SCHEME AND SYLLABUS

FOR

Learning Outcomes based Curriculum Framework

(LOCF)

For

B. Sc. Chemistry Honours (Revised)

DEPARTMENT OF CHEMISTRY

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (CG)

To be implemented from 2021-22 (Revised)

Semester wise Theory Papers and Practical

B.Sc. Hon's (Chemistry): LOCF 2021-2022

Department of Chemistry, School of Physical Sciences

Course Opted	Course Code	Name of the course	Credit	Hour/ week	Internal Assess	End Sem Exam
Semester I						
CC-I Theory	**CYUATT1**	Inorganic Chemistry-I	3	3	30	70
CC-I Practical	**CYUALT1**	Inorganic Chemistry Practical-I	2	4	30	70
CC-II Theory	**CYUATT2**	Organic Chemistry-I	3	3	30	70
CC-II Practical	**CYUALT2**	Organic Chemistry Practical-I	2	4	30	70
AEC-I Theory	**CYUATA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-I Theory	**CYUATL1**	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-I Theory	**CYUATG1**	1A Physics-I, 1B Mathematics-I, 1C Zoology-I 1D Botany-1, 1EAnthropology-1, 1F Biotechnology-1, 1G Forensic Science-1	3	3	30	70
GEC-I Practical	**CYUALG1**	Generic Elective- Practical-I	2	4	30	70
Additional Credit Course I	**CYUATC1**	Select one from the Pool of Value added Courses offered				
		TOTAL	**19**	**25**	**240**	**560**
Semester II						
CC-III Theory	**CYUBTT1**	Physical Chemistry-I	3	3	30	70
CC-III Practical	**CYUBLT1**	Physical Chemistry Practical-I	2	4	30	70
CC-IV Theory	**CYUBTT2**	Organic Chemistry-II	3	3	30	70
CC-IV Practical	**CYUBLT2**	Organic Chemistry Practical-II	2	4	30	70
AEC-II Theory	**CYUBTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-II Theory	**CYUBTL1**	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-II Theory	**CYUBTG1**	2A Physics-I, 2B Mathematics-I, 2C Zoology-I 2D Botany-1, 2EAnthropology-1, 2F Biotechnology-1, 2G Forensic Science-1	3	3	30	70
GEC-II Practical	**CYUBLG1**	Generic Elective- Practical-II	2	4	30	70
Additional Credit Course II	**CYUBTC1**	Select one from the Pool of Value added Courses offered				
		Total	**19**	**25**	**240**	**560**
Semester III						
CC-V Theory	**CYUCTT1**	Physical Chemistry-II	3	3	30	70
CC-V Practical	**CYUCLT1**	Physical Chemistry Practical-II	2	4	30	70
CC-VI Theory	**CYUCTT2**	Organic Chemistry-III	3	3	30	70
CC-VI Practical	**CYUCLT2**	Organic Chemistry Practical-III	2	4	30	70
CC-VII Theory	**CYUCTT3**	Molecular Spectroscopy & Photochemistry	3	3	30	70
CC-VII Practical	**CYUCLT3**	Spectroscopy Practical	2	4	30	70
AEC-III Theory	**CYUCTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-III Theory	**CYUCTG1**	3A Physics-I, 3B Mathematics-I, 3C Zoology-I 3D Botany-1, 3EAnthropology-1, 3F Biotechnology-1, 3G Forensic Science-1	3	3	30	70
GEC-III Practical	**CYUCLG1**	Generic Elective- Practical-III	2	4	30	70
Additional Credit Course III	**CYUCTC1**	Select one from the Pool of Value added Courses offered				
		Total	**22**	**30**	**270**	**630**
Semester IV						
CC-VIII Theory	**CYUDTT1**	Physical Chemistry-III	3	3	30	70
CC-VIII Practical	**CYUDLT1**	Physical Chemistry practical-III	2	4	30	70
CC-IX Theory	**CYUDTT2**	Inorganic Chemistry-II	3	3	30	70
CC-IX Practical	**CYUDLT2**	Inorganic Chemistry practical-II	2	4	30	70
CC-X Theory	**CYUDTT3**	Introduction to Quantum Chemistry	3	3	30	70
CC-X Practical	**CYUDLT3**	QuantumChemistry Practical	2	4	30	70

AEC-IV Theory	**CYUDTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-IV Theory	**CYUDTG1**	4A Physics-I, 4B Mathematics-I, 4C Zoology-I 4D Botany-1, 4EAnthropology-1, 4F Biotechnology-1, 4G Forensic Science-1	3	3	30	70
GEC-IV Practical	**CYUDLG1**	Generic Elective- Practical-IV	2	4	30	70
Additional Credit Course IV	**CYUDTC1**	Select one from the Pool of Value added Courses offered				
		Total	**22**	**30**	**270**	**630**
Summer Internship*	**CYUDLF1**		6*	90	30	70
		Semester V				
CC-XI Theory	**CYUETT1**	Inorganic Chemistry-III	3	3	30	70
CC-XI Practical	**CYUELT1**	Inorganic Chemistry Practical-III	2	4	30	70
CC-XII Theory	**CYUETT2**	Analytical Chemistry	3	3	30	70
CC-XII Practical	**CYUELT2**	Analytical Chemistry Practical	2	4	30	70
AEC-V Theory	**CYUETA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
DSE-I Theory	**CYUETD1**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-I Practical	**CYUELD1**	Select one from the Pool of DSE Courses offered	2	4	30	70
DSE-II Theory	**CYUETD2**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-II Practical	**CYUELD2**	Select one from the Pool of DSE Courses offered	2	4	30	70
Additional Credit Course V	**CYUETC1**	Select one from the Pool of Value added Courses offered				
		TOTAL	**22**	**30**	**270**	**630**
		Semester VI				
CC-XIII Theory	**CYUFTT1**	Green Chemistry	3	3	30	70
CC-XIII Practical	**CYUFLT1**	Green Chemistry Practical	2	4	30	70
CC-XIV Theory	**CYUFTT2**	Materials Chemistry	3	3	30	70
CC-XIV Practical	**CYUFLT2**	Materials Chemistry Practical	2	4	30	70
DSE-III Theory	**CYUFTD1**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-III Practical	**CYUFLD1**	Select one from the Pool of DSE Courses offered	2	4	30	70
Seminar	**CYUFSS1**	Followed by report submission and seminar	2	4	30	70
Dissertation/Project	**CYUFL**	Followed by report submission, presentation and Viva-Voce.	7	14	30	70
Additional Credit Course VI	**CYUFTC1**	Select one from the Pool of Value added Courses offered				
		MOOC's**				
			2-5	2-5		
		TOTAL	**24**	**34**	**240**	**560**
TOTAL CREDITS AND MARKS			**134**			

As per UGC LOCF guidelines, University / departments have liberty to offer GEC and SEC courses offered by any department to students of other departments.

The No. of GE course is four. One GEC course is compulsory in first 4 semesters each. In present scheme it is proposed to have minimum two GEC courses (from one subject) in first twosemester after which student shallchange twoGEC for another subject in III[rd] and IV[th] semester, so that all the student can have exposure of one additional subject.

* May be offered during summer. Summer Internship: duration will be 2-4 weeks (minimum 90 working hours).

** MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

Abbreviations:

CC= Course code; AEC= Ability Enhancement Course;
GEC= Generic Elective Course; SEC= Skill Enhancement Course;
DSE= Discipline Specific Elective Course.

CHEMISTRY-DSE I-IV (ELECTIVES) (CREDIT: 05 EACH)

1. Medicinal Chemistry
2. Electrochemistry
3. Polymer Chemistry
4. Environmental Chemistry
5. Advanced Material Chemistry
6. Advanced Analytical Chemistry
7. Nuclear & Radiation Chemistry
8. Organic Spectroscopy
9. Heterocyclic Chemistry
10. Biochemistry
11. Organometallics and Bioinorganic Chemistry
12. Introduction to Nanochemistry & Applications

SKILL ENHANCEMENT COURSE (ANY FOUR) (CREDIT: 02 EACH)

1. Science Communication andPopularization
2. Biofertilizer
3. Personality Development
4. Computer Applications in Chemistry
5. Herbal Science & Technology
6. Fermentation Science & Technology
7. Environment Impact Analysis
8. IT Skill for Chemist
9. IPR and business skill for chemist
10. Analytical Clinical Biochemistry
11. Mushroom Culture Technology

ABILITY ENHANCEMENT COURSE (AEC) offered by Department of Chemistry (CREDIT: 02 EACH)

1. Chemistry in Everyday life
2. History of Indian Science
3. English for communication
4. Intellectual Property Rights
5. Good Laboratory Practices
6. Introduction to Forensic Science &
7. Technology
8. Renewable Energies (Solar & Biogas)
9. Cheminformatics
10. Water remediation and conservation studies
11. Research methodology
12. Chemistry of food, nutrition and preservation

VALUE ADDED COURSES (Optional)

1. Fuel Chemistry (Course Coordinator- Dr. S. S. Thakur and Prof. G. K. Patra)
2. Cosmetic Formulation (Course Coordinator- Dr. S. Banerjee)
3. Polymer Chemistry (Course Coordinator- Dr. A. Srivastava)
4. Eco-Friendly Lubricants – Chemistry And Application (Course Coordinator- Dr. B. L. Sahu and Dr. B. Mondal)
5. Efficient Technologies for Food Processing and Shelf Life Extension (Course Coordinator- Dr. Niraj Kumari and Dr. A. Srivastva)

NAME OF THE GENERIC ELECTIVE OFFERED BY DEPARTMENT OF CHEMISTRY (CREDIT: 05)

SEMESTER-I

GE Theory-I: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons

GE PRACTICAL – I

SEMESTER-II

GE Theory-II: Kinetic Theory of Gases, Chemical Energetics, Equilibria & Functional Group Organic Chemistry

GE PRACTICAL – II

SEMESTER-III

GE Theory-III: Solid, Solutions, Phase Equilibrium & Chemical kinetics, Conductance, Periodic Properties and Chemistry of s-, p-, and d- block elements

GE PRACTICAL – III

SEMESTER-IV

GE Theory-IV: Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life

GE PRACTICAL - IV

Prof. C. R. Sinha
(External Expert)

Dr. V. K. Rai
(Member)

Dr. A. K. Singh
(Member)

Prof. G. K. Patra
(Member)

Dr. S. S. Thakur
(HOD)

1. Introduction

Chemistry is referred to as the science that systematically studies the composition, properties, and reactivity of matter at atomic and molecular levels. The scope of chemistry is very broad. The key areas of study of chemistry comprise Organic chemistry, Inorganic Chemistry, Physical Chemistry and Analytical Chemistry. Organic chemistry deals with study of substances containing carbon mostly, whereas inorganic chemistry deals with study of all other elements/compounds/substances and their chemical properties. Physical chemistry deals with applications of concepts, laws to chemical phenomena. Analytical chemistry, in general, deals with identification and quantification of materials. Development of new interdisciplinary subjects like nano-materials, biomaterials, etc., and their applications from chemistry point of view added new dimension to materials chemistry. Thus, the degree programme in chemistry also intended to cover overlapping areas of chemistry with physics, biology, environmental sciences. Further, a broad range of subjects such as materials chemistry, biomaterials, nanomaterials, environmental chemistry, etc., has also been introduced which can be helpful for students/faculty members to broaden the scope of their studies and hence applications from job prospective point of view. Therefore, as a part of efforts to enhance employability of graduates of chemistry, the curricula also include learning experiences with industries and research laboratories as interns. In addition, industrial visits/industrial projects are encouraged and added to the curriculum to enhance better exposure to jobs/employment opportunities in industries, scientific projects and allied sectors.

This modified syllabus has been drafted to enable the students to equip for national-level competitive exams that they may attempt in the future. To ensure implementation of a holistic pedagogical model, several allied disciplines are covered/introduced in this framework, including Physics, Mathematics, Biology and some generic, and ability enhancement electives. In addition, employability of B.Sc. Chemistry graduate is given due importance such that their core competency in the subject matter, both theoretical and practical, is ensured. To expand the employability of graduates, several skill development courses are also introduced in this framework.

2. About the department

The Department of Chemistry was established in 2009 as a new Science Department to provide quality education in the conventional areas of Science and grow into a center for

teaching and research with an aim to acquire prominent position in the academic map of India. The Department offers both UG and PG level advanced courses in Chemical Sciences along with an integrated 5 years Master programme with exit option after completing 3 years B. Sc. (Hon's). The Department is also offering a Ph. D. programme in different areas in Chemistry. There are four major specializations offered in M. Sc. such as Physical Chemistry, Inorganic Chemistry, Analytical Chemistry and Organic Chemistry. The students are monitored and evaluated by regular class tests, seminars, assignments, mid and end-semester examinations. The Department already has fifteen regular faculties [Professor (01) Associate Professor (03) and Assistant Professor (11)].

