, Taste Inhibition, Modification and Enhancement, Common Vegetable and Spice Flavours. (Lectures: 12)

PRACTICALS (Credits: 02, Laboratory Periods-60)

1. Determination of Moisture in different Food Products by hot air oven-drying method.
2. Paper chromatography of synthetic food dyes (*ascending and circular both*).
3. Quantitative determination of Food dyes in Powdered drink mixes by Spectrophotometric method.
4. Colorimetric determination of Iron in vitamin / dietary tablets.
5. Determination of rancidity of edible oils by Kriess Test.
6. Estimation of Vitamin C in a given solution/ Lemon Juice/ Chilies by 2, 6-dichlorophenol Indophenol Method.
7. Isolation of Casein from milk.
8. Qualitative test for Amino acids and proteins (Biuret Test, Xanthoproteic Test, Ninhydrin Test, Millon's Test, Nitroprusside Test, etc).
9. Determination of total fat by acid hydrolysis method.

REFERENCES:

Theory:

- DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), Principles of Food Chemistry, 4th Edition, Springer.
- Msagati, T.A.M. (2013), Chemistry of Food Additives and Preservatives, WileyBlackwell.
- Fennema, O.R. (2017), Food Chemistry, 5th Edition, CRC Press.
- Attokaran, M. (2017), Natural Food Flavors and Colorants, 2nd Ed., Wiley-Blackwell.
- Potter, N.N., Hotchkiss, J.H, (1995) Food Science, 5 th Ed., Chapman & Hall.
- Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), Food Additives, 2 nd Edition, CRC Press.
- Coultate, T. (2016), Food: The Chemistry of its Components, 6th Edn., Royal Society of Chemistry. 8. Belitz, H. D.; Grosch, W. (2009), Food Chemistry, Springer.

Practicals:

1. Ranganna, S. (2017). Handbook of analysis and quality control for fruits and vegetable products, 2nd Edn., McGraw Hill Education.
2. Sawhney, S.K., Singh, R. (2001), Introductory Practical Biochemistry, Narosa Publishing House.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Food Chemistry, Water, Carbohydrate, Vitamins and minerals, Food additives.

11.2.5. Course Code: ANALYTICAL CHEMISTRY (DSE-AC5) Course Title: INDUSTRIAL CHEMICALS AND ENVIRONMENT

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this course is to make students aware about various processes being used in industry and to learn basis properties of gases and their industrial production, uses, storage and hazards. Manufacturing, applications, analysis and hazards of the Inorganic Chemicals, Preparation of Ultra-Pure metals for semiconducting technology, Air and Water pollution, control measures for Air and Water Pollutants, Catalyst and Biocatalyst, Energy and Environment.

Learning Outcomes:

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

- The different toxic gases and their toxicity hazards
- Safe design systems for large scale production of industrial gases.
- Manufacturing processes, handling and storage of inorganic chemicals.
- Hazardous effects of the inorganic chemicals on human beings and vegetation.
- The requirement of ultra-pure metals for the semiconducting technologies
- Composition of air, various air pollutants, effects and control measures of air pollutants.
- Different sources of water, water quality parameters, impacts of water pollution, water treatment.

Unit 1: Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Introduction to clean technology.

(Lectures: 08)

Unit 2: Industrial Gases and Inorganic Chemicals

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

(b) Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate. Preparation of metals (ferrous and nonferrous) and ultra-pure metals for semiconductor technology.

(Lectures: 10)

Unit III. Environment

(a) Air Pollution: Pollutants and their sources, pollution by SO_2, CO_2, CO, NOx, H_2S and other foul-smelling gases. Green House effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

(b) Water pollution and Water Quality Standards: Pollutants and their sources, Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluent from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, *etc.* Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

(c) Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear fusion / fission, solar, hydrogen, geothermal, tidal and hydel.

(Lectures: 12)

PRACTICALS (Credits: 02, Laboratory Periods: 60)

1. Percentage of available chlorine in bleaching powder.
2. Measurement of chloride, sulphate and salinity of water samples by simple titration method. ($AgNO_3$ and potassium chromate)
3. Estimation of total alkalinity of water samples (CO_3^{-2}, HCO_3^-) using double titration method.
4. Measurement of dissolved CO_2.
5. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
6. Study of some of the common bio-indicators of pollution.
7. Estimation of SPM in air samples.
8. Preparation of borax/ boric acid.

9. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
10. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
11. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
12. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).

REFERENCES:

Theory

- Manahan, S. E. (2017), Environmental Chemistry, CRC Press.
- Buchel, K. H.; Moretto, H. H.; Woditsch, P. (2003), Industrial Inorganic Chemistry, Wiley-VCH.
- De, A. K. (2012), Environmental Chemistry, New Age International Pvt., Ltd.
- Khopkar, S. M. (2010), Environmental Pollution Analysis, New Age International Publisher.
- Stocchi E. (1990) Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
- Felder, R. M.; Rousseau, R. W. (2008) Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
- Kent, J. A. (2007) Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.

Practicals

- Vowles, P. D.; Connell, D. W. (1980), Experiments in Environmental Chemistry: A Laboratory Manual, Vol. 4, Pergamon Series in Environmental Science.
- Gopalan, R.; Anand, A.; Sugumar R. W. (2008), A Laboratory Manual for Environmental Chemistry, I. K. International.
- Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, Prentice Hall.
- Banewicz, J. J.; Kenner, C.T. Determination of Calcium and Magnesium in Limestones and Dolomites, Anal. Chem., 1952, 24 (7), 1186–1187.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.
- Visit to chemical industries to get information about the technologies, methods to check pollutants and its treatment.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Toxic gases, Water pollution, Air pollutants, Chemical Industries.

11.2.6. Course Code: ANALYTICAL CHEMISTRY (DSE-AC6)
Course Title: COMPUTER APPLICATION IN CHEMISTRY
Total Credits: 04 (Credits: Theory-03, Practical-01)
(Total Lectures: Theory- 45, Practical-30)

Objectives: The aim of this paper is to make the students learn the working of computer and its applications in chemistry via programming language, QBASIC and use of software as a tool to understand chemistry and solve chemistry-based problems.

Learning Outcomes:

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

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

Unit 1: Basic Computer system

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High Level languages (Machine language, Assembly language; QBASIC, FORTRAN and C++); Compiled versus interpreted languages. Debugging Software Products (Office, chemsketch, scilab, matlab, and hyperchem), internet application.

(Lectures: 05)

Unit 2: QBASIC commands and Library functions

QBASIC for solving some of the basic and complicated chemistry problems). QB4 version of QBASIC can be used. Arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the following QBASIC commands: INPUT and PRINT; GOTO, If, ELSEIF, THEN and END IF; FOR and NEXT; Library Functions (ABS, INT, CINT, MOD, ASC, CHR$, LEN, EXP, INT, LOG, RND, SQR, TAB and trigonometric Functions), DIM, READ, DATA, REM, RESTORE, DEF FNR, GOSUB, RETURN, MID$, LEFT$, RIGHT$, SCREEN, VIEW, WINDOW, LINE, CIRCLE, LOCATE, PSET Simple programs using QBASIC commands, Matrix addition and multiplication.

(Lectures: 20)

Unit 3: Use of QBASIC for solving problems in Chemistry

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods and binary bisection) with examples of polynomial equations used in chemistry; Numerical differential, Numerical integration (Trapezoidal and Simpson's rule), Calculation of area under the curves for chemistry problems, e.g., entropy calculations, Simultaneous equations, Statistical analysis-mean, variance, standard deviation, error, least square method.

Plotting linear graphs using experimental data, plotting (i) trigonometric functions-particle in a one-dimensional box(ii) exponential function (iii) Ideal gas isotherms. Plotting van der Waals Isotherms, and observe whether van der Waal gas equation is valid at temperatures lower than critical temperature where we require to solve a cubic equation.

(Lectures: 20)

PRACTICALS (Credits:01; Laboratory Periods: 30)

Computer programs using QBASIC based on numerical methods

1. Simple programs to calculate numerical values of chemistry problems.
2. Roots of equations: (e.g. volume of gas using van der Waals equation and comparison with ideal gas, pH of a weak acid).
3. Solving polynomial equation using iterative method. (van der Waal's equation of state, pH of a weak acid using exact expression)
4. Solving polynomial equation using Newton-Raphson's method. (van der Waal's equation of state, pH of a weak acid using exact expression)
5. Matrix operations: addition, multiplication and transpose
6. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
7. Numerical integration using trapezoidal method. (e.g. entropy/ enthalpy change from heat capacity data).
8. Numerical integration using Simpson's rule
9. Mean, standard deviation
10. Least square curve fitting method for linear equation.
11. Calculate the relative intensities of peaks of a proton obtained after spin-spin coupling with 4 equivalent neighboring protons in a high-resolution NMR spectrum using GOSUB RETURN.

Computer programs using QBASIC for plotting graphs

1. van der Waals isotherm
2. Compressibility versus pressure curves
3. Maxwell distribution curves
4. Concentration-time graph using kinetics data
5. pH metric titration curve
6. Conductometric titration curves for strong acid-strong base titrations.
7. Calibration curve using Lambert Beer's law
8. Particle in a one-dimensional box.

Plotting graphs using spreadsheet

1. Particle in a one-dimensional box.
2. van der Waals isotherms below critical temperature, at critical temperature and above critical temperature.
3. Radial plots and radial distribution functions for orbitals of hydrogen atom.
4. Plotting characteristics graphs of zero, first and second order reactions using concentration time data and determine the order of the reaction.

References:

Theory:

- McQuarrie, D. A. (2008), Mathematics for Physical Chemistry, University Science Books.
- Mortimer, R. (2005), Mathematics for Physical Chemistry,3rd Edition, Elsevier.
- Steiner, E. (1996), The Chemical Maths Book, Oxford University Press.
- Yates, P. (2007), Chemical Calculations, CRC Press.
- Harris, D. C. (2007), Quantitative Chemical Analysis,6th Edition, Freeman, Chapters 3-5.

Practical:

- Levie, R.D. (2001), How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge University Press.
- Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1st Edition, McGraw Hill Education.

Teaching Learning Process:

- Blend of conventional blackboard teaching and modern teaching learning tools
- Problem solving and quizzes for enhanced understanding of the concepts
- Explaining the algorithm for solving a problem.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Hardware, Software, Programming Language, ASCII, BCD, QBASIC, library functions, Library commands, mathematical operators, QBASIC commands, Library commands, mathematical operators, QBASIC commands numerical methods, graphs.

11.2.7. Course Code: CHEMISTRY(DSE-C1)
Course Title: Functional Group Organic Chemistry- II
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: This is designed for better understanding of the organic functional groups, which include carboxylic acids and their derivatives (aliphatic and aromatic), amines (aliphatic & aromatic), diazonium salts and their reactivity patterns. The concept of amino acids, peptides has also been introduced with detailed reactions mechanistic pathways will be discussed to unravel the spectrum of organic chemistry and the extent of organic transformations.

Learning Outcomes:

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

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Understand and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Design newer synthetic routes for various organic compounds.

Unit I: Carboxylic acids and their derivatives (aliphatic and aromatic)

Preparation: Acidic and alkaline hydrolysis of esters. Reactions: Hell-VolhardZelinsky reaction, the acidity of carboxylic acids, the effect of substitution on acid strength. Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction and Perkin condensation.

(Lectures: 10)

Unit II: Amines (aliphatic & aromatic) and Diazonium Salts

Amines Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation, the basicity of amines.

Diazonium salt Preparation: from aromatic amines Reactions: conversion to benzene, phenol and dyes.

(Lectures: 10)

Unit III: Amino Acids

Amino Acids and Peptides -Zwitterion, isoelectric point and electrophoresis. Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis. Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Determination of the primary structure of peptides by degradation Edman degradation (N-terminal) and C– terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (*t*-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. An elementary approach to the structure of proteins.

(Lectures: 10)

PRACTICALS (Credits :02, Laboratory Periods: 60)

1. Estimation of Carboxylic acids (ascorbic acid and any other water soluble acid). (*Take at least two samples*).

2. Estimation of aniline by bromination ($KBr+KBrO_3$) method.

3. Estimation of glycine by Sorenson's method.

4. Titration curve of glycine and determination of its Isoelectric point.

5. Systematic qualitative identification and derivative preparation of organic compounds following these functional groups amine 1°-,2°- and 3°-amines, amide and nitro-compounds.

REFERENCES:

Theory:

- Morrison, R. N.; Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. (2002) Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), Intermediate for Organic Synthesis, I.K. International.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.