The department has two laboratories possessing necessary chemicals, reagents, glassware, lab wares and basic instruments for performing experiments in physical, inorganic, organic and analytical chemistry, in general, and synthesis, analysis (qualitative and quantitative) and characterization of different inorganic and organic compounds in more particulars.

The departmental has its own library in addition to central library of the University. Sufficient number of books is available in departmental library to fulfill the requirement of the faculty members and students. A number of reference books and access to online journals are also available in the Central Library.

Over the period, the Department has been nurtured under the able guidance of Prof J S Dangi and Prof G K Patra. The soul of the department is their teachers headed by Dr. Santosh Singh Thakur, The faculty members are specialized in frontier areas of Chemical Sciences and have excellent expertise in their own field. The faculty members of the department have significantly contributed to the scientific world through scientific and research publications and have received many distinguished national and international awards and fellowships such as JSPS Postdoctoral Fellowships, ORISE, USA Postdoctoral fellowship, NSC, Taiwan postdoctoral fellowship, BK21 and KOSEF postdoctoral fellowship, South Korea, DST – Inspire faculty fellowship, National Postdoctoral fellowship, DS Kothari Postdoctoral fellowship etc. Department has got several research projects from funding agencies DST, UGC, CSIR, CGCOST etc. during past 12 years. Department has produced good number of publications in reputed national and international journals. Faculty members of the department are on the editorial boards of some journals and are referees for both national and

international journals. Recognizing the research outcome, the Department has received special financial assistance under DST-FIST phase I. This has helped the Department in establishing a number of modern, sophisticated instruments.Department has also organized Several National as well as International Seminar/Symposium on various areas of Chemical Sciences. We are proud that our collective enthusiasm is continuously generating a good number of bright students.

3. Learning Outcome Based Curriculum planning:

Curriculum is the heart of any educational system. It can be focused either to achieve the objectives of each course of the programme or on the expected learning outcomes from each course. The objective-based curriculum refers to the overall targets to be achieved through the curriculum which may be long-term or immediate. On the other hand, the learning outcome based curriculum is very specific in nature in terms of changes in the cognitive, affective and psychomotor behavior of the students as a result of their exposure to the curriculum. The outcome-based curriculum provides the teacher very specific targets which he can achieve through the selected instructional process as compared to the objective-based curriculum which provides general outcomes. The learning outcome-based curriculum has very close relationship with the learning of the students whereas the objective-based curriculum focuses on only providing knowledge to the students. In other words, higher cognitive skills are developed through learning outcome-based curriculum. Hence, it is preferred to develop learning outcome-based curriculum which will provide specific directions to the teacher concerning the transaction process and expected changes in the behavior of the students as well

4.Learning outcomes-based curriculum framework for B.Sc. Chemistry(Honours)

a) Attributes of a ChemistryGraduate

Attributes of chemistry graduates under the outcome-based teaching-learning framework may encompass the following:

- **Core competency:** The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry. These fundamental concepts would reflect the latest understanding of the field, and therefore, are dynamic in nature and require frequent and time-boundrevisions.
- **Communication skills:** Chemistry graduates are expected to possess minimum standards of communication skills expected of a science graduate in the country. They are expected to read and understand documents with in-depth analyses and logical arguments. Graduates are expected to be well-versed in speaking and communicating their idea/finding/concepts to wideraudience

- **Critical thinking:** Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientificarguments.
- **Psychological skills:** Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels. Psychological skills may include feedback loops, self-compassion, self-reflection, goal-setting, interpersonal relationships, and emotionalmanagement.
- **Problem-solving:** Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across thedisciplines;
- **Analytical reasoning:** Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoningetc.
- **Research-skills:** Graduates are expected to be keenly observant about what is going on in the natural surroundings to awaken their curiosity. Graduates are expected to design a scientific experiment through statistical hypothesis testing and other *a priori* reasoning including logicaldeduction.
- **Teamwork:** Graduates are expected to be team players, with productive co- operations involving members from diverse socio-culturalbackgrounds.
- **Digital Literacy:** Graduates are expected to be digitally literate for them to enroll and increase their core competency via e-learning resources such as MOOC and other digital tools for lifelong learning. Graduates should be able to spot data fabrication and fake news by applying rational skepticism and analytical reasoning.
- **Moral and ethical awareness:** Graduates are expected to be responsible citizens of India and be aware of moral and ethical baseline of the country and the world. They are expected to define their core ethical virtues good enough to distinguish what is construed as illegal and crime in Indian constitution. Emphasis is given on academic and research ethics, including fair Benefit Sharing, Plagiarism, Scientific Misconduct and soon.
- **Leadership readiness:** Graduates are expected to be familiar with decision-making process and basic managerial skills to become better leader. Skills may include defining objective vision and mission, how to become a charismatic inspiring leader and soon.

b) QualificationDescriptors for B.Sc. Chemistry(Honour)

The qualification descriptors for a Bachelor's degree in Chemistry (Honours) may include following:

(i). Systematic and fundamental understanding of chemistry as a discipline.

(ii). Skill and related developments for acquiring specialization in the subject.

(iii). Identifying chemistry-related problems, analysis and application of data using appropriate methodologies.

(iv). Applying subject knowledge and skill to solve complex problems with defined solutions.

(v). Finding the opportunity to apply subject-related skills for acquiring jobs and self-employment.

(vi). Understanding new frontiers of knowledge in chemistry for

professionaldevelopment.

(vii). Applying subject knowledge for solving societal problems related to application of chemistry in day-to-day life.

(ix). Applying subject knowledge for sustainable environment-friendly green initiatives.

(x). Applying subject knowledge for new research and technology.

5. TYPES OF COURSES

5.1. Core Course:

A course, which is to be studied compulsorily by a candidate as a core requirement is termed as a Core Course. The credits for the core courses will be 5. The distribution of credits is as per Table 1 of clause 7.10.

5.2. Elective Course:

Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables exposure to some other discipline/subject / domain or nurtures the candidate's proficiency/skill is called an Elective Course. The distribution of credits is as per Table 1 of clause 7.6.

5.2.1. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. These courses will be offered to the students of the same department in which they have been admitted. These courses may be interdisciplinary. The credit for each core course will be 5.

5.2.2. Generic Elective (GE) Course: An elective course chosen generally from other disciplines/subject offered by sister departments, to seek additional exposure of the subject, is called a Generic Elective. A core course offered in a discipline/subject may be treated as an elective by another discipline/subject and vice versa and such electives may also be referred to as Generic Elective. The credit for each Generic course will be 5.

5.2.3. Ability Enhancement Courses (AEC): The Ability Enhancement Courses are the courses based upon the content that leads to Knowledge enhancement. The credit for each AEC course will be 2. There will be five AEC courses in each Honors Program out of which one course on Environmental Science, one on English Language/ Hindi Communication. The other three courses will be selected by the students from the pool of AEC courses, as notified by the University.

5.2.4. Skill Enhancement Courses (SEC): SEC courses are skill-based courses, which are aimed to provide hands-ontraining, competencies, skills etc. These courses may be chosen from a pool of SEC courses, as notified by the University. There will be two SEC courses in each Honors Program. The credit for each SEC course will be 2.

5.3 Project work / Dissertationis considered as a special course involving the application of knowledge in solving/analyzing/exploring a real-life situation / difficult problem. A Project/Dissertation work would be of 7 credits. These courses are designed to acquire special/advanced knowledge, such as supplement study/support study to project work, and a candidate studies such a course on his own with advisory support by a faculty member. Project work / Dissertation submission will be followed by a presentation and Viva-voce.

5.4 Seminar: Seminar will be conducted by the faculty members of the department in which a student has to defend/present a topic allotted to him/her by the course coordinator. Every student has to present minimum of 2 presentations. The seminar classes will preferably be conducted for 2 hours during a working day in a week.

5.5 Internship: An internship is a professional learning experience that offers meaningful, practical work related to a student's field of study or career interest. An internship gives a student the opportunity for career exploration and development, and to learn new skills. It offers the employer the opportunity to bring new ideas and energy into the workplace, develop talent and potentially build a pipeline for future full-time employees.

An internship consists of

- a part-time work schedule that includes a part of written documentation as the report.
- Provides a clear project description for the work experience related to a specific field.
- Orients the student to the organization, its culture and proposed work assignment(s), etc for professional courses.
- Helps the student develop and achieve learning goals.

The internship may include Project Work, Subject-specific skill course, Internship, summer internship, Visits to field sites, Excursions, Industrial Visits, Industrial training, Research activities, and any other as may be required for specific degree programs on practical grounds.

The credits for the internship will be 4-6 for BA/BSc/BCom/other basic degree programs.

The technical and professional degree programs may opt for internship or apprenticeship in full

semester with 24 credits.

5.6 Additional Credit courses: University Additional Credit Electives (UACE), Value Added Courses (VAC), Certificate courses (CC), Online Certificate Courses (OCC), and others as notified by the University from time to time. The credits for such courses will be 2 – 4 as notified by the university. A separate regulation for these courses is designed by the university.

5.7. The Board of Studies of each department will decide the course structure and syllabus for a specific program and update in the information in Table 3.

5.8. The minimum credits for the award of Undergraduate degree program in BA/BSc/BCom will be 133. The maximum credits for such programs should not exceed 150.

5.9. An undergraduate degree with Honors in a discipline will be awarded the following course structure as per the UGC guidelines

- 14 Core Courses
- 04 Generic Elective Courses (GE)
- 03 Discipline Specific Elective (DSE) Courses
- 05 Ability Enhancement Courses (AEC)
- 02 Skill Enhancement Courses (SEC)
- 01 Dissertation / Project
- 01 Seminar
- 01 Internship
- Additional Credit Courses (as notified by the University)
- Online MOOC's Courses (As per UGC/University guidelines)

5.10. The credits of the courses are given in the following tables:

Table 1: Credit Distribution

Courses	**Credits**
	Theory + Practical
Core Courses (14 courses)	(3 + 2) x 14 = 70
Generic Elective (4 courses)	(3 + 2) x 4 = 20
Discipline Specific Elective (3 courses)	(3 + 2) x 3 = 15
Ability Enhancement Course (5 Courses)	(2+0) x 5 = 10
Skill Enhancement Course (2 Courses)	(2+0) x 2 = 4
Dissertation (1 Course)	7
Seminar (1 Course)	2
Internship (1 Course)	6
Additional Credit Courses (Optional)	(As per UGC/University guidelines and notification)
MOOC's Courses**	(As per UGC/University guidelines) 2-5
Total	**134**

Table 2: Structure of Courses

Semester	Core Courses (14)	GE (4)	DSE (4*)	AEC (5)	SEC (2)	Seminar (1)	Dissertation (1)	Internship (1)	Additional Credit Courses (Optional)
I	C1 C2	GE1		AEC1	SEC1				
II	C3 C4	GE2		AEC2	SEC2				
III	C5 C6 C7	GE3		AEC3					
IV	C8 C9 C10	GE4		AEC4					
V	C11 C12		DSE1 DSE2	AEC5					
VI	C13 C14		DSE3			Seminar	Dissertation		
Summer								Internship	
MOOC's**									

* May be offered during summer. Summer Internship: duration will be 2-4 weeks (minimum 90 working hours).

** MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

Credit Distribution and Structure of the Courses: B .Sc.Chemistry (Honors)

Semester	**Core Courses (CC)**	**Ability Enhancement Courses (AEC)**	**Skill Enhancement Courses (SEC)**	**Discipline Specific Elective (DSE)**	**Generic Elective Course (GEC)**		**Credit hour load**
1	**CC-I CC-II**	**AEC-1**	**SEC-1**	**-**	**GEC-1**		**19**
2	**CC-III CC-IV**	**AEC-2**	**SEC-2**	**-**	**GEC-2**		**19**
3	**CC-V CC-VI CC-VII**	**AEC-3**	**-**	**-**	**GEC-3**		**22**

4	**CC-VIII CC-IX CC-X**	**AEC-4**	**-**	**-**	**GEC-4**	**Internship* (6 credit)**	**22+6**
5	**CC-XI CC-XII**	**AEC-5**		**DSE-1 DSE-2**	**-**		**22**
6	**CC-XIII CC-XIV**			**DSE-3**	**-**	**Seminar (02 credits); Dissertation/ Project (7 credits)**	**24**
MOOCs**							
Credits	**42 (T) +28 (P)=70**	**10**	**4**	**9(T) + 6 (P)=15**	**12(T)+ 8(P)=20**	**6+2+6=15**	**134**
% Course	**52.24**	**7.46**	**2.99**	**11.19**	**14.93**	**11.19**	**100**

* May be offer during summer

** MOOC's courses may be offered at least one time during entire UG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to the subject is not available on MOOC's platform, department may continue with regular courses..

Courses Structure

1. Core Courses (CC)

Sr.No.	Name of the course	L	P	Credits
CC 1	Inorganic Chemistry-I	3	0	**3**
	Inorganic Chemistry Practical	0	2	**2**
CC 2	Organic Chemistry-I	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 3	Physical Chemistry-I	3	0	**3**
	Physical Chemistry Practical	0	2	**2**
CC 4	Organic Chemistry-II	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 5	Physical Chemistry-II	3	0	**3**
	Physical Chemistry Practical	0	2	**2**
CC 6	Organic Chemistry-III	3	0	**3**
	Organic Chemistry Practical	0	2	**2**
CC 7	Molecular Spectroscopy &Photochemistry	3	0	**3**
	Spectroscopy practicals	0	2	**2**
CC 8	Physical Chemistry-III	3	0	**3**
	Physical Chemisry practical	0	2	**2**
CC 9	Inorganic Chemistry-II	3	0	**3**
	Inorganic Chemistry practical	0	2	**2**
CC 10	Introduction to Quantum Chemistry	3	0	**3**
	Chemistry Practical	0	2	**2**
CC 11	Inorganic Chemistry-III	3	0	**3**
	Inorganic Chemistry practical	0	2	**2**
CC 12	Analytical Chemistry	3	0	**3**
	Analytical chemistry practical	0	2	**2**
CC 13	Green Chemistry	3	0	**3**
	Green chemistry practical	0	2	**2**
CC 14	Chemistry of Materials	3	0	**3**
	Chemistry of Materials practical	0	2	**2**

2. Discipline Specific Elective (DSE)Course (Any three of the followings)

Sr No	Name of the course	L	P	Credits
1	Medicinal Chemitry	3	2	**5**
2	Electrochemistry	3	2	**5**
3	Polymer Chemistry	3	2	**5**
4	Environmental Chemistry	3	2	**5**
5	Advanced Materials Chemistry	3	2	**5**
6	Advaned Analytical Chemistry	3	2	**5**
7	Nuclear & Radiation Chemistry	3	2	**5**
8	Organic spectroscopy	3	2	**5**
9	Heterocyclic chemistry	3	2	**5**
10	Biochemistry	3	2	**5**
11	Organometallics and Bioinorganic chemistry	3	2	**5**
12	Introduction to Nanochemistry & applications	3	2	**5**

3. Generic Elective Courses (GEC) (for PCM & PCB combination)

Sr. No.	Name of the course	L	P	Credits
1	Mathematics-I:Mathematical methods in Chemistry	5	0	**5**
2	Life Science/Biology-I	3	2	**5**
3	Physics-I	3	2	**5**
4	Mathematics-II	5	0	**5**
5	Biology/Life Science-II	3	2	**5**
6	Physics-II	3	2	**5**

4. Generic Elective Courses (offered by Department of Chemistry, GGV for other departments)

Sr. No.	Name of the course	L	P	Credits
1	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	3	2	**5**
2	Kinetic Theory of Gases, Chemical Energetics, Equilibria & Functional Group Organic Chemistry	3	2	**5**
3	Solid, Solutions, Phase Equilibrium & Chemical kinetics, Conductance, Periodic Properties and Chemistry of s-, p-, and d- block elements	3	2	**5**
4	Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life	3	2	**5**

5. Ability Enhancement Courses (Any five of the followings)

Sr. No.	Name of the course	L	Credits
1	English for communication	2	2
2	Intellectual Property Rights	2	2
3	History of Indian Science	2	2
4	Good Laboratory Practices	2	2
5	Introduction to Forensic Science & Technology	2	2
6	Renewable Energies (Solar & Biogas)	2	2
7	Cheminformatics	2	2
8	Water remediation and conservation studies	2	2
9	Research methodology	2	2
10	Chemistry in Everyday life	2	2
11	Chemistry of food, nutrtion and preservation	2	2

6. **Skill Enhancement Courses (Any two of the followings)**

Sr. No.	Name of the course	L/ P	T	P	Credits
1	Personality Development	2	0	0	**2**
2	Computer Applications in Chemistry	2	0	0	**2**
3	Science Communication and Popularization	2	0	0	**2**
4	Biofertilizer	2	0	0	**2**
5	Herbal Science & Technology	2	0	0	**2**
6	Fermentation Science & Technology	2	0	0	**2**
7	Environment Impact Analysis	2	0	0	**2**
8	IT Skill for Chemist	2	0	0	**2**
9	IPR and business skill for chemist	2	0	0	**2**
10	Analytical Clinical Biochemistry	2	0	0	**2**
11	Mushroom Culture Technology	2	0	0	**2**

7. Additional Credit Courses (Optional)or **Value Added Courses**

S. N.	Name	Course Coordinator	L	P	Credit
1.	Fuel Chemistry	Dr. S. S. Thakur and Prof. G. K. Patra	1	1	2
2.	Polymer Chemistry	Dr. A. Srivastava	1	1	2
3.	Cosmetic Formulation	Dr. S. Banerjee	1	1	2
4.	Efficient Technologies for Food Processing and Shelf Life Extension	Dr. Niraj Kumari and Dr. A. Srivastva	1	1	2
5.	Eco-Friendly Lubricants-Chemistry And Application	Dr. Bharat Lal Sahu (Assistant Professor) Dr. Bijnaneswar Mondal (Assistant Professor)	1	1	2

CORE COURSES

Semester	Course	Name of the course	Credits
I	CC 1	Inorganic Chemistry-I	Theory 3
			Practical: 2

Learning objective:

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

- Develop an understanding on atomic theory, concept of wavefunction.
- Elements in periodic table; physical and chemical characteristics,periodicity.
- To predict the atomic structure, chemical bonding, and molecular geometry based on acceptedmodels.
- To understand atomic theory of matter, composition ofatom.
- Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form differentatoms.
- Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodictable.
- Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
- Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- Importance of hydrogen bonding, metallicbonding.

Inorganic Chemistry-I (Theory)

Unit I: Atomic Structure **10 Lectures**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $\psi 2$. Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit II: Periodicity of Elements **10 Lectures**

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and*p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective

nuclear charge in periodic table.

(b) Atomic radii (van'derWaals)

(c) Ionic and crystalradii.

(d) Covalent radii (octahedral andtetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionizationenthalpy.

(f) Electron gain enthalpy, trends of electron gainenthalpy.

(g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron densityratio.

Unit III: Chemical Bonding **14 Lectures**

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvationenergy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Ionic character from dipole moment andelectronegativities.

UNIT IV: Metallic bonding and Weak chemical forces **6 Lectures**

(iii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors,Insulators.

(iv) *Weak Chemical Forces:* vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility,dissolution.

Recommended Books/References:

1. Lee, J. D. *Concise Inorganic Chemistry,* Wiley, 5thEd^{n}.
2. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley &Sons,1999.
3. Atkins, P. W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.
4. Rodger, G. E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Inorganic Chemistry-I (Practical)

(A) TitrimetricAnalysis

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality oftitrants.

(iii) Use of primary and secondary standardsolutions.

(B) Acid-BaseTitrations

(i) Estimation of carbonate and hydroxide present together inmixture.

(ii) Estimation of carbonate and bicarbonate present together in amixture.

(iii) Estimation of free alkali present in differentsoaps/detergents

(C) Oxidation-ReductionTitrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$solution.

(ii) Estimation of oxalic acid and sodium oxalate in a givenmixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and externalindicator.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.

2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Semester	Course	Name of the course	Credits
I	CC 2	Organic Chemistry-I	Theory:3
			Practical: 2

Learning objectives:

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

- Basic of organic molecules, structure, bonding, reactivity and reactionmechanisms.
- Stereochemistry of organic molecules – conformation and configuration, asymmetricmolecules andnomenclature.
- Aromatic compounds and aromaticity, mechanism of aromaticreactions.
- Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.
- Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
- Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*.elimination.

OrganicChemistry-I (Theory)

UNIT I: Basics of Organic Chemistry **10 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric,resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II: Stereochemistry **6 Lectures**

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans andsyn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

UNIT III: Chemistry of Aliphatic Hydrocarbons **18 Lectures**

A. Carbon-Carbon sigmabonds

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

B. Carbon-Carbonpi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions.Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4- addition reactions in

conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilicadditions.

C. Cycloalkanes and ConformationalAnalysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

UNIT IV: Aromatic Hydrocarbons **6 Lectures**

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

Recommended Books/References:

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

Organic Chemistry-I (Practical)

1. Checking the calibration of thethermometer.
2. Purification of organic compounds by crystallization using the followingsolvents:

   a.Water b. Alcohol c. Alcohol-Water
3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting pointapparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillarymethod)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paper Separation of a mixture of two sugars by ascending paperchromatography
   b. Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography(TLC).
   c. chromatography

Recommended Books/Reference:

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

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
II	CC 3	Physical Chemistry-I	Theory:3
			Practical: 2

Learning objective:

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

- Familiarization with various states ofmatter.
- Physical properties of each state of matter and laws related to describe thestates.
- Calculation of latticeparameters.
- Electrolytes and electrolytic dissociation, salt hydrolysis and acid-baseequilibria.
- Understanding Kinetic model of gas and itsproperties.
- Maxwell distribution, mean-free path, kineticenergies.
- Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of correspondingstates.
- Liquid state and its physical properties related to temperature and pressurevariation.
- Properties of liquid as solvent for various household and commercialuse.
- Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simplesalts.
- Ionic equilibria – electrolyte, ionization,dissociation.
- Salt hydrolysis (acid-base hydrolysis) and its application inchemistry.

Physical Chemistry-I (Theory)

UNIT I: Gaseous state **12 Lectures**

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

UNIT II: Liquid state **5 Lectures**

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT III: Ionic equilibria **13 Lectures**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of

ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-proticacids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts.Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubilityproduct.

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations.Multistage equilibria in polyelectrolytes.

UNIT IV: Solid state **10 Lectures**

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

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India(2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa(2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw Hill (Fifth Edition)(2007)

Physical Chemistry-I (Practical)

1. **Surface tensionmeasurements.**
   a. Determine the surface tension by (i) drop number (ii) drop weightmethod.
   b. Study the variation of surface tension of detergent solutions withconcentration.
2. **Viscosity measurements using Ostwald'sviscometer.**
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at roomtemperature.
   b. Viscosity of sucrose solution with the concentration ofsolute.
3. **pH metry**
   a. Effect on pH of addition of HCl/NaOH to solutions of aceticacid,sodium acetate and their mixtures.
   b. Preparation of buffer solutions of differentpH
      i. Sodium acetate-aceticacid
      ii. Ammonium chloride-ammoniumhydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strongbase.
   d. Determination of dissociation constant of a weakacid.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York(2003).
3 Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).
4 Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Semester	Course	Name of the course	Credits
II	CC 4	Organic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Familiarization about classes of organic compounds and their methods ofpreparation.
- Basic uses of reactionmechanisms.
- Name reactions, uses of various reagents and the mechanism of theiraction.
- Preparation and uses of various classes of organiccompounds.
- Organometallic compounds and theiruses.
- Organic chemistry reactions and reactionmechanisms.
- Use of reagents in various organic transformationreactions.

OrganicChemistry-II (Theory)

UNIT I: Chemistry of Halogenated Hydrocarbons **8 Lectures**

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_N^i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li and their use in synthesis.

UNIT II: Alcohols, Phenols, Ethers and Epoxides **6Lectures**

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

UNIT III: Carbonyl Compounds **10 Lectures**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT IV: Carboxylic Acids and their Derivatives **10 Lectures**

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

UNIT V: Sulphur containing compounds **6 Lectures**

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:

1 Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc(2009).

2 McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013. 3 P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, NewDelhi.

4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India,2003.

OrganicChemistry-II (Practical)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic preparations:
   i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistryapproach)
   ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumannreaction.
   iii. Oxidation of ethanol/ isopropanol (Iodoformreaction).
   iv. Bromination (anyone)
      a. Acetanilide by conventionalmethods
      b. Acetanilide using green approach (Bromate-bromidemethod)
   v. Nitration: (anyone)
      a. Acetanilide/nitrobenzene by conventionalmethod
      b. Salicylic acid by green approach (using ceric ammoniumnitrate).
   vi. Selective reduction of *meta*dinitrobenzene to*m*-nitroaniline.
   vii. Reduction of *p*-nitrobenzaldehyde by sodiumborohydride.
   viii. Hydrolysis of amides andesters.
   ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
   x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid,

oxalic acid, phenyl acetic acid and phthalicacid).

xi. Aldol condensation with either conventional or greenmethod.

xii. Benzil-Benzilic acidrearrangement.

Collected solid samples may be used for recrystallization, melting point and TLC.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1 Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)

2 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson(2012)

3 Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press(2000)

4 Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

Semester	Course	Name of the course	Credits
III	CC 5	Physical Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Laws of thermodynamics andconcepts.
- Partial molar quantities and itsattributes.
- Understanding the concept of system, variables, heat, work, and laws ofthermodynamics.
- Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy,etc.
- Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law ofthermodynamics.
- Understanding the application of thermodynamics: Joule Thompson effects, partial molar quantities.
- Understanding theories/thermodynamics of dilutesolutions.