Practical:

- Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005),College Practical Chemistry, University Press (India) Ltd.
- Ahluwalia, V.K.; Dhingra, S. (2004),Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
- Vogel, A.I. (1972),Textbook of Practical Organic Chemistry, Prentice-Hall.
- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Teaching Learning Process:

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

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory Examination Presentations by Individual Student/ Group of Students

Keywords: Carboxylic Acids and Derivatives, Nitro Compounds, Amines and Diazonium Salts, Amino Acids, Peptides, Zwitterion, Isoelectric Point.

11.2.8. Course Code: CHEMISTRY (DSE-C2)
Course Title: CONDUCTANCE, ELECTROCHEMISTRY AND CHEMICAL KINETICS

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: In electrochemical cells the students will learn about electrolytic and galvanic cells, measurement of conductance and its applications, measurement of emf and its applications. The student will also learn about the reaction rate, order, activation energy and theories of reaction rates.

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

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Unit 1: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Arrhenius theory of electrolytic dissociation, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, determination of transference number using Hittorf and Moving Boundary methods. Applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(Lectures: 08)

Unit 2: Electrochemistry

Review of reversible and irreversible cells, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells, liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

(Lectures: 12)

Unit 3: Chemical Kinetics and Catalysis

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction, Concept of activation energy and its calculation from Arrhenius equation. Theories of reaction rates: Collision theory and activated complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only) Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

(Lectures:10)

PRACTICALS (Credits :2; Laboratory Periods: 60)

Conductance

1. Determination of molar conductance, degree of dissociation and dissociation constant of a weak acid.
2. Perform the following conductometric titrations: **a**) Strong acid *vs* strong base **b**) Weak acid *vs* strong base. **c**) Mixture of strong acid and weak acid *vs.* strong base.

Potentiometry

3. Perform the potentiometric titrations of
   a) Strong acid vs strong base
   b) Weak acid vs strong base.
   c) Potassium dichromate vs. Mohr's salt Chemical Kinetics
4. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.
5. Study the kinetics of Iodide-persulphate reaction by Initial rate method or integrated rate law method.
6. Effect of substrate concentration on acid phosphatase activity and determination of its K_m, V_{max} and K_i (with respect to inorganic phosphate).

REFERENCES:

Theory:

- Castellan, G. W .(2004),P hysical Chemistry, Narosa.
- Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol.1, 6th Edition, McGraw Hill Education.
- Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol.5, 3rd Edition, McGraw Hill Education.
- Puri, B.R., Sharma, L.R. and Pathania M.S. (2020), Principles of Physical Chemistry, Vishal Publishing Co.

Practical:

- Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), Senior Practical Physical Chemistry, R. Chand & Co.
- Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol 7, 1st Edition, McGraw Hill Education.

- Batra, S.K., Kapoor, V and Gulati, S. (2017) 1 st Edition, Experiments in Physical Chemistry, Book Age series.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Rate law, Order of reaction, Activation Energy, Conductance, Transference Number, Electrode potential, Electrochemical series.

11.2.9. Course Code: CHEMISTRY (DSE-C3)
Course Title: PHASE EQUILIBRIUM AND SOLUTIONS
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The students will gain an understanding of phase, co- existence of phases, phase diagram, CST and distribution law and its applications.

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

- Understand phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation.
- Apply the concepts of phase and its applications in purification etc.
- Learn about distribution law and its importance in solvent extraction.

Unit 1: Phase Equilibria

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria,
Phase diagram for one component systems (H_2O, CO_2 and S), with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Phase diagram of three component system, Triangular plots, water-chloroform-acetic acid system.
Application of phase in explaining phenomenon in everyday life.

(Lectures: 15)

Unit 2: Solution

Concentration term, lowering of vapour pressure, Raoult's law. Thermodynamic basis of the colligative properties - lowering of vapour pressure, elevation of Boiling Point, Depression of Freezing point and Osmotic pressure and derivation of expressions for these using chemical potential. Concept of activity and activity coefficients. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST (both upper and lower) and effect of impurities on CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

(Lectures: 15)

PRACTICALS (Credits: 02; Laboratory Periods:60)

Phase Equilibrium

1. Determination of critical solution temperature and composition at CST of the phenol water system
2. To study the effect of impurities of sodium chloride and succinic acid on the CST of phenol-water system.
3. Construction of the phase diagram using cooling curves :
   (i) simple eutectic
   (ii) congruently melting systems.
4. Distribution of I_2/acetic/ benzoic acid between water and chloroform/CCl_4 or cyclohexane.
5. Study of equilibrium of any one of the following reactions by distribution method:

(i) $I_2\ (aq) + I^-\ (aq) \rightleftharpoons I_3^-(aq)$

(ii) $Cu^{2+}\ (aq) + nNH_3 \rightleftharpoons [Cu(NH_3)_n]^{2+}$

REFERENCES:

Theory:

- Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
- Ball, D. W. (2017), Physical Chemistry, 2 nd Edition, Cengage Learning, India.
- Castellan, G. W. (2004), Physical Chemistry, 4 th Edition, Narosa.
- Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol 1, 6 th Edition, McGraw Hill Education.
- Kapoor, K.L. (2020) A Textbook of Physical Chemistry, Vol 3, 5th Edition, McGraw Hill Education.

Practical:

- Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & amp; Co, New Delhi.
- Kapoor, K.L. (2019), A Textbook of Physical Chemistry, Vol.7, 1 st Edition, McGraw Hill Education.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments in Physical Chemistry, 8 th Edition, McGraw-Hill, New York

Additional Resources:

- Moore, W.J. (1972), Physical Chemistry, 5th Edition, Longmans Green & Co. Ltd.
- Glasstone, S. (1948), Textbook of Physical Chemistry, D. Van Nostrand company, New York.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Phase rule, One-component system, Eutectic, Congruent, Incongruent, Raoult's, law, Gibbs-Duhem-Margules, Critical solution temperature.

11.2.10. Course Code: CHEMISTRY (DSE-C4)
Course Title: NOVEL INORGANIC SOLIDS
Total Credits: 04 (Credits: Theory-03, Practical-01)
(Total Lectures: Theory- 45, Practical-30)

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

Learning Outcomes:

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

- Understand the mechanism of solid-state synthesis.
- Explain about the different characterization techniques and their principles.
- Understand the concept of nanomaterials, their synthesis and properties.
- Explain the mechanism of growth of self-assembled nanostructures.
- Understand the real-world importance of bioinorganic nanomaterials.
- Explain the importance of composites and their applications.
- Understand the importance and real-life application of solid materials

Unit 1: Synthesis of Inorganic solids

Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Chemical vapor deposition (CVD), Ion-exchange and Intercalation method.

(Lectures:05)

Unit 2: Characterization techniques of inorganic solids

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

(Lectures: 10)

Unit 3:

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments. One-dimensional metals, molecular magnets, inorganic liquid crystals.

(Lectures: 10)

Unit 4: Nanomaterials

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

(Lectures: 10)

Unit 4: Composite Materials

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

(Lectures: 10)

PRACTICALS (Credits:01; Laboratory Periods: 30)

1. Synthesis of silver nanoparticles by chemical methods / green approach and characterization using UV-visible spectrophotometer.
2. Synthesis of metal sulphide nanoparticles (MnS, CdS, ZnS & CuS) and their characterization using UV-visible spectrophotometer.
3. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
4. Synthesis of inorganic pigments ($PbCrO_4$, $ZnCrO_4$, Prussian Blue, Malachite).
5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
6. Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.

REFERENCES:

Theory:

- West, A. R. (2014), Solid State Chemistry and Its Application, Wiley.
- Smart, L. E.; Moore, E. A., (2012), Solid State Chemistry: An Introduction CRC Press Taylor & Francis.
- Rao, C. N. R.; Gopalakrishnan, J. (1997), New Direction in Solid State Chemistry, Cambridge University Press.
- Poole Jr.; Charles P.; Owens, Frank J. (2003), Introduction to Nanotechnology, John Wiley and Sons.

Practicals:

- Orbaek, W.; McHale, M.M.; Barron, A. R.; Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory, J. Chem. Educ. 92, 2015, 339−344.
- Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981), Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics, 5, 1981, 355-358.
- Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; Synthesis of ZnO Nanoparticles by Precipitation Method, Orient J Chem 2015, 31(2).

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Solid State Chemistry, Nanomaterials, Solid electrolyte, Inorganic Pigments, Self-assembled, Composite Materials, Instrumentation.

11.2.11. Course Code: CHEMISTRY (DSE-C5)
Course Title: MAIN GROUP CHEMISTRY
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The objective of this paper is to provide basic understanding of the fundamental principles of metallurgy through study of the different methods of extraction and refining of metals. The course illustrates the diversity and fascination of inorganic chemistry through the study of structure, properties and utilities of s- and p-block elements and their compounds

Learning Outcomes:

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

- Understand the basis of occurrence of metals in nature and the methods that can be applied on minerals to extract the metals from them.
- Explain the importance of free energy of formation of oxides with the choice of reducing agent for extracting the metals.
- Understand and explain the importance of refining of metals and the choice of a refining procedure.
- Explain the group trends observed for different properties of s and p block elements
- Explain the structures and the bonding basis of compounds of s- and p- block elements
- Explain the uniqueness observed in alkali metals and some other main group elements
- Understand and explain the polymerization of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Unit 1: General Principles of Metallurgy

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

(Lectures: 06)

Unit 2: General Properties

General group trends of s- and p-block elements with special reference to melting and boiling points, flame colour, metallic character and complex formation tendency, diagonal relationship and anomalous behaviour of first member of each group, Alkali metal solutions in liquid ammonia

(Lectures:05)

Unit 3: Structure, Bonding, Properties and Applications

Structure, bonding, properties (Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability) and applications of the following:

Crown Ethers and cryptates of Alkali metals

Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.

Oxides: Oxides of nitrogen, phosphorus and sulphur.

Oxoacids: oxoacids of phosphorus, sulphur and chlorine

Halides of phosphorus (Lectures:15)

Unit 4: Inorganic Polymers

Preparation, properties, structure and uses of the following:

Borazine, Silicates and Silicones

(Lectures:04)

PRACTICALS (Credits:02; Laboratory Periods: 60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations including interfering radicals and water insoluble. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: CO_3^{2-}, NO_2^- , S^{2-}, SO_3^{2-} , SO_4^{2-} , $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^- , Br^- , I^- ,

NO_3^- , BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+} (*At least 10 combinations of mixture to be prepared*).

REFERENCES:

Theory:

- Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India.
- Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education.
- Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
- Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
- Housecraft, E. H.; Sharpe, A.G. (2018), Inorganic Chemistry, 5th Edition, Pearson.
- F.A. Cotton & G. Wilkinson (1999), Advanced Inorganic Chemistry, 6th Edition, John Wiley & Sons.

Practicals:

- Vogel, A.I. (1972), Qualitative Inorganic Analysis, Longman.
- Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, Prentice Hall.

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: s-Block Elements, p-Block Elements, Borazine, Silicones, Silicates, Solutions in Ammonia, Anomalous Behaviour, Inorganic Polymers, Oxides, Oxyacids.

11.2.12. Course Code: CHEMISTRY(DSE-C6)
Course Title: Active Methylene Compounds, Polynuclear hydrocarbon and Heterocyclic compounds
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The purpose of this course to introduce the chemistry and applications of polynuclear hydrocarbons, active methylene and heterocyclic compounds. The learners are introduced to spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Learning Outcomes:

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

- Understand the fundamentals of functional group chemistry, polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Become familiar with their particular properties, chemical reactions, criterion of aromaticity with reference to polynuclear hydrocarbons and heterocyclic compounds, trends in basicity of amines and heterocyclic compounds and their behaviour at different pH.
- Understand the Synthetic applications of these compounds including their medicinal applications through their reaction chemistry.

Unit I: Active methylene compounds

Preparation and reactions, Claisen ester condensation, Keto-enol tautomerism. Reactions: Synthetic uses of ethylacetoacetate and malonic esters (preparation of non-heteromolecules having up to 6 carbons).

(Lectures: 08)

Unit II: Polynuclear Aromatic compounds:

Introduction, Classification, Structure, Nomenclature and uses. Aromaticity of polynuclear hydrocarbons, structure elucidation of Naphthalene and general methods of preparation of naphthalene, phenanthrene and anthracene (including Haworth method, Friedel Craft acylation, Diels Alder reaction and Pschorr Synthesis).
Relative reactivity of naphthalene, phenanthrene and anthracene in comparison to benzene.
Properties: Physical properties, discussion on the following reaction (with mechanism) for Naphthalene, Anthracene and Phenanthrene: Addition reactions, Oxidation, Electrophilic substitution- Friedel Craft reaction, Chloromethylation, Halogenation, Formylation, Nitration and sulphonation. Reduction reaction and Diels Alder reaction. (Lectures:09)

UNIT-III: Heterocyclic Compounds

Introduction, importance, classification and nomenclature of heterocyclic compounds (containing only one hetero atom). General discussion on the following aspects of heterocyclic compounds: Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings)

General methods of synthesis for: Furan, Pyrrole (Paal-Knorr synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Properties: Physical properties, discussion on the following reaction (with mechanism) for Furan, Pyrrole, thiophene, Pyridine- Electrophilic substitution- Nitration, sulphonation, halogenation, Formylation, acylation, mercuration and carboxylation. Oxidation, Reduction, Addition, Reactions showing acidic /basic character. Reaction with diazonium salts, Ring opening, Ring expansion and Nucleophilic substitution reaction wherever applicable should be discussed

(Lectures:13)

PRACTICALS (Credits: 02, Laboratory Periods-60)

1. Nitration of simple compounds like Chlorobenzene/Bromobenzene.
2. Benzoylation of p-toluidine (or any other compound).
3. Oxidation of toluene to benzoic acid.
4. Detection of Nitrogen/sulphur/halogens in the given organic compound.
5. Systematic identification of bifunctional compounds (Salicylic Acid, Cinnamic acid and nitro phenols) and preparation of their derivatives.
6. Systematic identification of Aromatic hydrocarbons and aryl halides.
7. Multistep synthesis: (a) Cyclohexanone to caprolactam (b) Aniline to p-bromo aniline

REFERENCES:

- Morrison, R. T.; Boyd, R. N. (2010) Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
- Finar, I. L.(2002) Organic Chemistry (Volume 1& 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. (2013),Organic Chemistry, Oxford University Press.
- Gilchrist, T.L. (1997),Heterocyclic Chemistry, Pearson Education.
- Ram V. J.; Sethi, A.; Nath, M.; Pratap, R.; (2019), The Chemistry of Heterocycles (Chemistry of six to eight membered N, O, S, P and Se heterocycles), Elsevier publication.
- Ahluwalia, V.K.; Dhingra, S. (2000), Comprehensive Practical Organic Chemistry: Qualitative Analysis, Universities Press.
- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

- Mann F.G, and Saunders, B.C. (2009) Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
- Vogel A.I. (2012) Elementary Practical Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Polynuclear Aromatic Compounds, Active Methylene Compounds, Heterocyclic Compounds.

11.2.13. Course Code: CHEMISTRY(DSE-RM)
Course Title: RESEARCH METHODOLOGY FOR CHEMISTS
Total Credits: 04 (Credits: Theory-03, Practical-01)
(Total Lectures: Theory- 45, Practical-30)

Objectives: To make the students aware of fundamental but mandatory ethical practices in chemistry. To make the students aware of data analysis. To make the students aware of literature survey in different modes. To make the students aware of safety handling and safe storage of chemicals. This paper will help student to learn to avoid plagiarism. To learn different e-resources.

Learning Outcomes:

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

- Ethical practices in chemistry
- Data analysis
- Literature survey in different modes
- Three R (recovery, recycling and reuse of laboratory chemicals).
- e-resources.
- Plagiarism, consequences

Unit 1: Literature Survey

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

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.
Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information. publications of scientific work. Writing ethics. Avoiding plagiarism.

(Lectures: 20)

Unit 2: Chemical Safety and Ethical Handling of Chemicals

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

(Lectures: 12)

Unit 3: Data Analysis

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments. Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

(Lectures: 13)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Collection of chemical structure using ChemSpider and creating a database.
5. Collection of chemical structure using SciFinder and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals

REFERENCES:

- Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
- Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.

- Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
- Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
- Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
- OSU safety manual 1.01.

TEACHING LEARNING PROCESS:
Conventional chalk and board teaching with power point presentation, you tube videos and presentations from/for students on relevant topics.

ASSESSMENT METHODS:
Internal assessment through assignments and class test. End semester written and practical examination.

KEYWORDS: Research methodology, Literature Survey, Chemical Safety, safe storage, disposal, Ethical Handling, Data Analysis, print, digital and Information Technology and Library Resources.

11.3. SKILL INHANCEMENT COURSES (SEC)

NOTE: These are suggestive SEC courses. A student may however choose any SEC from the central pool of chemistry, physics or maths.

11.3.1. Course Code: ANALYTICAL CHEMISTRY (SEC-1) Course Title: CHEMISTRY LAB STANDARD OPERATIONS AND SAFETY MEASURES

Total Credits: 02 (Credits: Theory-00, Practical-02)
(Total Lectures: Theory- 00, Practical-60)

Objectives: The course is aimed at introduction to a Chemistry Laboratory and cultivation of working skills in chemistry laboratory among the students for enhanced learning and to create a trained workforce which can responsibly learn imbibe and explore verticals on structured knowledge safely, as envisaged in the syllabi of the discipline.

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

- Conversant about the safe working practices in chemistry laboratory.

- Familiar with different glass apparatus
- Able to handle the apparatus, chemicals and equipment safely properly.
- Able to understand working protocols related to various methods and instruments in chemistry laboratory.

PRACTICALS/ Hands-on-Training: (Credits:02; Laboratory Periods: 60)

Part A: Safety Measures

1. Design an illustrative chart exhibiting creativity at transaction of Do's and Don'ts instructions for working in a chemistry laboratory.
2. Carry out Classification and labeling of the given set of chemicals based upon Globally Harmonized System.
3. Carry out preparation of the indicative MSDS (Material Safety Data Sheet) of given set of chemicals as per Standard MSDS format.
4. Carry out detailed survey of the Chemical Abstract Service (CAS) Registry Number and identify the given set of CAS RN and explain the different sections of CAS RN.
5. Design an illustrative chart exhibiting creativity at transaction of Common Safety Symbols along with its description. Associate appropriate safety symbol with each of the given set of chemicals.
6. Draw and elucidate the National Fire Protection Association Hazard Labels.
7. Identify and enlist the Incompatible Chemicals from a given set of chemicals available in the laboratory.
8. Labeling and storage of Chemical in laboratory
9. On the basis of MSDS analysis, identify the required storage conditions for the given set of chemicals.
10. Describe procedure for the storage, maintenance and handling of compressed gas cylinders.
11. Explore guidelines for the Storage of shelf chemicals and reagents.
12. Carry out a brief review of common pathways by which working Chemicals can enter the Body
13. Carry out a detailed study of the Limits of Exposure of given Chemicals.
14. Classify the Hazard based on storage, handling, and disposal of chemicals
15. Identification and describe handling protocols for Substances with Greater Hazardous Nature
16. Carry out detailed investigations on procedural protocols for safe Disposal of Chemicals
17. Carry out study on recommended Safety and Emergency Equipment essential for the safe practices in a Chemistry Laboratory
18. Study the guidelines in the Event of a Chemical Accident or Spill.
19. Write Detailed description on Fire Safety in the laboratory
20. Carry out investigations of the data regarding Institute Safety Policies: Safety Audits / Inspections

Part B: Chemistry Lab Standard Operations

1. Carry out exploration on Holding, Handling and use of Common Laboratory Apparatus as per given list of laboratory apparatus.

2. Carry out investigations of various types of apparatus in labs based on material they are made of such as Pyrex Glass (borosilicate Glass) Apparatus, Fused Silica Apparatus: Corning Vycor Glass, Porcelain apparatus, Plastic Apparatus, Metal Apparatus.
3. Understanding the protocol of Cleaning and drying and polishing of Glassware apparatus.
4. Carry out detailed investigations on Identification, diagrammatic representation, set up of Apparatus assemblies and details exploration on operational procedural protocols for glassware apparatus with Interchangeable ground glass joints: Typical Assemblies.
5. Carry out calibration of Volumetric/ Graduated Glassware Apparatus along with description on Temperature Standards
6. Carry out Calibration of thermometers.
7. Carry out exploration and investigations of working protocol for various Heating equipment in laboratory: Burners, Hot Plates, Electrical Heating Mantles, Electric Oven, Microwave Oven, Muffle Furnace, Infrared lamps, Crucible and Beaker Tongs and Emersion heaters.
8. Carry out exploration and investigations of working protocol for various Stirring apparatus in laboratory: Stirring rods; Policeman, Boiling rods, Use of Mechanical agitation-Magnetic Stirrer and Mechanical Shaker.
9. Carefully analyze the Glass, Cork and Rubber Stoppers and investigate their preparation and appropriate applications.
10. Carry out detailed investigations of Heating and Cooling Bath, and determine their working ranges and working protocols.
11. Differentiate among Various types of Filter Paper and explore their applications.
12. Preparation of a fluted filter paper and its advantages.
13. Care and Use of Analytical Balance: Mass and Weight, Two-Pan Balance and Electronic Balance
14. Carry out Calibration of weighing balances and accuracy in measurement.
15. Explore and differentiate between different forms of water for Laboratory Use: Distilled (Grade I to III), De-ionized and tap water, and carry out conductance measurement /other analytical investigations for the differentiation purpose.
16. Introduction to Gas absorption traps and their importance
17. Experimental determination of the melting point using various methods
18. Use of melting point apparatus
19. Experimental determination of the boiling point using various methods
20. To Purify given organic solvents
21. Hand on training for working with typical assemblies of apparatus for distillation and refluxing.
22. Assessment of Fire hazards attending the distillation of inflammable solvents
23. Purification of given solid organic compounds by crystallisation method.
24. Recrystallization of given non-volatile organic solids and outline the Difficulties encountered in recrystallization process
25. Removal of traces of colouring matter and use of decolourising carbon.
26. Carry out exploration and investigations of working and working protocol for Filtration Apparatus: Filtration with suction
27. Explore and imbibe knowledge about types of Vacuum Pump; Water and Oil Pump and their applications.
28. Investigate Conventions for Drying of the recrystallized material
29. Recrystallization in an atmosphere of inert gas
30. Performing Evaporation of the solvent in the laboratory.
31. Various procedures for the precipitation and washing of the precipitates.

32. Application of various methods and instruments for drying of solid organic compounds.
33. Incineration of Filter paper with precipitate
34. Differentiate between various types of centrifugation methods, principle, uses and application of centrifugation method.
35. Preparation of anhydrous liquids or solutions of organic compounds in organic solvents .
36. Introduction to Chromatographic adsorption: Paper and Thin Layer Chromatography.
37. Preparation of Thin Layer Chromatography (TLC) Plates.
38. Calculation of yields for different chemical processes.
39. In-depth Understanding and Preparation of Chemical Laboratory Reagents
40. Explore methodologies of Preparation and Storage of Standard Solutions.

Important Instruction Note on working approach:

• A student is required to perform/investigate a minimum of 5 exercises from Part A and 10 exercises from Part B. Moreover, exercises related to MSDS, CASRN safety symbols identification is required to be performed mandatorily.

• The exercises mentioned above will be performed by the student strictly in accordance with the instructions received and only under the supervision of the teacher concerned.

REFERENCES:

- Skoog D.A., West D.M., Holler F.J., Stanley R.C. (2003) Fundamentals of analytical chemistry, 9th Edition, Cengage Learning.
- Mendham, J.; Denney, R.C.; Barnes, J.D.; Thomas, M.J.K. (2007), Vogel's Quantitative Chemical Analysis, 6th Edition, Prentice Hall.
- Furniss, B. S; Hannaford, A. J.; Smith, Peter W. G.; Tatchell, A. R (2012) Vogel's Text Book of Practical Organic Chemistry, 5th Edition, Longman Scientific and Technical, Longman Group Ltd.
- Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003) Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York.
- https://iupac.org/
- https://edu.rsc.org/resources/practical/experiments

Teaching Learning Process:

- Hands-on laboratory exercises
- Conventional teaching learning method.
- Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Presentation on good lab practices.
- Semester end University examination.

Keywords: glass apparatus, reagents, safety measures, laboratory guidelines.