Physical Chemistry-II (Theory)

UNIT-I: Introduction to thermodynamics **6 Lectures**

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.*First law:* Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabaticconditions.

UNIT II: Thermochemistry **6 Lectures**

Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

UNIT III: Second Law **6 Lectures**

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy.Calculation of entropy change for reversible and irreversible processes.

UNIT IV: Third law of thermodynamics **4 Lectures**

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

UNIT V: Free Energy Functions **6 Lectures**

Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation ofstate.

UNIT VI: Partial molar quantities **6 Lectures**

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

UNIT VII: Dilute solutions **6 Lectures**

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

Recommended Books/References

1 Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.

2 Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.

3 Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall,2012.

4 McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

6 *Commonly Asked Questions in Thermodynamics.* CRC Press,2011.

7 Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010. 8 Metz, C.R. *2000 solved problems in chemistry,* Schaum Series,2006.

Physical Chemistry-II (Practical)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities onit.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) I_2 (aq)+I^-→I_3^-(aq)
   (ii) Cu^{2+}(aq) + $n$$NH_3$ →$Cu(NH_3)_n$
3. Study the kinetics of the followingreactions.
   a. Acid hydrolysis of methyl acetate with hydrochloricacid.
   b. Saponification of ethylacetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

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

Semester	Course	Name of the course	Credits
III	CC 6	Organic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Nitrogen containing functional groups and theirreactions.
- Familiarization with polynuclear hydrocarbons and theirreactions.
- Heterocyclic compounds and theirreactions.
- Alkaloids andTerpenes
- Understanding reactions and reaction mechanism of nitrogen containing functional groups.
- Understanding the reactions and mechanisms of diazoniumcompounds.
- Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.
- Understanding the structure, mechanism of reactions of selected heterocycliccompounds.
- Classification, structure, mechanism of reactions of few selected alkaloids andterpenes.

OrganicChemistry-III (Theory)

UNIT I: Nitrogen Containing Functional Groups **8 Lectures**

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

UNIT II: Polynuclear Hydrocarbons **8 Lectures**

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.**UNIT III:Heterocyclic Compounds** **12 Lectures**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT IV: Alkaloids **6 Lectures**

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of

Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT V: Terpenes **6 Lectures**

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

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7thEdn., Pearson.
2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons (1976).
3. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc(2009).
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
5. Kalsi, P. S. *Organic reacations and their mechanisms*, New Age Science(2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press Inc., New York(2001).
7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).
9. Clayden J., Greeves N., Warren S., Organic Chemistry, (2nd Ed)., (2012), Oxford University Press.

OrganicChemistry-III (Practical)

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols,etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy
3. Preparation of methylorange.
4. Extraction of caffeine from tealeaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple labprocedures.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

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

Qualitative Analysis, University Press(2000).

Semester	Course	Name of the course	Credits
III	CC 7	Molecular Spectroscopy & Photochemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Interaction between radiation and molecules at various energy levels.
- About various type of spectroscopic techniques.
- Characterization of molecules using various spectroscopic techniques.
- Law of Photochemistry, quantum yield and Franck-Condon Principle.
- About photochemical reaction, Fluorescence and Phosphorescence.

Molecular Spectroscopy &Photochemistry (Theory)

Unit-I **15 Lectures**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Unit-II **10 Lectures**

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

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Unit-III **15 Lectures**

Photophysical and photochemical processes: laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. kinetics of photochemical reactions ($H_2 + Br_2 = HBr$, $2HI = H_2 + I_2$), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and itsapplications).

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*University Science Books,1998
4. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age (revised second

edition).

5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi(2006).

Molecular Spectroscopy &Photochemistry (Practical)

(i) Determination of indicator constant-colorimetry.

(ii) Verification of Beer's Law - Determination of concentration of solution by colorimetry.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/reference books:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.

Semester	Course	Name of the course	Credits
IV	CC 8	Physical Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion the course, the learner shall be able to understand:

- Phases, components, Gibbs phase rule, Phase diagrams andapplications.
- Chemical kinetics: type of reactions, determination of rate, theories of reaction rate, steady stateapproximation.
- Catalyst – mechanism, acid base catalysis, enzymecatalysis.
- Adsorptionisotherms.
- Understanding phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phasediagram.
- Understanding the basics of chemical kinetics: determination of order, molecularity, and understanding theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.
- Catalyst – mechanism of catalytic action, enzymecatalysis.
- Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory andsignificance.

PhysicalChemistry-III (Theory)

UNIT-I: Phase Equilibria **10 Lectures**

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 with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water- chloroform-acetic acid system, triangular plots.*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics **10 Lectures**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III: Catalysis **10 Lectures**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts.Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT-IV: Surface chemistry **10 Lectures**

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press, 2014.
2 Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa,2004.
3 McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books,2004.
4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition,Prentice-Hall,2012.
5 Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011
6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.
7 Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.
8 Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.
9 Metz, C. R. *Physical Chemistry 2nd Ed.,* Tata McGraw-Hill,2009.

PhysicalChemistry-III (Practical)

Conductometry

1 Determination of cellconstant

2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3 Conductometric titrations of: (i) Strong acid Vs. strong base, (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and weak acid vs. strong base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base, (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base, (iv) Potassium dichromate vs. Mohr'ssalt.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommend books/References:

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

Semester	Course	Name of the course	Credits
IV	CC 9	Inorganic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Oxidation-Reductions and their use inmetallurgy.
- Chemistry of s and p-blockelements.
- Chemistry of noblegases.
- Inorganic polymers and theiruse.
- Understanding redox reactions in hydrometallurgyprocesses.
- Structure, bonding of s and p block materials and theiroxides/compounds.
- Understanding chemistry of boron compounds and theirstructures.
- Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure andbonding.
- Understanding chemistry of inorganic polymers, their structures anduses.

Inorganic Chemistry-II (Theory)

UNIT-I: Oxidation-Reduction and general principle of metallurgy **8 Lectures**

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel- de Boer process and Mond's process, Zonerefining.

UNIT-II: Chemistry of *s* and *p* Block Elements **16 Lectures**

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation.Complex formation tendency of *s* and *p* block elements.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate andnitrate.

Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly-halide ions, pseudo-halogens, properties of halogens.

UNIT-III: Noble Gases **8 Lectures**

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

UNIT-IV: Inorganic Polymers **8 Lectures**

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes.Borazines, silicates and phosphazenes, and polysulphates.

Recommended books/references:

1 Lee, J.D. *Concise Inorganic Chemistry*, ELBS,1991.

2 Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y.1994.

3 Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.

4 Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH,1999.

5 Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

6 Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010

7 Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Inorganic Chemistry-II (Practical)

(A) Iodo / IodimetricTitrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution(Iodimetrically).

(ii) Estimation of (i) arsenite and (ii) antimonyiodimetrically

(iii) Estimation of available chlorine in bleaching powderiodometrically.

(B) Inorganicpreparations

(i) Cuprous Chloride,Cu_2Cl_2

(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chromealum.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/references:

Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* Sixth Edition Pearson, 2009.

Semester	Course	Name of the course	Credits
IV	CC 10	Introduction to Quantum Chemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Basics of Quantum Chemistry
- Basic idea about operators, Schrodinger equation and its applications.
- Use of Schrodinger equation in simple harmonic oscillator model, hydrogen atom and hydrogen like atoms.
- Quantum mechanical approach towards valence bond and molecular orbital theory.

Introduction to QuantumChemistry (Theory)

Unit-I **15 Lectures**

Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals.

Unit-II **15 Lectures**

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions.Rigid rotator model and discussion of application of Schrodinger equation.idea about transformation to spherical polar coordinate, discussion on solution.

Unit-III **10 Lectures**

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H_2^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations.

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,* UniversityScience Books, 1998.
4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill(2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA(2004).

Introduction to QuantumChemistry (Practical)

i. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.

ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans*2-butene.

iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules. (Software: ChemSketch, ArgusLab(www.planaria-software.com),TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similarsoftware.

- Determination of indicator constant -colorimetry.
- Verification of Beer's Law - Determination of concentration of solution bycolorimetry.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/reference books:

1. Essentials of computational chemistry – Theories and models, C. J. Crammer, Wiley, 2nd Edn., 2.Principle and applications of quantum chemistry, V.K.Gupta, Elsevier, 2016.
3. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
4. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.
5. A.R. Leach, *Molecular Modelling Principles and Application*, Longman,2001.
6. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons,1997.
7. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers,2008.

Semester	Course	Name of the course	Credits
V	CC 11	Inorganic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes, chelate.
- Transition metals, its stability, color, oxidation states andcomplexes.
- Lanthanides, Actinides – separation, color, spectra and magneticbehavior
- Bioinorganic chemistry – metal ions in biological system, its toxicity;hemoglobin.
- Understanding the nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects.
- Understanding the transition metals stability in reactions, origin of colour and magnetic properties.
- Understanding the separation of Lanthanoids and Actinoids, its color, spectra and magneticbehavior.
- Understanding the bioinorganic chemistry of metals in biologicalsystems.
- Hemoglobin and its importance in biologicalsystems.

Inorganic Chemistry-III (Theory)

UNIT-I: Coordination Chemistry **10 Lectures**

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbitalsplitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelateeffect,

UNIT-II: Transition Elements **10 Lectures**

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

UNIT-III: Lanthanoids and Actinides **10 Lectures**

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide

contraction, separation of lanthanides (ion-exchange method only).

UNIT-IV: Bioinorganic Chemistry **10 Lectures**

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

Recommended text books/References:

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

Inorganic Chemistry-III (Practical)

1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed:

   Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-,Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.
2. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
3. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λ_{max} of the prepared complex usinginstrument).
4. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitutionmethod.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education,2002.
2. Marr & Rockett *Practical Inorganic Chemistry.* John Wiley & Sons1972.

Semester	Course	Name of the course	Credits
V	CC 12	Analytical Chemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the student shall be able to understand:

- Familiarization with fundamentals of analyticalchemistry.
- Basics of spectroscopic, thermal, electrochemicaltechniques
- Learning basics of separation techniques and itsapplications.
- Understanding analytical tools, statistical methods applied to analyticalchemistry.
- Understanding principle of UV-Vis spectroscopy and itsapplications.
- Understandingprinciplesofthermo-gravimetric analysis and study of thermaldecomposition of materials/characterization ofmaterials.
- Understanding basics of electro-analytical techniques and itsapplications.
- Understandingprinciplesofseparationtechnology andits use in advanced instrumentations.

AnalyticalChemistry (Theory)

UNIT-I: Qualitative and quantitative aspects of analysis **4 Lectures**

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT-II: Spectroscopy **8Lectures**

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

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT-III: Thermal analysis **6 Lectures**

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from theirmixture.

UNIT-IV: Electroanalytical methods **6 Lectures**

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

UNIT-V: Separation techniques **16 Lectures**

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

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

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC andHPLC.

Recommended Books/Reference Books:

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

2 Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. WardsworthPublishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.

5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis, Saunder College Publications,(1998).*

6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.

7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.

8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

9 Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5thEdn., Brooks & Cole(1997).

AnalyticalChemistry (Practical)

At least two experiments from each section

I. Chromatography:

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the $R_f$values.

(iii) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their $R_f$values.

(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. SolventExtractions:

(i) To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Determine the pH of the given aerated drinks fruit juices, shampoos andsoaps.

(iii) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

III. Analysis ofsoil:

(i) Determination of pH ofsoil.

(ii) Total solublesalt

(iii) Estimation of calcium, magnesium, phosphate,nitrate

IV. Ionexchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchangeresins.

(ii) Separation of metal ions from their binarymixture.

(iii) Separation of amino acids from organic acids by ion exchangechromatography.

V. Spectrophotometry

(i) Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infraredspectroscopy.

(iii) Determination of dissolved oxygen inwater.

(iv) Determination of chemical oxygen demand(COD).

(v) Determination of Biological oxygen demand(BOD).

(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

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

Semester	Course	Name of the course	Credits
VI	CC 13	GreenChemistry	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Green chemistry and itsprinciples.
- Green synthesis andreactions.
- Green chemistry for sustainablesolutions.
- Understanding principles of greenchemistry.
- Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
- Atom economy and design of chemical reactions using theprinciple.
- Understanding the use of green chemistry principle and processes in laboratoryreactions.

Green Chemistry (Theory)

UNIT-I: Introduction to Green Chemistry **4 Lectures**

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis 12 Lectures

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts;maximumincorporationofthematerialsusedintheprocessintothefinalproducts,Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

UNIT-III: Green Synthesis / Reactions **16 Lectures**

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylationreaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative toIodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning ofgarments.
5. Designing of Environmentally safe marineantifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made fromcorn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats andOils

UNIT-IV: Future Trends in Green Chemistry **8 Lectures**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C_2S_3); Green chemistry in sustainabledevelopment.