11.3.2. Course Code: ANALYTICAL CHEMISTRY (SEC-2)
Course Title: CHEMISTRY:IT SKILLS AND DATA ANALYSIS
Total Credits: 02 (Credits: Theory-00, Practical-02)
(Total Lectures: Theory- 00, Practical-60)

Objectives: The objective of this course is to introduce the basic computer skills to the students that will help them in solving chemistry problems. The students are introduced to recording of the experimental data, errors and data reduction. The paper also acquaints the students with different software for data tabulation, calculation, graph plotting, data analysis, drawing of structures and document preparation.

Learning Outcomes:

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

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

PRACTICALS/ HANDS ON TRAINING (Credits:02; Laboratory Periods: 60)

1. **Introductory writing activities**:
(i) Introduction to word processor
(ii) Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.
(iii) Preparing a word processing document having tables, chemical structures and chemical equations

2. Measurements in chemistry:
(i) Decimal places, significant figures, combining quantities.
(ii) Recording laboratory data and data treatment.
(iii) Uncertainty in experimental techniques: Displaying uncertainties
(iv) Experimental errors. Types of errors, accuracy and precision

3. Statistical treatment:
(i) Calculations of mean, variance, standard deviation, relative error.
(ii) Student t distribution, rejection of discordant data, Q-test
(iii) Data reduction- Numerical data reduction, graphical data reduction.
(iv) Propagation of errors: Combination of errors, combination of random and systematic errors
(v) Error propagation in numerical data reduction

(vi) Curve fitting: the method of least squares (regression).

4. **Handling numeric data**: Spreadsheet software (Excel/Libre Office Calc), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs.

5. Simple calculations using a spreadsheet
(i) Linear regression rate constants from concentration- time data
(ii) Molar extinction coefficients from absorbance data
(iii)Numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid)
(iv) Integration (e.g. entropy/enthalpy change from heat capacity data).
(v) Statistical analysis using Excel functions LINEST and Least Squares.
(vi) Statistical significance testing: The t test. The Ftest.

6. Plotting graphs using a spreadsheet
(i) Planck's distribution law
(ii) Radial distribution curves for hydrogenic orbitals
(iii) Maxwell-Boltzmann distribution curves as function of temperature and molecular weight)
(iv) Ideal gas isotherms
(v) Pressure-volume curves of van der Waals gas (van der Waals isotherms)
(vi) Data from phase equilibria studies.
(vii) Graphical solution of equations.
(viii) Simulation of pH metric titration curves.

7. **Presentation**: Preparing a presentation on a chemistry topic that includes text, tables, graphs and equations.

8. **Chemistry software**:
(i) Introduction to different software available for drawing chemical structures (Free and Open Source, Proprietary and Online) like ACD Chemsketch and 3-D viewer, ChemDraw, ChemDraw online
(ii) isualization software like Pymol, Avogadro, Molview, MarvinSketch
(iii) Draw structures of various compounds (aliphatic, aromatic, heterocyclic with different functional groups) using software. Save the structures in various file formats. Incorporate the structures in word document.
(iv) Use the software to find IUPAC name and SMILES notation for the structures.

Additional exercise
Use of Origin, MATLAB and GNUPLOTS for plotting simple graphs

REFERENCES:

- Steiner, E. (2008) The Chemical Maths Book Oxford University Press.
- Yates, P. (2007) Chemical calculations, CRC Press.
- Harris,D.C. (2007) Quantitative Chemical Analysis. Freeman, Chapters 3-5.
- Levie, R. de. (2001) How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press.

- E. Joseph Billo (2011) Excel for chemists, A comprehensive guide, 3rd Ed., Wiley

Teaching Learning Process:

• Hands on exercise on computers

• Handling of experimental data and data reduction using different available software.

Assessment Methods:

• Continuous evaluation of laboratory work and record file.

• Oral assessment, quizzes.

• Presentation

• Semester end University examination.

Keywords: Uncertainty in measurements, least square, spreadsheet, curve fitting method, Spreadsheet, charts, tables, graphs, LINEST, t-test, F-test, chemistry software

11.3.3. Course Code: ANALYTICAL CHEMISTRY (SEC-3)
Course Title: CHEMISTRY OF COSMETICS & TOILETRIES
Total Credits: 02 (Credits: Theory-00, Practical-02)
(Total Lectures: Theory- 00, Practical-60)

Objectives: This course is designed for introducing chemistry students to the world of cosmetics and toiletries. Cosmetics play an important role in our everyday lives as they make an individual's appearance more attractive & boost one's self-esteem and confidence. Keeping in view the tremendous potential which the cosmetic industry has today around the globe, this has been designed to impart the theoretical and practical knowledge on basic principles of cosmetic chemistry, manufacture, formulation of various cosmetic products.

Learning Outcomes:

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

- understand the basic principles of various cosmetic formulations
- know different ingredients and their roles in cosmetic products.
- appreciate the role of herbal ingredients in various cosmetic products
- learn the use of safe, economic and body-friendly cosmetics
- prepare new innovative formulations to achieve the aimed efficacies and effects

PRACTICALS (Credits: 02; Laboratory Periods: 60)

1. Definition, History and Classification of cosmetic & cosmeceutical products.
Skin Care Products: Basic structure and function of skin. Principles of formulation of skin care products. Role of herbs in Skin Care: Aloe and turmeric. General Ingredients and preparation of

(a) Preparation of Talcum powder (chemical based and herbal)
(b) Face cream/ vanishing cream/ cold cream/ suntan cream/lather shaving cream (any two)
(c) Body lotion

2. **Hair Care Products**: Basic structure of hair and classification of hair. Principles of formulation of Hair care products. Types of shampoo and conditioners. Role of herbs in Hair care: Henna and amla. Role of primary and secondary surfactants in shampoo. General Ingredients and preparation of
(a) Shampoo (chemical based and herbal)
(b) Conditioners

3. **Hand Care and hygiene Products**: Principles of formulation of hand sanitizers and hand wash. General Ingredients and preparation of:
(a) Handwash
(b) Hand sanitizer

4. **Nail preparation**: Structure of nail, Nail lacquers, Nail polish remover. General Ingredients and preparation of:
(a) Nail polish and nail polish remover

5. **Personal hygiene products**: Total fatty matter, alkali content and pH of soaps. Bathing soap and toilet soap. Antiperspirants and deodorants. General Ingredients and preparation of
(a) Soaps
(b) Cream Soaps

6. **Oral hygiene products**: **Common problem associated with teeth and gums. Role of herbs in oral care: Neem and clove.** Principles of formulation of Oral hygiene products. Flavours and essential oils. General Ingredients and preparation of
(a) Tooth powder (chemical based and herbal)
(b) Tooth paste

REFERENCES:

1. Barel, A.O.; Paye, M.; Maibach, H.I.(2014), Handbook of Cosmetic Science and Technology, CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012), Text Book of Cosmetics, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K. (2011), Pharmaceutics and Cosmetics, Pragati Prakashan.
4. Butler, H. (2000), Poucher's Perfumes, Cosmetic and Soap, Springer

Additional Resources:

1. Flick, E.W. (1990), Cosmetic and toiletry formulations, Noyes Publications/ William Andrew Publishing.
2. Natural Ingredients for Cosmetics; EU Survey 2005
3. Formulation Guide for cosmetics; The Nisshin OilliO Group, Ltd.
4. Functional Ingredients & Formulated Products for Cosmetics & Pharmaceuticals; NOF Corporation

Teaching Learning Process:

- Conventional chalk and board teaching,
- Hand-on practice on various formulations of cosmetic products

- Power point presentation on important topics.
- Theory coupled with preparation of cosmetic products in the lab.

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Cosmetics, Ingredients, Formulations, Soap, Cream, Shampoo, Wash, Sanitizer.

11.3.4. Course Code: ANALYTICAL CHEMISTRY (SEC-4)
Course Title: CHEMICAL ASPECTS OF FORENSIC SCIENCE
Total Credits: 02 (Credits: Theory-01, Practical-01)
(Total Lectures: Theory- 15, Practical-30)

Objectives: Forensic science is the branch of science which has been drawn from chemistry, physics, biology to apply in criminal investigations governed by the legal standards of admissible evidence and criminal procedure. Forensic science is important because it helps to establish the guilt or innocence of potential suspects. The objective of this course is to introduce students to this fascinating branch of science and familiarize them with important concepts like fingerprints, explosives/arson, drugs and their detection.

Learning Outcomes:

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

- Learn about the concepts of latent fingerprints,
- Various methods of detection of latent fingerprints,
- Explosive analysis in forensic science,
- Collection and preservation of evidence from crime scene etc

Unit 1: History of Development of Forensic Science in India

Definitions, Scope and Need of forensic science, Ethics in forensic science, History of Forensic science, Basic principles of forensic science, Organizational structure of forensic science laboratories, Different branches in forensic science

(Lectures: 02)

Unit 2: Fingerprints

Definition, History of fingerprint identification, Fingerprint as forensic evidence, Visible Finger marks, Latent Finger marks, ten-digit classification, Methods of Development of latent fingerprints using conventional methods–Powdering (Black and grey, fluorescent and magnetic), Methods of development of latent fingerprint using chemical method (iodine fuming, silver nitrate, Ninhydrin, Vacuum metal deposition), Automated Fingerprint identification system (AFIS), Poroscopy and Edgescopy

(Lectures: 05)

Unit 3: Forensic Chemistry

Scope & significance of Forensic Chemistry, Types of cases/exhibits received for analysis.
Trap Cases: Collection, and Preliminary analysis of evidence in trap cases.
Alcoholic Beverages: Types of alcohols, country made liquor, illicit liquor, denatured spirits, Indian made foreign alcoholic and non-alcoholic beverages.
Dyes: Scope & Significance of dyes in crime investigation, analysis of ink by TLC and UV visible spectrophotometry. Petroleum products and their adulterations: Chemical composition of various fractions of Petroleum Products, Analysis of petrol, kerosene, diesel.
Fire/Arson and Explosives Fire: Introduction to Fire & Arson, origin of fire, Chemistry of Fire, Fire tetrahedron, Fire-fighting operations, preservation of fire scene, collection of evidences, Seat of fire, cause of fire, motives, Analysis of fire debris, Case studies related to fire and Arson. Explosive and Explosion: Scope & significance of explosive analysis in forensic science, Types of explosives, deflagration and detonation, explosive trains, collection, preservation and forwarding of exhibits, preliminary analysis of explosives. Dos and Don'ts. Case studies related to explosives.
Drugs of abuse: Classification, including designer drugs. Ill effects of drugs of abuse, Preliminary and confirmatory tests.

(Lectures: 08)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. Development of fingerprint through conventional powder method.
2. Development of fingerprint through chemical methods.
3. To check the alcohol presence in different liquor.
4. Phenolphthalein test for trap cases.
5. Identification of Handwriting Individual Characteristics.
6. Study of Disguise in handwriting.
7. TLC of amino acids

REFERENCES:

- Saferstein, R. (1990) Criminalistics, Prentice Hall, New York.
- JaVed I. Khan, Thomas J. Kennedy Donnell R. Christian, Jr. (2011) Basic Principles of Forensic Chemistry, Humana.
- Hillary Moses Daluz (2018) Fundamentals of FINGERPRINT ANALYSIS, CRC Press
- Anthony, C. Moffet et.al (2011) Clarke's Analysis of Drugs and Poisons 4th Ed., Pharmaceutical Press.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Hand-on practice on various formulations of cosmetic products
- Power point presentation on important topics.
- Theory coupled with preparation of cosmetic products in the lab.

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Latent fingerprints, Arson, explosives, Fire tetrahedron.

11.3.5. Course Code: ANALYTICAL CHEMISTRY (SEC-5)
Course Title: CHEMINFORMATICS
Total Credits: 02 (Credits: Theory-00, Practical-02)
(Total Lectures: Theory- 00, Practical-60)

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

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

- Have a comprehensive understanding of drug discovery process and techniques including structure-activity relationship, quantitative structure activity relationship and the use of chemo informatics in this, including molecular modelling and docking studies.
- Appreciate role of modern computation techniques in the drug discovery process and

perform their own modelling studies.

PRACTICAL/ HANDS-ON TRAINING: (Credits: 02; Laboratory Periods:60)

Introduction to Cheminformatics: History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modelling and Structure elucidation.

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

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

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modelling Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Cheminformatics in Drug Design. Molecular docking – Protein Ligand Interactions.