Recommended Books/References:

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

GreenChemistry (Practical)

Any six experiments may be conducted

1. Preparation and characterization of nanoparticles of gold using tealeaves.
2. Preparation of biodiesel from vegetable/ waste cookingoil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates GreenChemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atomeconomy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead ofcyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dryice.
7. Mechanochemical solvent free synthesis ofazomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II)complex.
9. Photoreduction of benzophenone to benzopinacol in presence ofsunlight.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC(2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC(2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7(2013).
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society(2008).

6. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society(2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.
8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders,1995.

Semester	Course	Name of the course	Credits
VI	CC 14	Chemistry of Materials	Theory:3
			Practical: 2

Learning objective:

After completiton of the course, the learner shall be able to understand:

- Crystalline solids – parameters,symmetry.
- Silica based materials inapplications.
- Technological importance of ionic liquids, preparation of materials– using sol-gel technique.
- Nano-structured materials, self-assembledstructure.
- Composites and itsapplications
- Understanding basic parameters of crystalline solids, symmetry and crystalstructures.
- Mesoporous/microporous silica based materials, functionalized hybrid materials and its applications.
- Preparation of inorganic solids, host-guest chemistry, ionic liquids and itssignificance.
- Understanding self-assembled structures, nano-structured materials, carbon nanotubes, applications.
- Understanding composites and their industrialapplications.

Chemistry ofMaterials (Theory)

UNIT-I: Basics of crystalline solids **8 Lectures**

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism,twinning.

UNIT-II: Silica based materials **8 Lectures**

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications

UNIT-III: Inorganic solids/ionic liquids of technological importance **8 Lectures**

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guest chemistry (elementaryideas).

UNIT-IV: Nanomaterials **8 Lectures**

Overview of nanostructures and nano-materials: classification. Preparation of gold and silver

metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control.Carbon nanotubes and inorganic nanowires.

UNIT-V: Composite materials **8 Lectures**

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

Recommend books/References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition,2012.
3. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. JohnWiley,1974.
4. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley2003.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Chemistry ofMaterials (Practical)

1. Preparation of urea-formaldehyderesin
2. Preparations of novalac resin/resolresin
3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly other materials synthesis can bedesigned).
4. Preparation of silver nano material. (Similarly other nano materials of other metals synthesis can bedesigned).
5. Analysis of XRD pattern ofcrystals.
6. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
7. Estimation of particle size from the BET, SEMtechniques.
8. Density measurement of ionicliquids
9. Determining dynamic viscosities of given ionicliquids
10. Determination of hydration number IRspectra.

Note: Experiments may be added/deleted subject to availability of time and facilities

DISCIPLINE SPECIFIC ELECTIVE COURSES

Semester	Course	Name of the course	Credits
V,VI	DSE1	MedicinalChemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- The basics of medicinal chemistry, biophysicalproperties
- Biological activityparameters
- Drugmetabolism
- Biophysical and chemical properties of enzymes, hormones, vitamins
- Concept of rational drug design

Unit 1: Bio-physicochemical properties

Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i, K_d, LD_{50}, EC_{50}, IC_{50}, CC_{50}, ADMET properties.

Unit 2: Structural properties

Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along with bond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples, Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drug and recemates, Examples such as catecholamines, etc.

Unit 3: Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist, Examples.

Unit 4: Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardivascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents.

Unit 5: Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

Unit 6: Concept of rational drug design

Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR.

Recommended books/References:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John MarloweBeale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwerpublication.
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACKPublishing.
4. Burgers Medicinal Chemistry by Manfred E. Wolff, AlfredBurger
5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, HobokenN.J.Wiley,
6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press.2012.
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society(1995)
8. Patrick, G. Medicinal Chemistry, Oxford.University Press(2000).

Suggested list of Experiments

1. Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation.
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by ColumnChromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & SodiumBenzoate)
4. Synthesis & Purification of following Compoundsusing:

   (i) Precipitation or Recrystallization. (ii) Synthesis of Benzimidazole. (iii) Synthesis of Anthranilic Acid. (iv) Synthesis of Sulphanilamide. (v) Synthesis of benzoic acid from benzyl alcohol. (vi) Synthesis of 1,4 – dihydropyridine.
5. Computational modeling of drug design/use of softwares may be demonstrated tostudents.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested books/references:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D.Barnes, M. J. K Thomas, 6th Edition, Pearson's Education Ltd.
2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
3. Vogel''sTextbookofPracticalOrganicChemistry,B.S.Furniss,A.J.Hannaford,P. W. G. Smith, A. R. Tatchell, 5th edition (2008), Pearson's Education Ltd

Semester	Course	Name of the course	Credits
V,VI	DSE2	Electrochemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- Basic principle of laws ofelectrochemistry.
- Understanding about chemical cells and theirfunction.
- Understanding about electrodes, EMFmeasurement.
- Understanding about potentiometric titrations and their applications.

Unit-I

Arrhenius theory of electrolytic dissociation.Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Molar conductivity at infinite dilution.Kohlrausch law of independent migration of ions.Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants ofsalts.

Unit-II

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.Chemical cells, reversible and irreversible cells with examples.Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and withouttransference,liquidjunctionpotential;determinationofactivitycoefficientsand transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-III: Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKavalues.

Unit-IV: Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecularinterpretation.

Recommended books/reference books

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP

(2009).

4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley(2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc.(2005).

List of suggested laboratory experiments

1. Determination of pH of a given solution using glasselectrode.
2. Determination of cellconstant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak acid.
3. Conductometric titration: strong acid *vs*. strong base, weak acid *vs*. strongbase.
4. Potentiometric titration: strong acid *vs*. strong base, weak acid *vs*. strong base,potassium dichromate vs. mohr'ssalt.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/reference books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).
2. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.
3. Garland,C.W.;Nibler,J.W.&Shoemaker,D.P.*ExperimentsinPhysicalChemistry8thEd.;* McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).

Semester	Course	Name of the course	Credits
V,VI	DSE3	Polymer Chemistry	Theory: 3
			Practical: 2

Learning objective:

After completion of the course, the learner can be able to understand:

- The mechanism of polymer materialformation.
- Molecular weight and structure propertyrelationship
- Polymerization procedure and Zigler-Nattacatalysis.
- Characterization ofpolymers

Unit 1: Introduction

Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit 2: Polymeric Structure and Property Relationship

Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit 3: Polymerization Chemistry

Industrial methods of polymerization such as a bulk, solution, emulsion, suspension.Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Unit 4: Characterization of Polymers

Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Recommended books/References:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork.1990.
2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996.
3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press,1987
4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970).
5. W. Billmeyer, Text book of polymer science, 3rdEdn., 2007,Wiley.
6. J.R.Fried, Polymer Science and Technology, (2005), PHIpublication.
7. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers,

New York(1962).

List of suggested laboratory practicals

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (purification of monomer should betaught)
2. Preparation of phenol-formaldehyderesins.
3. Emulsion polymerization ofpolymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$ solution) by viscometry. (students should be explained regarding principles and use of ubblohde/ostwaldviscometer).
5. Estimation of amount of HCHO in a given solution by sodium bisulphitemethod.
6. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated tostudents)
7. Determination of exchange capacity of cation exchange resins and anion exchangeresins.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/Reference books

1. P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002).
2. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).
3. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)

Semester	Course	Name of the course	Credits
V,VI	DSE4	Environmental Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Compositon of atmosphere
- Biogeochemical cycles
- Hydrological cycle
- Water qualityparameters
- Atomospheric chemical phenomon and environmentalpollution
- Water pollution, parameters of water pollution, treatment of pollutedwater.

Unit 1: Environment

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

Unit 2:Hydrosphere

Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

Unit 3: Atmosphere

Chemical composition of atmosphere – particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

Unit 4: Aquatic chemistry

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial, municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary), Solid waste treatment. Soil pollution and Noisepollution.

Recommended Books/References:

1. De.A.K.Environmental Chemistry, Wiley Eastern Ltd,1990.
2. Miller T. G. Jr., Environmental Science, Wadsworth publishing House, Meerut Odum. E. P. 1971.
3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewispublisher
5. Environmental chemistry, Sharma and Kaur, 2016, Krishnapublishers
6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.

7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freemanpublication.
9. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa(2009).
10. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
11. Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern(1995)

List of suggested laboratory practicals

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).
2. Determination of Biological Oxygen Demand (BOD_5).
3. Determination of Chemical Oxygen Demand(COD).
4. Finding out percentage of available chlorine in bleachingpowder.
5. Measurement of chloride, sulphate and salinity of water samples by titration method ($AgNO_3$ and potassiumchromate).
6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titrationmethod.
7. Estimation of SPM in airsamples.

Note: Experiments may be added/deleted subject to availability of time and facilities

List of Recommended books/Reference Books:

1. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).
2. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, NewDelhi.
3. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
4. A. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, NewDelhi.
5. S. M. Khopkar, *Environmental Pollution Analysis*: New Age Int. Publisher, NewDelhi.

Semester	Course	Name of the course	Credits
V,VI	DSE5	Advanced Materials Chemistry	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Structure of molecules in solid state. How the atoms/molecules arranged in solid state and crystals.
- Characterizations of solid materials.
- Fundamentals of nanomaterials.
- Synthesis and characterization of nanomaterials.
- Different types of polymers.
- Synthesis and characterization of polymers.

Unit 1: Crystal structure of solids

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant based synthesis. Growth of single crystals.

Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by an atom and a crystal.Single crystal and powder diffraction.Electron and neutron diffraction.Concept of reciprocal lattice.Electron microscopy techniques.

Unit 2: Nanomaterial fundamentals

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role of surfactant in shape and size control of nanomaterials.Synthesis of nanowires and nanotubes by CVD and MOCVD method.

Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy.

Nanomaterial properties and applications: Magnetic properties of nanoparticles; superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domain to multidomain transition. magnetic nanoparticles as MRI contrast agents.

Unit 3: Frontier areas of polymer science and technology

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Recommended books/References:

1. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*.2009, Artech House, LondonPublication.

2. Physical methods for chemistry: R. S. Drago, 1992, Saunders collegepublication.

3. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International (P) Ltd., 2015.

4. P. J. Flory, Principle of polymer chemistry, Cornell UniversityPress.

5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.

6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

List of suggested Laboratory Experiment

1. Preparation of gold and silvernano-particles.
2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) andphenolphthalein
3. Determination of composition of dolomite (by complexometrictitration).
4. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystallinesystem.
5. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
6. Estimation of particle size from the BET, SEMtechniques.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/Reference Book:

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

Semester	Course	Name of the course	Credits
V,VI	DSE6	Advanced Analytical Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Methods in chemical analysis.
- Polarography: Instrumentation and applications.
- Theory and application of atomic spectroscopy.
- Theory and application thermogravimetric analysis.
- Theory and principle of chromatography.
- Analysis of fuel and drugs.

Unit 1: Statistical methods in chemical analysis

Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

Unit 2: Polarography

Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications.

Unit 3: Atomic spectroscopy

Atomic absorption spectroscopy, theory and application (with some examples).

Unit 4: Thermal analysis

Theory, methodology, instruments and applications of theromogravimetric analysis (TGA/DTA), and differential scanning calorimetry (DSC).

Unit 5: Chromatography

Principles of chromatography, paper, column and thin layer chromatography, Gas-liquid chromatography, HPLC.

Unit 6: Analysis of fuel and drugs

Fuel analysis: Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel, Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point.

Drug analysis: Classification of drugs, Analysis of some standard drug using various chromatographic techniques.

Recommended books/references:

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

2 Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*
6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.
7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.
8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

List of suggested laboratory experiments

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. Preparation of buffer solutions of different pH (i. Sodium acetate-acetic acid, ii. Ammonium chloride-ammoniumhydroxide

2. Principles involved in chromatographic separations. Paper chromatographic separation of following metalions:

   i. Ni (II) and Co(II)
   ii. Fe (III) and Al(III)

3. Chromatographic separation of the active ingredients of plants, flowers and juices byTLC.
4. IR/DSC analysis of known polymer sample (for students demonstrationonly)
5. Determination of flash point & fire point of given fuelsample.
6. Determination of viscosity index, cloud point, pour point of given fuelsample.
7. Determination of calorific value of given fuel sample/coal sample using bombcalorimeter.
8. Proximate analysis of given coalsample.
9. Determination of the iodine number ofoil.
10. Determination of the saponification number ofoil.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/Reference books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009
4. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning IndiaEdition.

Semester	Course	Name of the course	Credits
V,VI	DSE7	Nuclear & Radiation Chemistry	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Nuclear forces, nuclear stability, binding energy.
- Radioactive elements and general characteristics.
- Measurement of radioactivity.
- Radiation chemistry.
- Nuclear pollution and Radiological safety.

Unit 1: Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half-life, mean life period), units of radioactivity, Transient and secular equilibria, Carbon dating and itsusefulness.

Nuclear reactions: Bethe notation, types of nuclear reactions (n, p, α, d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions. Nuclear fission: the process, fragments, mass distribution, and fission energy.

Unit 2: Measurement of radioactivity, idea about accelerator and detectors, Van de Graaaf and linear acceletors, synchrontrons, Geiger-Muller detector, Scintillaton detectors, Type of nuclear reactions, Nuclear fission, Nuclear fusion, Nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor. Nuclear fusion and stellarenergy.

Unit 3: Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm,Sievert)

Unit 4: Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry. Radioactive isotopes and their applications, Isotopic dilution analysis, Neutron activation analysis, disposal of nuclear waste, nuclear.

Recommended Books/references:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice –Hall,
3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman &Hall.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication,Moscow.
5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry,Wiley
6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, SecondEdition.

Suggested laboratory practicals:

1. The safe laboratory use of radionuclide andradioisotopes
2. demonstration of activity on Geiger-Muller and scintillation basedcounter.

3. liquid scintillation counting, alpha spectrometry, gamma spectrometry – to identify and quantify radioisotopes.

4. occurrence of radon daughter particles in environmentalsamples.

5. Liquid-liquid separation/extraction of radio nuclide from environmental samples/water samples.

6. Isotopic application in removal process adsorption / ionexchange.

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE8	**Organic Spectroscopy**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Spectroscopic techniques used for characterization of organic compounds.
- Basic Principles of UV, IR and NMR Spectroscopy and Mass Spectrometry.
- Application of various spectroscopy in characterization of chemical compounds.

Unit 1: Basic Principles of UV Spectroscopy

Application of Woodward-Fiser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.

Unit 2: Basic principles of IR Spectroscopy

Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Unit 3: NMR (^{1}H and ^{13}C NMR)

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

Unit 4: Basic principles Mass Spectrometry

Application of fragmentation rule in characterization of organic compounds.Problems on structure elucidation of organic compounds based on spectral data.

Recommended Books/References:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill: *Spectroscopic Identification of Organic Compounds*, John Wiley &Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India(2012).

Suggested laboratory experiments

1. Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy)
2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. (azodyes, acetanilides, benzoic acid, etc.)

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE9	**HeterocyclicChemistry**	Theory: 3
			Practical: 2

Learning Objectives

After completion of the course, the learner can be able to understand:

- Chemistry of heterocyclic compounds.
- Synthesis, structures and characterizations of three to five membered rings.
- Chemistry of Condensed five-memberedHeterocycles.

Unit 1

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches andreactivities.

Unit 2

Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches andreactivities.

Unit 3

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products:synthesis of Peniciline andcephalosporine.

Unit 4: Five-membered aromatic heterocycles:

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties and reactivities.
2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches andreactivities.
3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties andreactivity.

Unit 5: Condensed five-memberedHeterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry ofIndoles.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley,2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York,1968.
4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London,1978.
5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),.Vol 1-8, Pergamon Press,1984.
6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press,1985.
7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic

Press,1974.

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds inlab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) inlab.
3. Spectroscopic identification of simple organic compounds
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basiccondition).

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE10	**Biochemistry**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Biological importance of carbohydrates.
- Classification, biological importance of proteins.
- Nomenclature, Characteristics, Classification of enzymes.
- Biological importance of lipids.
- Structure of DNA/RNA and their role in living organisms.

Unit 1: Carbohydrates: **8 Lectures**

Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle.

Unit 2: Proteins: **8 Lectures**

Classification, biological importance; Primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Denaturation of proteins.

Unit 3: Enzymes: **8 Lectures**

Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes,Coenzymes and cofactors, Enzyme inhibitors, Biocatalysis in Green Chemistry" and ChemicalIndustry

Unit 4: Lipids: **8 Lectures**

Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.

Unit 5: Structure of DNA/RNA: **8 Lectures**

Structure of DNA (Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

Recommended Books/References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman andCo.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IVEdition.W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/McGraw-Hill

Suggested Practical in Biochemistry

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknownsample.
2. Action of salivary amylase at optimumconditions
3. Effect of pH on the action of salivaryamylase
4. Effect of temperature on salivaryamylase

5. Effect of inhibitor on salivaryamylase
6. Study of the activity of Trypsin using fresh tissueextracts.
7. Effect of temperature, organic solvents, on semi-permeablemembrane.
8. Isolation of Genomic DNA from EColi

Note: Experiments may be added/deleted subject to availability of time and facilities

Semester	Course	Name of the course	Credits
V,VI	DSE11	**Organometallics and BioinorganicChemistry**	Theory: 3
			Practical: 2

Learning Objectives:

After completion of the course, the learner can be able to understand:

- Chemistry of coordination compounds.
- Characteristics of organometallic compounds.
- Structures and characterizations of organometallic compounds.
- Applications of organometallic compounds.
- Role of metals in biological systems.

Unit 1:Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$.

Unit 2: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit 3: Bioinorganic chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy

production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Recommended books/reference books

1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH,1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997

List of Laboratory experiments

1. Rection of metal with halide – preparation of Grignard reagent.

2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline)

3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.

4. Preparation of any two of the following complexes and measurement of their conductivity measurement:

   a. tetraamminecarbonatocobalt (III)nitrate
   b. tetraamminecopper (II)sulphate
   c. potassium trioxalatoferrate (III)trihydrate

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended books/reference books

1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.
2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*,Prentice-Hall.

Semester	Course	Name of the course	Credits
V,VI	DSE12	**Introduction to Nanochemistry & Applications**	Theory: 3
			Practical: 2

Learning objectives:

After completion of the course, the learner can be able to understand:

- Idea of nanoscience.
- Chemistry of nanostructures and nano-materials.
- Properties of nano-materials.
- Synthesis of nano-materials.
- Characterizations of nano-materials.

Unit-I: Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit-II: Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit-III: Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit-IV: Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Recommended Books/References books:

1. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004
3. R.W.Kelsall,I.W.Hameley,M.Geoghegan,Nanoscale Science and Technology, John Wiley& Sons, England,2005.
4. Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.
5. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi,2012.

List of Laboratory Experiments suggested:

1. Synthesis of ZnOnanoparticles.
2. Preparation of Silvernanoparticles.
3. Verification of Beer-Lambert law using nano-particles

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended/Ref. Books:

1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.

GENERIC ELECTIVE COURSES

Generic Elective Course (GE) (any four) for other Departments/Disciplines:

Semester	Course	Name of the course	Credits
I	GE-I	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Inorganic Chemistry – 1

Unit – 1: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matterand radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it.Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation).Radial and angular nodes and their significance.Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms.Stability of half-filled and completely filled orbitals, concept of exchange energy.Relative energies of atomic orbitals, Anomalous electronic configurations.

(9Hours)

Unit – 2: Chemical Bonding

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionicbonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds.Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basisof VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonalbipyramidal and octahedral arrangements, such as $BeCl_2$, BF_3, SiF_4, PCl_5, SF_6, NH_3, H_2O, OF_2, ClF_3, SF_4, XeF_4, XeF_6, H_3O^+, I_3^-, I_3^+, ICl_2^-, XeF_5^+.

Concept of resonance and resonating structures in various inorganic and organic compounds.

(7Hours)

Unit – 3: Molecular Orbital Theory

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(7Hours)

Section – B: Organic Chemistry – 1

Unit – 1: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

(6Hours)

Unit – 2: Stereochemistry

Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis - trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(7Hours)

Unit – 3: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons).*Preparation:*Catalytic hydrogenation, Wurtz reaction, Kolbe'ssynthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons)*Preparation:*Elimination reactions: Dehydration of alkenes anddehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:*cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons)*Preparation:*Acetylene from $CaC_2$and conversion into higheralkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$.

(9Hours)

Reference Books:

- J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S.
- F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- Douglas, McDaniel and Alexader: *Concepts and Models in Inorganic Chemistry*, John

Wiley.
- James E. Huheey, *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principlesof Structure and Reactivity*, Pearson Publication.
- T. W. Graham Solomon: *Organic Chemistry, John Wiley and Sons.*
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
- E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
- I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand

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GE PRACTICAL – I (Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons)

(30Hours)

Section – A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section – B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.
- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Semester	Course	Name of the course	Credits
II	GE-II	Kinetic Theory of Gases, Chemical Energetics, Equilibria& Functional Group Organic Chemistry	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Physical Chemistry – 1

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).

(8 Hours)

Unit – 2: Chemical Energetics

Chemical Energetics: Introduction of different terms and processes in thermodynamics: [systems (isolated, closed, open) and surrounding, macroscopic properties, state and path functions and their differentials.

First Law: concept of heat, q, work, w, internal energy, U, sign convention for heat and work, nature of work, path dependence of work and heat; statement of first law; enthalpy, H, heat changes at constant volume and constant pressure; heat capacities (C_v, C_p) and relation between them for ideal gases. Reversible and irreversible processes, maximum work, thermodynamic quantities (w, q, ΔU, ΔH) and its calculation for isothermal and adiabatic reversible expansion of ideal gases. Ideal gas law for adiabatic reversible expansion, comparison of adiabatic and isothermal reversible expansion. Joule-Thomson effect, JouleThomson coefficient in ideal and real (van der Waal) gases, inversion temperature.

Thermo-chemistry: Standard state, standard enthalpy of formation, Hess's Laws of constant heat summation and its application. Change in internal energy (ΔU) and enthalpy (ΔH) of chemical reactions, relation between ΔU and ΔH, variation of heat of reaction with temperature (Kirchhoff's equation). Enthalpy of neutralization. Bond Energy – Bond dissociation energy and its calculation from thermo-chemical data.– Kirchhoff's equation.

Second law of thermodynamics, concept of entropy, free energy work functions, Gibbs Helmholtz equation and its applications

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(9 Hours)

Unit – 3: Chemical and Ionic Equilibrium

Free energy change in a chemical reaction.Thermodynamic derivation of the law of chemical

equilibrium.Distinction between G and G^{o}, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.Buffer solutions.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

(6 Hours)

Section – B: Organic Chemistry – 2

Functional group approach for the following reactions (preparations & reactions) to bestudied in context to their structure.

Unit – 1: Aromatic Hydrocarbons & Alkyl and Aryl Halides

***Aromatic Hydrocarbons*:** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation andacylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4carbons on benzene); aromatic hydrocarbon side chain reactions.

Alkyl Halides (upto 5 Carbons): Types of Nucleophilic Substitution (S_N2, S_N1, S_Ni)reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitroformation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vssubstitution.

***Aryl Halides*:** *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer &Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilicsubstitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 or $NaNH_2/NH_3$ reagent system. Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(7 Lectures)

Unit – 2: Alcohols, Phenols, Ethers, Aldehydes and Ketones (Upto 5 Carbons)

***Alcohols*:** *Preparation:* Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc.HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

***Phenols*:** (Phenol case) *Preparation:* Cumenehydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.

***Ethers (Aliphatic and Aromatic)*:** Cleavage of ethers with HI.

Aldehydes and Ketones (Aliphatic and Aromatic): (Formaldehye, acetaldehyde, acetone andbenzaldehyde); *Preparation:* from acid chlorides and from nitriles. *Reactions* -Reaction withHCN, ROH, $NaHSO_3$, NH-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro'sreaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishnerreduction.Meerwein-PondorffVerley reduction.

(9 Hours)

Unit – 3: Carboxylic acids and their derivatives& Amines salt

Carboxylic acids (aliphatic and aromatic):*Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction. *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and theirinterconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction,Perkin condensation.

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons), *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamidereaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2,Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts:*Preparation:*from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

(6Hours)

Reference Books:

- T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry*CengageLening India Pvt. Ltd., New Delhi (2009).
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

GE PRACTICAL – II(Kinetic Theory of Gases, Chemical Energetics, Equilibria& Functional Group Organic Chemistry)

(30Hours)

Section – A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionic Equilibria

pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section – B: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possessingmonofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Criteria of Purity: Determination of melting and boiling points.
2. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
3. Preparations: Mechanism of various reactions involved to be discussed.
   Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* UniversitiesPress
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Semester	Course	Name of the course	Credits
III	GE-III	Solid, Solutions, Phase Equilibrium & Chemical Kinetics, Conductance,Periodic Properties and Chemistry of s-, p-, and d-block elements	Theory: 3
			Practical: 2

Section – A: Physical Chemistry – 2

Unit – 1: Solids

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.Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals.Glasses and liquid crystals.

(6Hours)

Unit – 2: Solutions, Phase Equilibrium&Chemical Kinetics

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions.Lever rule.Azeotropes.Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation.Nernst distribution law and its applications, solvent extraction.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H2O and Na-K only).

The concept of reaction rates.Effect of temperature, pressure, catalyst and other factors on reaction rates.Order and molecularity of a reaction.Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction.Concept of activation energy and its calculation from Arrhenius equation.