1. **Overview of Rational Drug Design, Ligands and Targets**
2. ***In silico* representation of chemical information**
   i. CIF IUCr Crystallographic Information Framework
   ii. CML Chemical Markup Language
   iii. SMILES -- Simplified Molecular Input Line Entry Specification
   iv. InChi -- IUPAC International Chemical Identifier
   v. Other representations
3. **Chemical Databases and Data Mining**
   i. Cambridge Structural Database CCDC CSD
   ii. Crystallographic Open Database COD
   iii. Protein Data Bank PDB Ligand Explorer
   iv. Chemspider
   v. Other Data Bases
4. **Molecular Drawing and Interactive Visualization**
   i. ChemDraw
   ii. MarvinSketch
   iii. ORTEP
   iv. Chimera, RasMol, PyMol
5. **Computer-Aided Drug Design Tools**
   i. Molecular Modeling Tools
   ii. Structural Homology Modeling Tools
   iii. Docking Tools and Screening Tools
   iv. Other tools
6. **Building a Ligand**
   i. Building *ab initio*
   ii. Building from similar ligands
   iii. Building with a known macromolecular target
   iv. Building without a known macromolecular target
   v. Computational assessment of activity and toxicity and drugability

REFERENCES:

- Andrew R. Leach & Valerie, J. Gillet (2007) An introduction to Chemoinformatics. Springer.
- Gasteiger, J. & Engel, T. (2003) Chemoinformatics: A text-book. Wiley-VCH.
- Gupta, S. P. (2011) QSAR & Molecular Modeling. Anamaya Pub.: New Delhi.

Teaching Learning Process:

- Combination of instructions and practicals.
- Hands on exercise on cheminformatics

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- Review of case study
- End semester University Theory and Practical Examination

Keywords: Cheminformatics, Virtual Chemical Library, Virtual Screening, SAR-QSAR, Drug Design lead discovery.

11.3.6. Course Code: ANALYTICAL CHEMISTRY (SEC-6)
Course Title: GREEN METHODS IN CHEMISTRY
Total Credits: 02 (Credits: Theory-00, Practical-02)
(Total Lectures: Theory- 00, Practical-60)

Objectives: This course is designed to make the students aware of chemistry that is good for human health and the environment. By gaining thorough knowledge of the green chemistry principles, students would be able to think of suitable remediation technologies for the leaning up of hazardous substances. Also, students would be able to design, develop and run chemical processes in a sustainable way.

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

- Think to design and develop materials/ processes that reduce the use and generation of hazardous substances in industry.
- Know how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment.
- Get ideas of innovative approaches to environmental and societal challenges.
- Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols.
- Convert biomass into valuable chemicals through green technologies.

PRACTICALS (Credits: 02; Laboratory Periods: 60)

1. Definition and Importance of green chemistry. Introduction to the prevention of Waste/ by products and waste/ pollution prevention hierarchy. Provide the scheme for the traditional as well as green method for the synthesis of ibuprofen and ask them to calculate and compare the amount of waste generated in both the processes.
2. Principle and calculation of atom economy. Use of molecular model kit to simulate the reaction to investigate how the atom economy can illustrate Green Chemistry. Preparation of propene by two methods can be studied

(I) Hoffman elimination

(II) Dehydration of propanol
The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy

3. Prevention/ minimization of hazardous/ toxic products reducing toxicity. Risk = (function) hazard x exposure.

(a) Nitration of salicylic acid using green method $Ca(NO_3)_2$
(b) Preparation and characterization of nanoparticles of gold using tea leaves/silver

nanoparticles using plant extracts.
(c) Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method
(d) Acetylation of primary aromatic amine using the green method.

4. Use of Green solvents and comparison of greenness of solvents:
(a) Explain about supercritical fluids with special reference to carbon dioxide. Extraction of Dlimonene from orange peel using liquid CO2 prepared from dry ice
(b) Introduction to water as a solvent for chemical reactions. preparation of Manganese (III) acetylacetonate using green method
(c) Advantages and application of solventless processes in organic reactions.
(i) Benzil- Benzilic acid rearrangement in solid State under solvent-free Condition.
(ii) Mechanochemical solvent free, solid–solid synthesis of azomethine using ptoluidine and o-vanillin/p-vanillin

5. Energy requirements for reactions – alternative sources of energy: use of microwaves and photochemical energy.
(a) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
(b) Microwave assisted ammonium Formate-mediated Knoevenagel reaction: panisaldehyde, ethyl cyanoacetate, ammonium formate.

6. Selection of renewable starting material rather than depleting, Illustrate with few examples such as biodiesel and polymers from renewable resources (such as green plastic). Preparation of biodiesel from waste cooking oil and characterization.

7. Importance of using catalytic reagents in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
(a) Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide
(b) Rearrangement of diazoaminobenzene to *p*-aminoazobenzene using K10 montmorillonite clay

8. Students should be asked to prepare a presentation/project based on any of the following topics:

- Bhopal Gas Tragedy and safer route to carbaryl synthesis
- Flixiborough accident and safer route to cyclohexanol
- Use of Surfactants for SC-CO2 for precision cleaning and dry cleaning of garments replacing PERC.
- A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards
- Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils.
- Synthesis of anti-tuberculosis drug Paramycin from waste water stream
- Synthesis of vitamin D3 using photochemical energy
- Greener Manufacturing of Sitagliptin Enabled by an Evolved Transaminase
- Microwave assisted solvent free synthesis of aspirin
- Synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G using biocatalyst.

REFERENCES:

Theory:

- Anastas, P.T., Warner, J.C. (2014), Green Chemistry, Theory and Practice, Oxford University Press.
- Lancaster, M. (2016), Green Chemistry: An Introductory Text, 3rd Edn., RSC Publishing.
- Cann, M.C., Connely, M. E. (2000), Real-World cases in Green Chemistry, American Chemical Society, Washington.
- Matlack, A.S. (2010), Introduction to Green Chemistry, 2nd Edn., CRC Press.
- Alhuwalia, V.K.; Kidwai, M.R. (2012), New Trends in Green chemistry, Kluwer Academic Publishers, Springer.
- Sidhwani, I.T; Sharma, R.K. (2020), An Introductory Text on Green Chemistry, Wiley India Pvt Ltd.
- Etzkorn, F. A . (2019), Green Chemistry: Principles and Case Studies, Royal Society of Chemistry.

Practical:

- Kirchoff, M., Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment, American Chemical Society, Washington DC.
- Sharma, R.K., Sidhwani, I.T., Chaudhari, M.K. (2013), Green Chemistry Experiments: A monograph, I.K. International Publishing House Pvt Ltd. New Delhi.
- Pavia, D.L., Lamponam, G.H., Kriz, G.S.W. (2006), Introduction to organic Laboratory Technique- A Microscale approach, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
- Sidhwani,I.T; Saini, G.; Chowdhury, S. Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. University of Delhi, Journal of Undergraduate Research and Innovation, Volume 1, Issue 1, February 2015, ISSN: 2395-2334.
- Sharma, R. K., Gulati, S., Mehta, S. (2012), Preparation of Gold Nanoparticles Using Tea: A Green Chemistry Experiment, Journal of Chemical Education, 89 (10), 1316-1318.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Power point presentation on important topics.
- Theory coupled with experiments in the lab.

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Waste production, Problem and prevention; Emerging green technologies, Green Catalysts, Green Solvents, Green Energy, Photo-oxidation technologies, Industry-academia collaboration, Circular economy

11.3.7. Course Code: ANALYTICAL CHEMISTRY (SEC-7) Course Title: INTELLECTUAL PROPERTY RIGHTS AND ACADEMIC ETHICS

Total Credits: 02 (Credits: Theory-01, Practical-01)
(Total Lectures: Theory- 15, Practical-30)

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

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

- Learn theoretical concepts of evolution of Intellectual Property Laws, and to differentiate between the different kinds of IP.
- Know the existing legal framework relating to Intellectual Property in India.
- Comprehend the value of IP and its importance in their respective domains.
- This course may motivate the students to make their career in multifaceted field of
- Intellectual Property Rights

Unit 1: Introduction
Basic concept of Intellectual Property, Rationale behind Intellectual Property, Justifications for protection of IP, Categories of IPR, Genesis and scope, WTO, TRIPS Agreement and WIPO.
(Lectures: 02)

Unit 2: Copyright and Related rights
Meaning of copyright and its relevance. Subject matter, term and conditions of copyright protection, rights of holders and related rights. Transfer, infringement and exceptions (fair use) of copyright.
(Lectures: 02)

Unit 3: Patents
Understanding patents and criteria for patentability, Patentable subject matter, Non patentable inventions, Term of patent and Rights of patentee. Procedure for obtaining a patent. Infringement of patents and remedies.
(Lectures: 03)

Unit 4: Trade Marks
Trademark and related marks (Service Mark, Certification Mark, Collective Mark), defining a good Trademark & its function, Criteria for protection. What can be protected as trademark? Term of protection, Infringement, Passing Off and Character Merchandising.
(Lectures:03)

Unit 5: Industrial Design and Geographical Indication

Meaning, concept and term of design protection**.** What can be protected as Industrial Designs?

Meaning of GI, need and term of protection. GI granted in India, GI vs Trademark.

(Lectures: 03)

Unit 6: Academic Ethics

Academic dishonesty and plagiarism: passing off, repetition of same research / academic work,

copying of assignment, projects, lab. reports, misrepresentation of academic credentials, submission of false data (fabrication & falsification).

(Lectures:02)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. To identify and discuss the various IPRs in materials of everyday life like a hand sanitizer, mobile phone, a text book, pH meter and an organic compound bottle.
2. Identifying active components of common medicines from details on strip/bottle and examining the patents associated with them.
3. Version Importance and usage of Traditional Knowledge Digital Library with common Indian medicinal plants.
4. Use and demonstration of plagiarism detection software.
5. Collection of pirated or counterfeited goods (or cases in news) in day to day life.
6. Collection of various types of trademarks from newspaper/internet.
7. Discussion on the character merchandising items collected by students
8. To prepare a presentation or a video on different topics of IPR and present them before the class.
9. Work on the following and prepare a report of a case related to these categories of IPR.
   a. Copyright infringement search
   b. Patent Search
   c. Trademark Search
   d. Geographical Indications
   e. Industrial Design
   f. IPR e – diary.

REFERENCES:

- Pandey, N.; Dhami, K. (2014), Intellectual Property Rights, PHI Learning Pvt. Ltd.
- Acharya, N.K. (2001), Text Book of Intellectual Property Rights, Asia Law House.
- Ganguli, P. (2001), Intellectual Property Rights: unleashing the knowledge economy. Tata McGraw Hill.

Additional Resources:

- https://www.wipo.int
- Ahuja, V.K. (2017), Law Relating to Intellectual Property Rights, Lexis Nexis.
- Wadehra, B.L. (2000), Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications. Universal law Publishing Pvt. Ltd..

- Journal of Intellectual Property Rights (JIPR); NISCAIR(CSIR).

Teaching Learning Process:

- Conventional chalk and board teaching,
- Power point presentation on important topics.

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Intellectual Property, IP Laws, Patents, Copyright, Trademark, Design, GI, WIPO.

11.3.8. Course Code: ANALYTICAL CHEMISTRY (SEC-8)
Course Title: LAB TESTING AND QUALITY ASSURANCE
Total Credits: 02 (Credits: Theory-01, Practical-01)
(Total Lectures: Theory- 15, Practical-30)

Objectives: The objective of this course is to introduce the concept of quality check and quality control in chemical industries.

Learning Outcomes:

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

- The role of quality control chemist
- Analytical and separation techniques
- Sample preparation
- Fundamentals of quality check
- Safety procedures

Unit 1: Introduction

Industry and sub-sectors, standards for manufacturing in life-sciences, drug regulatory agencies, role of quality control chemist, quality management systems.

(Lectures: 02)

Unit 2: Modern Analytical methods and separation techniques

Gravimetric methods, volumetric methods, electroanalytical methods, spectroscopic methods, chromatographic techniques.

(Lectures: 04)

Unit 3: Sample preparation

Basics of sample preparation, preservation and storage, standards and guidelines for sample handling, good storage practices

(Lectures: 02)

Unit 4: Quality check

Overview, productivity concept, statistical analysis of laboratory data, measurements, calibrations, validation, reference standards and materials, requirements of a calibration lab, fundamentals of advanced QC approaches, Trouble shooting in QC, documentation, audit/process related query, Quality certifications, Government regulations in industries like pharmaceuticals, food supplements, cosmetics.

Lectures: 5)

Unit 5: Concepts of safety

Basic concept of safety, process of safety analysis, managing emergency procedures and first Aid.