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

(11Hours)

Unit – 3: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods.Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(5 Hours)

Section – B: Inorganic Chemistry – 2
Unit – 1: Periodic Properties & Acid-Base Concepts

Periodic Properties*:* Division of elements into *s*, *p*, *d*, and *f* blocks, covalent radii, van der Waals radii and ionic radii; ionization enthalpy, electron gain enthalpy, and electronegativity (Pauling, Mulliken, and Alfred-Rochow scales: Definition, methods of determination, trends in periodic table, and applications in predictingand explaining chemical behavior).
Acids and Bases: Arrhenius, Brønsted-Lowry, Lux-Flood and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases, Classification of acids and bases as hard and soft, Pearsons HSAB concept, acid-base strength and hardness and softness,symbiosis, application of HSAB theory.

(7Hours)

Unit – 2: Oxidation-Reduction
Redox equations, Standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon as reducing agent, Nernst equation, redox potentials to explore the feasibility of reaction and calculation of values of equilibrium constant. Reversible and irreversible cells.Concept of EMF of a cell.Measurement of EMF of a cell.

(5Hours)

Unit – 3: *Chemistry*of *s*-,*p*-and *d*- Block Elements
s-Block Elements: General characteristic properties, complexes of alkali metals, comparative study of hydrides, oxides, hydroxides, halides, carbonates and bicarbonates of group I and II, Diagonal relationship, Biological role of alkali and alkaline earth metals.
p-Block Elements: General characteristic properties, comparative study (including diagonal relationship and inert pair effect) of groups 13-17 (B, C, N, O, F) elements and group trends of compoundslike hydrides, oxides, halides, and oxy acids; preparation properties and structure, of diborane, borazine, alkalimetalborohydrides,fullerenes, silicates and silicones, inter-halogensand polyhalides.
Chemistry of Noble Gases: Isolation and separation of noble gases from air, chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds.
d-Block Elements: Characteristic properties of *d*-block elements. Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.Comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states and stereochemistry.

(11Hours)

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).
- R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York (1985).
- E. S. Gilreath, Fundamental Concepts of Inorganic Chemistry, McGraw Hill Edu. Pvt. Ltd.

- R. Sarkar (Part-I & II), General & Inorganic Chemistry, Central.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.

GE PRACTICAL – III (Solid, Solutions, Phase Equilibrium,Chemical Kinetics, Conductance & Periodic Properties and Chemistry of s-, p-, and d- block elements)

(30 Hours)

Section – A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

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

$Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

b) Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Conductance

a) Determination of cell constant

b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

c) Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

a) Strong acid vs. strong base
b) Weak acid vs. strong base
c) Potassium dichromate vs. Mohr's salt

Section – B: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}, Anions : CO_3^{2-}, S^{2-}, SO^{2-}, $S_2O_3^{2-}$, NO_3^{-}, NO_2^{-},Cl^{-}, Br^{-}, I^{-},SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-}

(Spot tests should be carried out wherever feasible)

Reference Books:

- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Semester	Course	Name of the course	Credits
IV	GE-IV	**Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life**	Theory: 3
			Practical: 2

Theory: 60 Hours

Section – A: Analytical Chemistry – 3

Unit – 1: Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature.Balances, burettes, volumetric flasks, pipettes, calibration of tools, sampling. Errors andStatistics: significant figures, rounding off, accuracy and precision, determinate andindeterminate errors, standard deviation, propagation of errors, confidence limit, test ofsignificance, rejection of a result.

(5Hours)

Unit – 2:Volumetric Titration

Standard solution, primary standard and secondary standard, titration, end point, indicator, concentration of standard solution- moles, Normality, molarity, Molality, parts per million(PPM), volumetric calculation, acid base titration and use of indicators,titration curves for strong acid vs strong base, weak acid with strong base, weak base with strong acid, theory of acid base indicator, Redox titration- titration of Mohr salt against $KMnO_4$, Titration of Oxalic acid against $KMnO_4$, Titration of $FeSO_4$ against $K_2Cr_2O_7$.

(6 Hours)

Unit – 3: Chromatography

Chromatographic Techniques:classification, theory of chromatographic separation, distribution coefficient, retention,sorption, efficiency and resolution. - Column, ion exchange, paper, TLC & HPTLC chromatography etc.

Solvent Extraction: Distribution Coefficient, distribution ratio, percent extracted, solvent extraction of metals ions, extraction of ion association complex, extraction of metal chelates, multiple batch extraction and applications.

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

Gas Chromatography: retention time or volume, capacity ratio,partition coefficient, theoretical plate and number, separation efficiency and resolution,instrumentation and application.

(8Hours)

Section – B: Inorganic Chemistry – 3

Unit – 1: Coordination Compounds

Werner's coordination theory and its experimental verification,effective atomic number concept, chelats, nomenclature of co-ordination compounds,isomerism in coordination compounds.

Crystal Field Theory: Crystal field effect, octahedral symmetry. Crystal field stabilization

energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry.Factors affecting the magnitude of D. Spectrochemical series.Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.Jahn-Teller distortion, Square planar coordination.

(7 Hours)

Unit – 2: Organometallics

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of

mononuclear and polynuclear carbonyls of 3d metals. p-acceptorbehaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

(6Hours)

Section – C: Organic Chemistry – 3

Molecules of Life

Unit – 1: Carbohydrates

Classification of carbohydrates, reducing and non reducing sugars, and General Properties, Glucose and Fructose,their open chain structure. Epimers, mutarotation and anomers, Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

(5Hours)

Unit – 2: Amino Acids, Peptides, ProteinsandNucleic Acids

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis.Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $-NH_2$group, complexationwith Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature)**, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

(8 Hours)

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.*, Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry*CengageLening India Pvt. Ltd., New Delhi (2009).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.
- S. Chand. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7thEd.*, W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. &Stryer, L. *Biochemistry 7thEd.*, W. H. Freeman

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GEPRACTICAL – IV (Electrochemistry, Chemical Kinetics, Co-ordination compounds, Organometallics and Molecules of life

(30 Hours)

Section – A: AnalyticalChemistry

1. Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.
4. To draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound and estimate the concentration of the same in a given solution.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -

phenanthroline complex in solution by Job's method.

6. Determination of concentration of Na+ and K+ using Flame Photometry.

Section – B: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

   Binary mixture of nickel and cobalt, copper and nickel, zinc and magnesium, iron and copper; aluminium and nickel.

2. Preparation of any two of the following complexes:
   (a) tetraaammine copper (II) sulphate
   (b)tetraamminecarbonatocobalt (III) nitrate
   (c) potassiumtrioxalatochromate (III)
   (d) potassiumtrioxalatoferrate (III)
   (e) sodiumhexanitritocabaltate (III)
   (f) prussin blue

Section – C: Organic Chemistry

1. Determination of the concentration of glycine solution by formylation method.
2. Titration curve of glycine
3. Action of salivary amylase on starch
4. Effect of temperature on the action of salivary amylase on starch.
5. Determination of the saponification value of an oil/fat.
6. Determination of the iodine value of an oil/fat
7. Differentiation between a reducing/nonreducingsugar.
8. Extraction of DNA from onion/ cauliflower

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.*, Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Ability EnhancementCourses

Semester	Course	Name of the course	Credits
I,II	AEC 1	English for communication	Theory:2

Learning Objective:

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

- The features of communication
- The various writing skills
- The scientific and technical writings

Unit I: Communication **3 Lectures**

Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Unit II: Writing Skills **5 lectures**

Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit III: Technical Writing **4 lectures**

Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

Semester	Course	Name of the course	Credits
I,II	AEC 2	Intellectual Property Rights	Theory:2

Learning Objective:

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

- Understand the concept of IPR
- Differentiate between various agreements ofIPR
- Compare copyrights, patents and GeographicalIndicators
- Examine various legal issues related toIPR
- Relate to various cyber issues concerning IPR

Keywords:

Copyright act, IPR and WTO, Patents, Bioprospecting, Biopiracy, Database

Unit I: Introduction to Intellectual PropertyRight(IPR) (7 lectures)

Copyright Act and IPR, Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO).Objectives, Rights, Patent Act 1970 and itsamendments.

Unit II: Patents, CopyrightsandTrademarks (7lectures)

Procedure of obtaining patents, working of patents. Infringement of patents, Copyrights: work protected under copyright laws, Rights, Transfer of Copyright, Infringement. Trademarks: Objectives of trademarks, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name.

Unit III: Protection of Traditional Knowledge, Industrial Designs and Plant Varieties (7 lectures)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bioprospecting and Bio-piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Plant varieties protection in India. Rights of farmers, National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit IV: Information Technology Related IPR (7 lectures)

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, and Moral Issues in Patenting Biotechnological inventions.

Practical:

The students are expected to prepare some project report based on the Success stories of Traditional Patents secured by India. Likewise, prepare a database for Indian products wherein is issue is still under consideration of the competent authorities. Prepare the dos and don'ts on Patents for Botanists.

Suggested Readings

1. N.S. Gopalakrishnan and T.G. Agitha, (2009) Principles of Intellectual Property Eastern Book Company,Lucknow.

2. David Kitchin QC , David Llewelyn , James Mellor , Richard Meade , Thomas Moody-Stuart,and D. Keeling, Robin Jacob (2005). Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet &Maxweel.
3. Ajit Parulekar and Sarita D' Souza, (2006) Indian Patents Law – Legal & Business Implications; Macmillan IndiaLtd.
4. B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd.,India.
5. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House,Delhi.

Semester	Course	Name of the course	Credits
I,II	AEC 3	History of Indian Science	Theory:2

Learning outcomes

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

- Develop understanding of various branches of science during differenteras
- Analyze the role played by different Indian organizations inscience
- Learn about the science and techniques used in ancient India
- Appraise the contribution of different Indian Scientists inscience

Keywords:

Astronomy, Ancient India, Colonial India, Modern India, Agricultural techniques, Green revolution

Unit I: Science in Ancient andMedievalIndia **8 Lectures**

History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques ofirrigation.

Unit II: Indian Science in before andafterIndependence **7 Lectures**

Introduction of different surveyors, botanists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, Establishment of Atomic Energy Commission, Launching of the space satellites, Botanical survey ofIndia.

Unit III: ProminentIndianscientists **8 Lectures**

Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Vikram Sarabhai.

Unit IV: Prominent research in Plant Sciences in Republic of India **7 Lectures**

History of plant tissue culture from India, Green revolution in India: causes, details, and outcomes. First gene cloning in plants, First genome sequencing from India.Premier Plant Research institutes and scientists in India, GM Mustard. Allelopathy Plant research in India

Practical:

There is no experimental lab based Practical. However, the students are expected to prepare some term paper reports on the Life and works of some noted Indian Scientists especially the Botanists. Likewise, students need to prepare and organize some discussion on the ancient and medieval science in India and trace the reasons of inadequate visibility in the world. Prepare term papers on GM Crops, the controversies and procedure for approval. Prepare term papers on the significance of Allelopathic research fromIndia.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Kuppuram G (1990) History of Science and Technology in India, South AsiaBooks.
2. Handa O. C. (2014) Reflections on the history of Indian Science and Technology, PentagonPress.
3. Basu A (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi &Co.
4. Habib I, (2016.)A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. A. Rahman et al (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. B. V. Subbarayappa & K. V. Sarma (1985), Indian Astronomy — A Source Book, Bombay.
7. Srinivasan S, Ranganathan S (2013) Minerals and Metals heritage of India, National Institute of AdvancedStudies.
8. Srinivasiengar C N, (1967) The History of Ancient Indian Mathematics, World Press Private Ltd.Calcutta.
9. Bhardwaj H C (2000) Metallurgy in Indian Archaeology. Tara BookAgency

Semester	Course	Name of the course	Credits
I,II	AEC 4	Good Laboratory Practices	Theory:2

Learning Outcomes

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

- Apply practical skills in science courses with the understanding of general laboratory practices
- Explore various research issues and theirsolutions
- Apply various techniques to study chemical compounds,salts
- Use various micro techniques used inchemistry

Keywords:

Laboratory calculations, calibration procedures, use of glassware, safety aspects inpreparation

Unit I: General Laboratory Practices 5 lectures

Common calculations in chemistry laboratories.Understanding the details on the label of reagent bottles.Preparation of solutions.Molarity and normality of common acids and bases.Dilutions.Percentage solutions.Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit II: Instrument-Techniques and laboratory preparation procedure. 5 lectures

Use of micropipette, analytical balances, pH meter, conductivity meter, rotary evaporator, potentiometer.Use of purified water in lab experiments, Cleaning and drying of glassware, Preparation of crystals from given salt.Preparation of Dyes, Demonstration of preparation of material using Sol-gel procedure.

Suggested Readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlinand Heidelberg GmbH & Co. K; 2nded.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory PracticeStandards: Application for field and Laboratory studies. WileyVCH.