(Lectures: 2)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. Calibration of glassware
2. Weighing of samples, accuracy of measurements
3. Preparation of TLC plates and separation of amino acids
4. Working protocols of various laboratory instruments-oven, pH-meter, conductivity meter, water baths, muffle furnace, spectrophotometer.
5. Calibration of instruments like colorimeter, pH-meter, conductivity meter, spectrophotometer using reference standards or reference materials.

Suggested exercise: Visit some industries to study the validation of simple procedures.

References:

- Skoog D.A., West D.M., Holler, F.J., Crouch S.R.(2014) Fundamentals of Analytical Chemistry, 9th Edition, Cengage learning.
- Quality control chemist participant manual prepared by LSSSDC in collaboration with NSDC India.
- iso.org

Teaching Learning Process:

- Conventional chalk and board teaching,
- Hand-on practice on various formulations of cosmetic products
- Power point presentation on important topics.
- Focus on real life applications of concepts
- Problem solving and case studies

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Quality Control, Instrumental Analysis, Quality Check, Safety

11.3.9. Course Code: ANALYTICAL CHEMISTRY (SEC-9)
Course Title: ESSENTIAL FOOD NUTRIENTS
Total Credits: 02 (Credits: Theory-01, Practical-01)
(Total Lectures: Theory- 15, Practical-30)

Objectives: This introductory course on food chemistry is designed in such a manner that the students develop a basic understanding of the components of food, their source, properties and interactions as well as changes that occur during processing, storage, and utilization.

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

- Build a strong understanding of chemistry of foods: composition of food, role of each component
- Understand some of the reactions and changes in individual food components which occur during processing, handling and storage

Unit 1: Carbohydrates
Introduction, sources, functions, deficiencies, Structures of monosaccharides: Glucose, Fructose, lactose and galactose; Lactose, Maltose, Sucrose, Maltitol, concept of reducing and non-reducing sugars; Role of carbohydrates as sweeteners in food; Lactose intolerance, galactosemia, dental plaque, overview of carbohydrate metabolism.

(Lectures: 03)

Unit 2: Lipids
Introduction, Sources, Functions, Deficiencies, Classification (Fatty acids, phospholipids, Fats & Oils, Waxes), Common fatty acids present in oils and fats, Omega- 3,6,9 fatty acids, Trans fats, Chemical properties: Iodine value, Saponification value, Effect of frying on fats, Changes in fats and oils- Rancidity, Lipolysis, Flavour reversion, Auto-oxidation and its prevention.

(Lectures: 05)

Unit 3: Proteins
Introduction, Sources, Functions, Deficiencies, Protein structure (primary, secondary and tertiary), Physico-chemical & Functional properties of proteins, Food proteins: Animal and Plant proteins.

(Lectures: 05)

Unit IV: Vitamins & Minerals
Vitamins: Introduction, Classification: Vitamins Fat Soluble Vitamins & water-soluble vitamins.
Minerals: Introduction, Classification: Macrominerals (Ca, P, Mg) & Microminerals (Se, Fe, I, Co, Zn, Cu, Se, Cr).

Role of vitamins and minerals in Food chemistry.

(Lectures: 02)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of Iron in vitamin / dietary tablets.

3. Estimation of Vitamin C in a given solution/ Lemon juice/ Chilies by 2, 6 Dichlorophenol indophenol method.
4. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
5. Determination of saponification value of the given fat/oil.
6. Determination of iodine value of the given fat/oil.
7. Qualitative tests for proteins and carbohydrates.
8. Qualitative analysis of cholesterol by Liebermann Burchard method.

REFERENCES:

Theory

- deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), Principles of Food Chemistry, 4th Edition, Springer.
- Msagati, T.A.M. (2013), Chemistry of Food Additives and Preservatives, Wiley-Blackwell.
- Fennema, O.R. (2017), Food Chemistry, 5th Edition, CRC Press.
- Attokaran, M. (2017), Natural Food Flavors and Colorants, 2nd Ed., Wiley-Blackwell.
- Potter, N.N., Hotchkiss, J.H, (1995) Food Science, 5th Ed., Chapman & Hall.
- Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), Food Additives, 2nd Edition, CRC Press.
- Coultate, T. (2016), Food: The Chemistry of its Components, 6th Edn., Royal Society of Chemistry.
- Belitz, H. D.; Grosch, W. (2009), Food Chemistry, Springer.
- Course: FOOD CHEMISTRY (iasri.res.in)

Practical

- Ranganna, S. (2017). Handbook of analysis and quality control for fruits and vegetable products, 2nd Edn., McGraw Hill Education.
- Sawhney, S.K., Singh, R. (2001), Introductory Practical Biochemistry, Narosa Publishing House.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Hand-on practice on various formulations of cosmetic products
- Power point presentation on important topics.
- Theory coupled with preparation of cosmetic products in the lab.

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Food nutrients, Carbohydrates, Proteins, Lipids, Vitamins, Minerals, Browning reaction.

11.3.10. Course Code: ANALYTICAL CHEMISTRY(SEC-10)
Course Title: FOOD FLAVOURS AND COLOURANTS
Total Credits: 02 (Credits: Theory-01, Practical-01)
(Total Lectures: Theory- 15, Practical-30)

Objectives: The contents of this paper give an introduction to quality attributes of food such as appearance and flavour. It will provide the students with an understanding of the chemistry of the flavour as well as colour constituents of foods.

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

- Understand mechanisms of flavour perception
- Understand various mechanisms of flavour formation
- Be familiar with the chemical dimension of flavour.
- Recognize off-flavour defects in foods and strategies to control it.

Unit 1: Flavours

Introduction and importance of flavours in food Taste & Odour: Structure and physiology of taste organs- tongue, papillae, taste buds, salivary glands, Mechanism of taste and odour perception.

Basic Types of taste : Salty, Sweet, Bitter, Sour, Umami taste, Chemical dimensions of basic tastes (sweet, salt, sour, bitter and umami), odour and other sensations (like astringency, coolness, pungency/pungency), Non-nutritive and nutritive sweeteners (including structures of aspartame, saccharin, sucralose, Stevioside), Molecular Theory of Sweetness, Taste Inhibition and enhancement, Chemical dimension of Flavours (peppers, peppermint, coriander, cinnamon, onion), Chemistry of food flavourings: Maillard browning, enzymic browning reactions, caramelisation browning, Off-Flavour in Food (Rancidity in Fats/Oils, Non Enzymic Browning), Control of enzymic browning (acidulants, chelating agents, heat treatment etc.

(Lectures: 09)

Unit 2: Food Colours

Introduction, Importance, Classification: Natural food colourants (Anthocyanins, Carotenoids, Chlorophyll), Examples of Pigments in common food (turmeric, tomato, carrot, orange); Nature-identical colourants (β-Carotene, Canthaxanthin and Riboflavin); Artificial/synthetic colourants: Azo dyes (e.g. amaranth dye, tatrazine, citrous red); Quinoline (e.g. quinoline yellow); Phthalein (e.g. erythrosine); Triarylmethanes and indigoid (e.g. indigo carmine), FD&C Dyes and Lakes.

(Lectures: 06)

PRACTICALS (Credits: 01; Laboratory Periods: 30)

1. Determination of the taste threshold for the different sensations – sweet, salty, sour.
2. Extraction of limonene from orange peels using supercritical carbon dioxide.
3. Quantitative determination of food dyes in powdered drink mixes by spectrophotometric method.
4. Extraction and separation of pigments present in spinach by Thin Layer Chromatography (TLC).

5. Experiment to demonstrate the enzymic browning and its prevention.
6. Determination of rancidity of edible oils by Kriess Test.
7. Estimation of carotenoids in sample by colorimetric method.

REFERENCES:

Theory:

- deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), Principles of Food Chemistry, 4th Edition, Springer.
- Msagati, T.A.M. (2013), Chemistry of Food Additives and Preservatives, Wiley-Blackwell.
- Fennema, O.R. (2017), Food Chemistry, 5th Edition, CRC Press.
- Attokaran, M. (2017), Natural Food Flavors and Colorants, 2nd Ed., Wiley-Blackwell.
- Potter, N.N., Hotchkiss, J.H, (1995) Food Science, 5th Ed., Chapman & Hall.
- Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), Food Additives, 2nd Edition, CRC Press.
- Coultate, T. (2016), Food: The Chemistry of its Components, 6th Edn., Royal Society of Chemistry.
- Belitz, H. D.; Grosch, W. (2009), Food Chemistry, Springer.
- Course: FOOD CHEMISTRY (iasri.res.in)

Practical:

- Ranganna, S. (2017). Handbook of analysis and quality control for fruits and vegetable products, 2nd Edn., McGraw Hill Education.
- Sawhney, S.K., Singh, R. (2001), Introductory Practical Biochemistry, Narosa Publishing House.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Power point presentation on important topics.
- Visit to food flavours & colours industries/laboratories
- Activities related to food chemistry should be conducted in classroom

Assessment Methods:

- Internal assessment through continuous evaluation.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Flavours, Sweeteners, Browning reaction, Pigments, Dyes.

11.4. GENERIC ELECTIVES (GE)

NOTE: These are suggestive GE courses. A student may however choose any GE from the central pool of Chemistry/ Physics/ Mathematics.

11.4.1. Course Code: ANALYTICAL CHEMISTRY (GE-1)
Course Title: MEDICINES IN DAILY LIFE
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The course is designed to study the basic details about various medicines of general uses, which are crucial for the various diseases. This course also gives the knowledge of active pharmaceutical ingredient in some medicines, their synthesis; therapeutic effect and side effects on human physiology. Medicines are essential for a healthy day-to-day life and therefore this course will aware the students about its positive and negative effects.

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

- Understand the role of different medicines on human physiology.
- Gain the knowledge of active pharmaceutical ingredient and their roles in different disease.
- Learn the proper use of different medicines and their effect and side effects.
- Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.

Unit 1: General Introduction

Introduction-Health, disease, drugs, chemotherapy, approaches in drug designing, classification of drugs and their origin.

(Lectures: 08)

Unit 2: Different Class of Medicines

Structure of active ingredients, uses, dosage, side effects and their natural remedies.
Analgesics and antipyretics- Aspirin, Paracetamol, Ibuprofen, Morphine, Codeine

Antibiotics- Amoxicillin, Norfloxacin, Ciprofloxacin

Antihistamines or antiallergics- Cetrizine and Levocetrizine (role of stereoisomers)

Antiparasitic- Albendazole

Antidiabetics- Insulin, Glipizide and Metformin

Antihypertensive – Amlodipine and its natural remedies- Rauwolfia.

Diuretic- Lasix

Antidepressant-Zoloft and its natural treatment

Antifungal – Fluconazole, Itraconazole

Antacids- Ideal properties of antacids, combinations of antacids, Sodium 40 Bicarbonate, ranitidine, milk of magnesia, aluminium hydroxide gel

Anticoagulants/antiplatelet drugs- Warfarin, Heparin and Ecosprin

Anaesthetics- Introduction and types of anasthetics.

Poison and Antidote: Sodium thiosulphate, Activated charcoal, Sodium nitrite

Astringents: Zinc Sulphate, Potash Alum

Supplements- Zinc and Calcium, Vitamins

Synthesis of small molecule drugs like aspirin and paracetamol

(Lectures :22)

PRACTICALS (Credits 02; Laboratory Periods: 60)

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.
2. Identification test- Magnesium hydroxide, Sodium bicarbonate, Calcium gluconate.
3. Preparation of inorganic pharmaceuticals- Boric acid Potash alum
4. Determination of sugar in a given sample.
5. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose and Sucrose).
6. Identification tests for Proteins
7. Qualitative analysis of vitamin C.
8. Isolation of paracetamol (API) from tablet
9. Isolation of aspirin (API) from Tablet and recording of melting point (synthesis needs discussion)
10. Synthesis of Paracetamol and Aspirin.

REFERENCES:

Theory:

- Patrick, G. L. (2001) Introduction to Medicinal Chemistry Oxford University Press.
- Lemke, T. L. & William, D. A. (2002) Foye's Principles of Medicinal Chemistry, 5th Ed., USA,
- Singh H.; Kapoor V.K. (1996), Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan.
- G.R. Chatwal (2010) Pharmaceutical chemistry, inorganic (Vol. 1), Himalayan

publishing house
- https://go.drugbank.com./

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
- Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
- Shaik Munwar, Shaik Ammaji (2019) Comprehensive Practical Manual of Pharmaceutical Chemistry, Educreation Publishing.
- Prasenjit Mondal, Sumanta Mondal (2019) Handbook of Practical Pharmaceutical Organic, Inorganic and Medicinal chemistry by Educreation Publishing.

Teaching Learning Process

- Lecture in class rooms
- Peer learning
- Technology driven learning
- Learning through experiment in the practical classes

Assessment Methods

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and practical Examination

Keywords: Medicines, Active pharmaceutical ingredient, drug.

11.4.2. Course Code: ANALYTICAL CHEMISTRY (GE-2) Course Title: CHEMISTRY: STATISTICAL METHODS AND DATA ANALYSIS

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: In this course the students will be given insight about the statistical treatment on the chemical analysis data along with illustration about the analysis of collected analytical data to take up a job of technician, scientist and laboratory manager. The presentation of data in different form such as "Table, Graph, Bar Diagram, Pie Chart, Venn diagram" are explained along with their reliability and validity.

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

- Familiar with interpretation and use of analytical data collected by different techniques,
- Significance of different analytical techniques and their applications,
- Reliability and presentation of data for reporting to different forum.

Unit 1: Basics of Chemical Analysis
Analytical Chemistry, Qualitative and quantitative analysis, Analytical methodology. Calibration of glass wares, recording laboratory data.

(Lectures: 06)

Unit 2: Different Methods of Chemical Analysis
Titrimetric method: volumetric titrimetry, standard solution, titrimetric curve, calculation; Gravimetric method: precipitation gravimetry, calculation and applications of gravimetry; and Spectrometric methods: introduction, principle and instrument, working quantitative aspects absorbance, applications in chemical analysis

(Lectures: 06)

Unit 3: Statistical Method of Analysis
Accuracy and Precision, Comparison of precision, Errors, Distribution of random errors, propagation of errors, measurement of errors, significant figure, inter laboratory error, methods of least square analysis of variance, Q test, Z test, T test, statistical treatment of finite sample, recommendations for treating outliers. Minimising errors in analytical procedure.

(Lectures: 06)

Unit 4: Data Analysis and Validation

Confidence interval, Testing of hypothesis, plotting of data, least square method, Figures of merit: sensitivity, detection limit, linear dynamic range, control test, upper control limit and lower control limit, Validation, reporting analytical results and significant figures

(Lectures: 05)

Unit 5: Sampling, Standardization, Labeling and Calibration

Analytical samples, sample size, constituent sample, real samples, sample, sample handling, preparing laboratory samples, automated sample handling, lab on chip and General laboratory principles, recording laboratory data, standards, comparison of standards, internal standard, external standards calibration, least square method, and multivariant calibration.

(Lectures: 07)

PRACTICALS (Credits: 02; Laboratory periods: 60)

1. Demonstrate the good laboratory practices like effect of dilution, temperature, taking observation, personal and apparatus safety.
2. Determine the quantitative presence of heavy metals like copper, chromium and iron in natural and laboratory samples using volumetric and gravimetric titration.
3. Determine the presence of magnesium ion in heavy water by EDTA method and prepare calibration curve.
4. Evaluate the absolute and method errors in a set of data collected during determination

of nitrogen in an organic compound.

5. Calculate the standard deviation and predict precision of analytical results.
6. Determine the concentration of pollutant in natural sample after using external standards methods.
7. Compare the inter laboratory error of a spectroscopic results.
8. Evaluate the limit of detection for colorimetric analysis of dyes and coloured metals in wastes water samples.
9. Demonstrate the control of interference by masking by complexation.
10. Report the ten analytic results in significant numbers along with standard deviation.
11. Determine the confidence limit and interval for a laboratory instrument like breath alcohol analyser.
12. Demonstrate the internal standard method for calibration of metal estimation.
13. Estimate the comparative effectiveness of different types of graphs like line, pi chart and bar graph.
14. Demonstrate the working of lab on chip like glucose sensor.

REFERENCES:

- R A Dey and A L Underwood (1991) Quantitative Analysis, 6th Edition, Pearson.
- DA Skoog, DM west, F J Holler, S R Crouch (2014) Fundamental analytical chemistry, Thomson Asia Ltd. Undergraduate Programme in Chemistry (Hons)
- (2000) Encyclopaedia of analytical chemistry: Applications, Theory, and Instrumentation, R A Meyor (Eds) Wiley and Sons.

Teaching Learning Process:

• Student centered teaching Learning process.
• Blend of conventional blackboard teaching and modern teaching learning tools
• Focus on real life applications of concepts
• Problem solving and quizzes for enhanced understanding of the concepts
• Engaging students in collaborative learning.
• Pre-lab learning of theoretical concept of the experiment.
• Performing the experiment, recording the data, calculating the result.
• Interpreting the result.
• Comparing the results of the class.
• Discussing the sources of error.

Assessment Methods:

• Class Tests at Periodic Intervals.
• Written assignment(s)
• Continuous evaluation of laboratory work and record file.
• Oral assessment, quizzes.
• Mock practical examination.
• Semester end University examination.

Keywords: Error, Calibration, data analysis, titrimetry, gravimetric analysis, precision.

11.4.3. Course Code: ANALYTICAL CHEMISTRT (GE-3)
Course Title: ENERGY AND ENVIRONMENT
Total Credits: 04 (Credits: Theory-03, Practical-01)
(Total Lectures: Theory- 45, Practical-30)

Objectives: The objective of this paper is to develop basic understanding of energy, issues related to energy, importance of energy in terms of economy, health and the environment. To understand different sources of energies, renewable and non-renewable sources of energy. To understand the importance of green fuels. This course will help the students to understand the adverse effect of pollution, and possible remediations.

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

- Describe basic energy concepts
- Account for conventional and renewable energy technologies and their application
- Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change
- Reflect on energy costs, analyse the consequences of today's energy consumption
- Efficient use of energy, water and other resources, Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality, Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation

Unit 1: Introduction

Introduction, chemistry and energy, conversion of chemical energy to electrical energy, Carbon cycle, Greenhouse gases, Global warming and climate change, Carbon footprint, zero-carbon or low-carbon energy. Electrical energy and steam energy, Energy Alternatives, Hidden Costs of Energy.

(Lectures: 10)

Unit 2: Production

Production methods for electric power: Non-Renewable (conventional) sources of energy: Fossil fuels: Coal, petroleum and Natural gas. Energy transformation. Renewable energy sources: solar, hydropower, wind, geothermal, wave, ocean thermal, tidal, ocean currents, nuclear energy, biomass.

(Lectures: 13)

Unit 3: Green Energy

Production methods for electric power: Renewable (green) energy, conversion and storage systems. Nuclear fusion, Hydrogen fuels, photovoltaic solar cells, hydroelectric. Sustainable energy, biomass, Biofuels, production of biofuels, advantages, blending of biofuels with conventional fuels, Carbon Capture and Reuse, Waste to Energy Technologies.

(Lectures: 12)

Unit 4: Air Pollution

Air Pollution, Urban and Indoor Air Pollution, Pollution and waste reduction measures, chemical remediation of air pollution. Effect of pollution on health and economy.

(Lectures:10)

PRACTICALS (Credits: 01; Laboratory Periods:30)

1. Conversion of biomass to biofuels (2-3 different biofuels)
2. Working on solar cell model.
3. Working on wind turbine model.
4. Working on geothermal energy model.
5. Working on hydroelectric plant model.
6. Presentations by students

REFERENCES:

Theory

- C.S. Rao (2015) Environment pollution control Engineering New Age International reprint, 2nd edition
- Bharucha, E. (2005) Textbook of Environmental Studies, Universities Press.
- Wright, R.T. (2008) Environmental Science-Towards a sustainable Future, Prentice Hall 9th edition.
- Ahluwalia, V. K. (2019) Energy and Environment, The Energy and Resources Institute (TERI).

Practicals

- Challapalli Narayan Rao (2022) Practical approach to implementation of Renewable Energy Systems, Evincepub Publishing,

TEACHING LEARNING PROCESS:

Student centric teaching approach must be followed. Questions and answers, both should come from students. Different ways of teaching include classical board teaching method, visual conceptual method, application based practical demonstration of the concept etc. are required in this course. In fact, the pedagogy is to make a class interesting and thus learning becomes enjoyable.

ASSESSMENT METHODS:

Assessment can be in form of Graded assignments, conventional class tests, class seminars and presentations by students on course topics with a view to strengthening the content through width and depth, end semester university examination for theory and practical.

Keywords: Energy, Renewable and non-renewable energy resources, Synthetic fuels, Biofuels, Carbon footprint, air pollution, remediation, pollution related health and economy.

11.4.4. Course Code: ANALYTICAL CHEMISTRY (GE-4)
Course Title: CHEMISTRY AND SOCIETY
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The course is designed to expand the literacy of chemistry among the non-chemistry student even arts as well as commerce with objective increase general awareness, background of chemistry and its importance. This paper will be helpful for a common student to understand the importance and role of chemistry in development of civilization, societal issues related to chemistry and their expected solutions.

Learning Outcomes:

At the end of this course the student will be able to:

- Increase the literacy of chemistry even in non-science students
- Understand the basic concept, principle and importance of chemistry
- Realize the importance of chemistry in daily life and future requirement.

Unit 1: Basics of Chemistry

Periodic table, Atom and molecules, chemical bonding, properties and chemical reactions with simple examples and illustration.

(Lectures: 04)

Unit 2: Chemistry in Heritage

Extraction and uses of metals like iron and stone in ancient times, metals in ornaments, medicines, weapons and chemistry for preservatives, basics of preservation and few examples of preservatives.

(Lectures: 08)

Unit 3: Chemistry in Life

Edible and non- edible molecules, biochemistry of foods and medicine with examples: Aspirin, Paracetamol. Ibuprofen and Penicillin, Cephalosporin, Chemistry for industry: Artificial sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics: Uses and environmental issues.

(Lectures: 08)

Unit 4: Chemical Pollution and Toxicity

Chemical source of water, air and soil pollution, biomagnification and metal toxicity with example and illustrations. monitoring of air pollution.

(Lectures: 04)

Unit 5: Testing of Chemicals

Flame test, solubility test, qualitative and quantitative identification of ions in natural samples like metal copper, iron and chromium ores and adulterant in foods.

(Lectures: 04)

Unit 6: Future of Chemistry

Basics of green chemistry, Reuse and recycling of by-products, zero waste chemistry and Alternate fuel and energy providing chemicals: biodiesel, natural gas and hydrogen.

(Lectures: 02)

PRACTICAL/HANDS-ON TRAINING: (Credits: 02; Laboratory Periods: 60)

1. Determine the organic contents and pH of milk and curd with and without additives.
2. Estimate the food adulterants in edible items.
3. Quantify the presence of metals by flame test.
4. Demonstrate the conversion of PET bottle into value added products.
5. Determine the quantitative presence of heavy metals like copper and chromium in natural sample like ore.
6. Demonstrate the exothermic and endothermic reaction in laboratory. .
7. Preparation aspirin and paracetamol and its identification using different spectroscopic techniques.
8. Compare the fuel efficiency of biodiesel and petrol.
9. Preparation of compounds using microwave
10. Demonstrate the biodegradability of natural and synthetic plastics.
11. Demonstrate the protection of rusting of iron after surface spray coating.
12. Estimate the protein contents in edible samples using chemical methods.
13. Small working project on heritage chemistry like bio compatibility of metals and medicinal importance of metals like iron, gold and silver.

REFERENCES:

- J D Lee (2021) Concise Inorganic Chemistry, Wiley India Pvt. Ltd.
- B K Sharma (2014) Industrial chemistry, Goel Publishing House, India
- Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2020) Analytical chemistry, Wiley.
- V. Subramanian (2020) A Text Book of Environmental Chemistry, Wiley.

TEACHING LEARNING PROCESS:

• Hands-on laboratory exercises
• Conventional teaching learning method. Engaging students in collaborative Learning

ASSESSMENT METHODS:

• Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.
• Presentation on lab practices.
• Semester end examination.

Keywords: Fundamental of chemistry, Chemistry for advancement in society, Chemistry and industry, Sustainable future of chemistry.

11.4.5. Course Code: ANALYTICAL CHEMISTRY (GE-5)
Course Title: BIOINORGANIC CHEMISTRY
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The purpose of the course is to introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and biology. The student would learn about the importance of inorganic chemical species, especially metals, in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

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

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

Unit 1: Introduction

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels, pumps.

(Lectures:06)

Unit 2: Role of Metals in Biological Systems

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

(Lectures: 08)

Unit 3: Role of Iron in Biological Systems

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism, Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

(Lectures: 08)

Unit 4: Bio-Inorganic Chemistry

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes

(Lectures: 08)

PRACTICALS (Credits: 02; Laboratory Periods: 60)

1. Preparation of Nickel-DMF complex and its estimation.
2. Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
3. Estimation of Mg^{2+}
4. Estimation of Ca^{2+} by substitution method
5. To estimate the concentration of Ca in commercially available medicines.
6. To estimate the Mg present in multivitamins (Take at least two types of Vitamin Tablets from market).
7. Isolation of Chlorophyll from plant leaves and its purification.
8. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
9. Separation of Fe(III) and Al(III) using chromatographic techniques.
10. Estimation of copper as CuSCN.

REFERENCES:

Theory:

- Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
- Shriver, D.D.; Atkins, P.; Langford, C.H. (1994) Inorganic Chemistry 2nd Ed., Oxford University Press.
- Cotton, F.A.; Wilkinson, G.; Gaus, P.L. (2021) Basic Inorganic Chemistry, 3rd Edition, Wiley India.
- Crichton, R.R. (2008), Biological Inorganic Chemistry: An Introduction. Amsterdam, Elsevier.
- Kaim, W., B. Schwederski and A. Klein. (2014), Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide. 2nd Edition, Wiley.

Practicals:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Additional Resources:

- Lippard, S.J.; Berg, J.M.(1994), Principles of Bioinorganic Chemistry, Panima Publishing Company.
- Greenwood, N.N.; Earnshaw, A. (1997), Chemistry of the Elements, 2nd Edition, Elsevier

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Bioinorganic chemistry; Sodium potassium pump; chlorophyll, ATP, Haemoglobin, myoglobin, ferritin, transferrin, toxicity, heavy metal ions, antidotes.

11.4.6. Course Code: ANALYTICAL CHEMISTRY (GE-6)
Course Title: ROLE OF METALS IN MEDICINES
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:
To make the learners familiar about role of metal ions in some commercially available medicines.

Learning Outcomes:
By the end of this course student will be able to learn:
• Role of metal ions in various biomolecules and their functions.
• Role of metals in commercially available medicines and their functions

Unit 1: Role of Metals in Biological Systems
Brief introduction of following metals in biological system Fe, Cu, Zn, Mn, Cr(III), V, Mo, W, Co, Ni, Na, K, Mg and Ca Chemical structure, Commercial name, Name of the disease it is made for and its brief mechanism of action shall be taught for all the mentioned metals below.

(Lectures: 04)

Unit 2: Diagnostic and Therapeutic Agents
Diagnostic and therapeutic agents with Pt (Cisplatin) and Ga for cancer, Au (auranofin) for arthritis and V(Vanadium) for diabetes.

(Lectures: 08)

Unit 3: Metals in Drugs
Li_2CO_3 (Camcolit) for manic-depressive illness, $NaHCO_3$ (Alka-seltzer) for heartburn, $Al(OH)_3$ (Gaviscon) for heartburn, As (melarsoprol) for sleeping sickness, Bi subsalicylate (pepto-Bismol) for heartburn and diarrhoea, Bi subcitrate (De-nol) peptic ulcer, Zinc oxide with Fe_2O_3 (Calamine lotion) as antimicrobial agent.

(Lectures:06)

Unit 4: Metals in Multivitamins

Cyanocobalamin (Co), Ferrous fumerate (Fe), Magnesium oxide (Mg), Zinc Sulfate (Zn), Manganese sulphate (Mn), Copper Sulfate (Cu), Sodium selenite (Se) and Chromiumtrichloride (Cr).

(Lectures:06)

Unit 5: Radiopharmaceuticals and MRI Contrast Agents

99mTc for heart, brain and bone imaging, 123I radiopharmaceuticals, BaSO4for X-ray contrast agent, Fe and Gd (III) as MRI contrast agents.

(Lectures:06)

PRACTICAL/Hands-on Training (Credits: 02; Laboratory periods: 60)

1. To estimate the acidity of commercially available antacids.
2. To estimate the concentration of Fe in commercially available medicines.
3. To estimate the concentration of Ca in commercially available medicines.
4. To estimate the strength of carbonate in tablets containing Li_2CO_3
5. To estimate the sodium bicarbonate in synthetic/commercially available drug.
6. To estimate the Zinc and Iron present in Calamine lotion.
7. To estimate the Mg present in multivitamins.
8. To estimate the Zn present in Multivitamins
9. Estimation of Vitamin C in commercially available tablets.

REFERENCES:

- (2009) Metals in Medicine, John Wiley & Sons Ltd, Nov
- Stephen J. Lippard (2020) Chapter-9, Metals in Medicine.
- Chris Jones and John Thornback (2007) Medicinal applications of coordination chemistry, Cambridge, UK: Royal Society of Chemistry,

Teaching Learning Process:

- Hands-on laboratory exercises
- Conventional teaching learning method. Engaging students in collaborative Learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.
- Presentation on lab practices.
- Semester end examination

Keywords: Metals, Drugs, Multivitamins, Diagnostic Agents, Radiopharmaceuticals

11.4.7. Course Code: ANALYTICAL CHEMISTRY (GE-7)
Course Title: STATES OF MATTER
Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives: The students will learn about the properties of ideal and real gases deviation from ideal behaviour, properties of liquid, types of solids with details about crystal structure.

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

- Derive ideal gas law from kinetic theory of gases and explain why the real gases deviate from ideal behaviour.
- Explain Maxwell-Boltzmann distribution, critical constants and viscosity of gases.
- Explain the properties of liquids especially surface tension and viscosity.
- Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl

Unit 1: Kinetic Theory of Gases

Postulates of kinetic theory of gases and derivation of the kinetic gas equation, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals equation of state for real gases. Boyle temperature (derivation not required), critical phenomena, critical constants and their calculation from van der Waals equation, Andrews isotherms of CO_2, Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions, most probable, average and root mean square velocities (no derivation), collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules, viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(Lectures:13)

Unit 2: Liquid State

Surface tension and its determination using stalagmometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents.

(Lectures:05)

Unit 3: Solid State

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography - law of constancy of interfacial angles. Law of rational indices, Miller indices. X–ray diffraction by crystals, Bragg's law and powder XRD. Powder diffraction patterns of NaCl, CsCl and KCl (qualitative treatment only), defects in crystals. Glasses and liquid crystals.

(Lectures:12)

PRACTICALS (Credits 02; Laboratory Periods:60)

1. Surface tension measurement (use of organic solvents excluded):
   Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
2. Viscosity measurement (use of organic solvents excluded):
   i. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
   ii. Study of the variation of viscosity of an aqueous solution with concentration of solute.

3. Solid State: Powder XRD
   i. Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
   ii. Carry out analysis of a given set of pXRD and determine the type of the cubic crystal structure
   iii. Determination of approximate crystal size from a given set of p-XRD

REFERENCES:

Theory:

- Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkin's Inorganic Chemistry, Oxford.
- Miessler, G. L.; Tarr, D.A. (2014), Inorganic Chemistry, Pearson.
- Castellan, G. W. (2004), Physical Chemistry, Narosa.
- Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol.1, 6th Edition, McGraw Hill Education.
- Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol.5, 3rd Edition, McGraw Hill Education.

Practicals

- Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),Senior Practical Physical Chemistry, R. Chand & Co

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Ideal/real gases, Surface tension, Viscosity, Crystal systems, Powder-XRD.

11.4.8. Course Code: ANALYTICAL CHEMISTRY (GE-8) Course Title: FRAGRANCES AND FLAVOURS: AN INDUSTRY'S PERSPECTIVE

Total Credits: 04 (Credits: Theory-02, Practical-02)
(Total Lectures: Theory- 30, Practical-60)

Objectives:

The use of fragrance is ubiquitous and is a global human phenomenon. Over thecourse of time, countless numbers of flavours and fragrances have found their way into everyday life, notably into foods, beverages and confectionery items; into personal care products (soaps, toothpastes, mouthwashes, deodorants, bath lotions and shampoos), perfumes, and other cosmetics as well as pharmaceutical formulations. Indeed, flavours and aromas are added to make such products more attractive or to mask the taste or smell of less pleasant ones. There is need to understand the applications of chemistry in the world of flavours and fragrances.

Learning Outcomes:

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

- Synthesis of various fragrance and flavour ingredients
- Formulation methods, how different factors affects the formulation process in Fragrance and Flavour industry
- Uphold safety regulation and execute quality processes
- Quality control in manufacturing process, legal aspects, classification of odour andodorants.
- Different methods used for separation, purification and isolation of perfumes and flavours like distillation, extraction, crystallization, etc.

UNIT 1: Fragrances

Introduction to fragrances, types of fragrances (Fragrance families and classification)
History of perfumes, Perfumery raw materials, classification of odour, its types, and odorants. India in the context of Fragrance Industry.
ABCs of perfumery, odour aspects of perfumes, fragrance pyramid, fragrance families, Some basic chemical knowledge to provide a better understanding of the structure of molecules possessing a sensory power, The volatility and solubility of sensory molecules.
Chemistry of aromatic compounds in perfume making, Composition of fragrances Current trends in fragrances, sensory analysis of different products, Study of the raw materials used in perfumery (origin, extraction method, and olfaction), Key chemical reactions for conversion of raw materials to fragrances. Extraction of essential oils used in perfumery.
Difference between alcohol and oil-based perfumes, Outline of health, safety and sustainability parameters in perfumer.

(Lectures: 18)

Unit 2: Sustainable fragrance by design

The challenges of sustainability and how it impacts the industry, Sustainability charter, Green chemistry principles, Commitment to Biodiversity

(Lecture: 04)

Unit 3: Flavours

Introduction to flavours, types of flavours, flavour raw materials,

Understanding of terms like, Flavour and Flavouring agents. Attributes of flavour, taste,odour, odour stimulation, basic tastes and the human olfactory system.
Stability of flavour in food, sensory evaluation of flavours in foods, Various flavour formulation, systematic approach to understanding flavour formation during food processing, food matrix, interaction of added flavours, Flavour enhancers, modifiers, precursors, suppressors, solvents, Key chemical reactions for conversion of raw materials to flavours, Forms of flavour and the manufacturing processes involving all types of flavours.Aroma recovery during processing. Biogenesis of flavours in fruits and vegetables, reaction flavours, off flavours. Selection and application of flavours in foods and beverages
Legal aspects (natural flavours and natural flavouring substances, nature identical flavouring substances, artificial flavouring substances), and the FSSAI act.

(Lectures: 18)

Unit 4: Extraction, isolation and purification of perfumes and flavour compounds

Extraction techniques for the separation of volatile oils from natural source- including. Distillation, Evaporation, Crystallization and Adsorption, supercritical fluid extraction methods of isolation of important ingredients.

(Lecture: 05)

PRACTICALS: (Credits: 02; Laboratory Periods:60)

1. Extraction of D-limonene from orange peel using liquid CO_2.
2. Extraction of caffeine from coffee beans using liquid CO_2.
3. Extraction of essential oils from lemon using steam distillation
4. Extraction of essential oils from lemon using liquid CO_2.
5. Extraction of essential oils from fragrant flowers.
6. Determination of esters by Thin Layer Chromatography
7. Memorisation of different raw materials used in perfumery, perfume language, Memorisation of perfumes
8. Testing up of different flavours
9. Analysis of spectra of perfume formulations.

REFERENCES:

- Arctander, S.,(2008) Perfume and flavour materials of Natural origin, Allured Publishing Corporation, USA
- Arctander, S.,(2017), Volume I and II, Perfume and Flavour Chemicals, (Aroma Chemicals), Allured Publishing Corporation, USA
- Curtis,T.; Williams, D. C.,(2001) 2nd Edition, An Introduction to Perfumery, MicellePress, USA.

- Sell, C., (2008), Understanding Fragrance Chemistry Allured Publishing Corporation, USA.
- Calkin, R.R.; Jellinek, J.S. (1994) Perfumery: Practice and Principles, John Wiley & Sons Inc.
- Gimelli, S.P., (2001), Aroma Science, Micelle Press, USA.
- Arctander, S.,(2019), Perfume and Flavour Materials of Natural Origin, OrchardInnovations.
  https://www.beyondbenign.org/lessons/essential-oil-extraction-using-liquid-co2/

Teaching Learning Process:

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

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment (s) / Presentation by individual students
- End semester University Theory and Practical Examination

Keywords: Flavours, odours, Fragrance Industry, FSSAI Act.

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