Semester	Course	Name of the course	Credits
I,II	AEC 5	Introduction to Forensic Science and technology	Theory:2

Learning Objective:

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

- Understand the scope of forensic science
- Understand about various types of evidences
- Analyse various evidences
- Utilize various chemical analytical tools to analyze evidences.

Unit I **20 Lectures**

Scope of forensic science, Evidences in criminal law (act, case studies), Physical evidences (identification, collection and preservation of sample, physical properties of sample material, use of physical evidences in criminal proceedings), biological evidences (drugs, effects, identification, serology of blood, semen, saliva, DNA evidence, use of biological evidence in criminal proceedings), trace evidences (finger print, blood stream, hair, firearms, fibers, paints, etc),

Unit II **10 Lectures**

basic techniques of chemical analysis (FTIR, Mass spectroscopy, HPLC and GC with example of analysis). Admissible and non-admissible scientific evidence in legal system, Principle and limitation of DNA finger printing.

Recommended Books/references:

1. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
2. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi(2002).
3. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton(2005)
4. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

Semester	Course	Name of the course	Credits
I,II	AEC 6	Renewable Energies (solar and biogas)	Theory:2

Learning Objective:

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

- Know about the renewable energy sources
- Utilize various renewable energy technologies to solve future energy consumption problems
- Identify biomass sources
- Estimate chemical composition of biomasses

Unit I: **10 Lectures**

Introduction to renewable energy sources – solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem Solar Energy Resources Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectraldistribution

Unit II: **10 Lectures**

Measurement of solar radiation Instruments: sunshine recorder, Pyranometer, Pyrheliometer, Albedometer. Radiation measurement stations in India (NIWE, IMD etc.), solar radiation data, graphs, Meteonorm and NASA-SSE databases Hands-on measurement of beam, diffuse and total radiation

Unit III: **15 Lectures**

Solar mapping using satellite data, Typical Meteorological Year, Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components

Basics Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. Biomass resource assessment Estimation of woody biomass, non woody biomass and wastes, ASTM standards, Bulk chemical properties Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids

Unit IV: **15 Lectures**

Chemical composition of biomass Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractable, COD.Structural properties Physical structure, particle size and size distribution, permeability. Physical properties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry).Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.

Semester	Course	Name of the course	Credits
I,II	AEC 7	Chemoinformatics	Theory:2

Learning Objective:

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

- Know about the history and prospects of chemo-informatics
- Represent molecules and chemical reaction using different notations, SMILES and Matrix representaion
- Search chemical structure and application of chemo-informatics in various fields

Unit I **5 Lectures**

Introduction to Chemo-informatics: History, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.

Unit II **10 Lectures**

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.

Unit III **10 Lectures**

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.

Unit IV **15 Lectures**

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling.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 and structure based drug design; Applications in Drug Design.

Recommended Books/references:

1. Andrew R. Leach and Valerie, J. Gillet (2007) *An introduction toChemoinformatics.* Springer: The Netherlands.
2. Gasteiger, J. and Engel, T. (2003) *Chemoinformatics: A text-book.* Wiley-VCH.
3. Gupta, S. P. (2011) *QSAR & Molecular Modeling.* Anamaya Pub.: NewDelhi.

Semester	Course	Name of the course	Credits
I,II	AEC 8	Water remediation and conservation studies	Theory:2

Learning Objective:

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

- Know about the various sources of water pollution
- Know the normal standard of potable water as per WHO recommendation
- Understand water conservation and erosion of soil
- Develop various water remediation and conservation studies

Unit-I **10 Lectures**

Sources of water pollutants, pollutants, Industrial and human contribution, WHO recommendation about potable water, current scenario of drinking water quality, chemistry of toxicants like arsenic, fluoride, chromium, lead and mercury, cause and effects of water pollution, remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonada techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bio-remediation, need of green chemistry, futurescope.

Unit-II **10 Lectures**

Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measures of water erosion control, Terraces for water erosion control:

Modeling of watershed processes, Case study of water-shed modeling for water conservation and water quality.

Recommended Books/references:

1. Cittenden J. C. , Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous G. , Water treatment: Principles and Design MWHpublication.
2. De A. K. Environmental Chemistry, WileyEastern
3. Clarson D., Dara S. S. A text book of Environmental chemistry and pollution control, S Chand Co. Soil and water analyticalmethod
4. Edzwald J., Water Quality & Treatment: A Handbook on Drinking Water (Water Resources and Environmental EngineeringSeries)

Semester	Course	Name of the course	Credits
I,II	AEC 9	Research Methodology	Theory:2

Learning Objective:

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

- Understand the concept of research and different types of research in the context of biology
- Develop laboratory experiment relatedskills.
- Develop competence on data collection and process of scientificdocumentation
- Analyze the ethical aspects ofresearch Evaluate the different methods of scientific writing andreporting

Keywords:

Qualitative, Quantitative, Reproducibility, Scientific methodology, Plagiarism, Scientific misconduct, Ethics in Science

Unit I: Basic ConceptsofResearch **12 lectures**

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs. qualitative; conceptual vs empirical).Research methods vs methodology.Literature-review and its consolidation; Library research; field research; laboratoryresearch.

Unit II: Data Collection and DocumentationofObservations **12lectures**

Maintaininga laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of fieldphotography.

Unit III: Overview of Application to Chemistryrelated problems **5 lectures**

Key chemistry research areas, chemoinfomatics.

Unit IV: Ethics and Good Practical's and Art of Scientific Writing **11 lectures**

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references.Power-point presentation.Poster presentation.Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Practical

1. Experiments based on chemicalcalculations.
2. Lab computationalexperiments.
3. Poster presentation on definedtopics.
4. Technical writing on topicsassigned.
5. Identification of different type of research in day by daylife.
6. Curation of relevant scientific literature from GoogleScholar.
7. Demonstration for checking of plagiarism using recommendedsoftware.
8. Technical writing on topicsassigned.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, NewDelhi.

Semester	Course	Name of the course	Credits
I,II	AEC 10	Chemistry in Everyday life	Theory:2

Learning Objective:

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

- Understand the chemical processes involved in daily life
- Know the respiration process in terms of chemistry
- Understand chemicals hazardous for health
- Understand chemical structures of various vitamins
- Understand role of minerals in important biological processes.

Unit I: Respiration and energy production in human body **8 Lectures**

Respiration, Respiratory enzymes, brief outline of hemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanine, hemerythrine. Energy production in body, ATP; enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.

Unit II: Chemical aspects of some common health hazards **5 Lectures**

Anemia, sickle cell anemia, leukemia, blood pressure irregulation, blood sugar, arthritis, carbon monoxide poisoning in mines, cyanide poisoning, fluorosis etc.

Unit III: Vitamins and minerals **5 Lectures**

Need for vitamin in body, types of vitamins, water soluble and fat-soluble vitamins, Vitamin B-12, vitamin C (Cyanocobalamine), D, Vitamin K. Role of minerals in body, iodine deficiency andremedy.

Unit IV: Significance of Radical chemistry in living system **10 Lectures**

Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural anti-oxidants like vegetables, beverages like tea and coffee, fruits.Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.

Unit V: Chemistry of Materials **10 Lectures**

Soaps and Detergents – their action, Biofuels – production of biofuels and its utility as alternative fuel source, Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA; Examples of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers. Use of polymeric materials in dailylife.

Suggested Laboratory experiments:

1. Analysis of soaps anddetergents.
2. Analysis of Biofuels - flash point, pour point, cloudpoint
3. Preparation ofNylon6/6,6
4. Testing of adulterant in food, oil andvegetable

5. Vitamin-Cpreparation.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/references:

1. Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley,1994.
2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, Elsevier,2008.
3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman,2008.
4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) *Bioinorganic Chemistry.* University Science Books(1994)
5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.
6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International.

Semester	Course	Name of the course	Credits
I,II	AEC 11	Chemistry of food, nutrition, and preservation	Theory:2

Learning objective:

On completion of this course, the students will be able

1. To know about the basic of human physiological system
2. To learn about the nutrition and itsimportance
3. To learn about the foodscience
4. To learn about the food preservation and itsutility
5. To learn about the Quantitative estimation and nutritional assessment data

Key words: Food, nutrition, preservation.

Unit-I **10 Lectures**

Basic of human physiological system and food science:Digestive System: Structure and functions of G.I. tract, Process of digestion and absorption of food, Structure and functions of liver, gallbladder and pancreas.Basic concept on Food, Nutrition and Nutrients (Nutrition, Malnutrition and Health: Scope of Nutrition.), Classification of Food, Classification of Nutrients.

Unit-II **10 Lectures**

Nutrition: Dietary fibers (composition, properties and Minerals and trace elements(biochemical and physiological role, bioavailability and requirement with examples), Vitamines (examples, biochemical and physiological requirements, deficiency and excesses), Water (requirement, water balance), basic idea about community nutrition (objective, importance of various programmes).

Unit-III **10 Lectures**

Food preservation: definition, objectives and principles of food preservation. Different methods of food preservation. Preserved Products: Jam, Jelly, Marmalade, Sauces, Pickles, Squashes, Syrups-types, composition and manufacture, selection, cost, storage, uses and nutritional aspects, Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Practical:

Identification of Mono, Di and polysaccharides, Identification of Proteins, Identification of glycerol., Determination of moisture content in food, ash content and determination of calcium, iron, vitamin-C.

Comparison with norms and interpretation of the nutritional assessment data and its significance. Weight for age, height for age, weight for height, body Mass Index (BMI) Waist - Hip Ratio (WHR). Skin fold thickness.

Quantitative estimation of Sugars (Glucose, lactose, starch), Estimation of acid value, iodine value, Saponification value of fats, Estimation of blood Glucose, Estimation of serum cholesterol.

Note: Experiments may be added/deleted subject to availability of time and facilities

Reference/suggested books

1. Sri Lakshmi B(2017): Nutrition Science,6th Multicolour Ed. New Age International

(P)Ltd.

2. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford UniversityPress.
3. Mann J and Truswell S(2017) : Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Wilson K and Walker J(2000): Principles and Techniques of Practical Biochemistry, 5th Ed. Oxford UniversityPress.
5. Sadasivan S and Manikam K(2007): Biochemical Methods, 3rd Ed. New Age International (P) Ltd.
6. Oser B. L. (1965). Hawk's Physiological Chemistry, 14th Ed. McGraw-HillBook.
7. Gopalan C, Rama Sastri BV and Balasubramanian S.C. (2016): Nutritive value of Indian Foods, Indian Council of MedicalResearch.
8. Subalakshmi, G and Udipi, SA(2006):Food processing and preservation, 1st Ed. New Age International(P)Ltd.
9. Srilakshmi B(2018): Food Science, 7th Colour Ed. New Age International (P) Ltd.
10. Potter NN and Hotchkiss JH(1999): Food science,5th Ed ,Spinger.

SKILL ENHANCEMENT COURSES

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 1	PersonalityDevelopment	Theory: 2

Learning outcomes:

After the completion of this course, the learner will be able to:

- Develop understanding of the concepts and principles of basic psychologicalskills
- Apply techniques and methods to enhance productivity and timemanagement
- Develop critical thinkingskills
- Organize human resources with improved leadershipqualities

Keywords:

Mental heuristics, Mental priming, Checklists, Stress management, Cognitive biases, Leadership qualities

Unit I: BasicPsychologySkills **8Lectures**

Mental Heuristics and Priming, Cialdini's six psychological principles, Charisma and charisma enhancements, facing interviews

Unit II: Productivity andTimeManagement **7 Lectures**

Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling theevents

Unit III:DealingNegativity **7 Lectures**

Work-life balance, stress management, coping with failures anddepression

Unit IV: Critical Thinking andHumanresources **8 Lectures**

Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadershipqualities.

Suggested Readings

1. Bast, F. (2016). Crux of time management for students. Available at:https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088
2. Cialdini, R.B. (2001). Influence: The Psychology of Persuasion, Revised Edition. Harper Collius.
3. Green, C.J. (2015). Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog EarPublishing.
4. Velayudhan, A. and Amudhadevi, N. V. (2012). Personality Development for College Students. LAP Lambert AcademicPublishing.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 2	Computer Applications inChemistry	Theory: 2

Learning outcomes:

After the completion of this course the learner will be able to:

- Apply the basic operations of spreadsheetapplications
- Recognize advanced resources for accessing scholarly literature frominternet
- Utilize bibliography management software while typing and downloadingcitations
- Operate various software resources with advanced functions and its open office substitutes

Keywords:

Spreadsheet, Google search, Subscription, Bibliography, MS office, Image processing

Unit I:SpreadsheetApplications **8 Lectures**

Introduction of spreadsheet (MS Excel), application, formulas and functions, performing basic statistics using spreadsheet applications, creating basic graphs using spreadsheet applications, logical (Boolean) operators.

Unit II:InternetResources **7Lectures**

Advanced Google search operators and Boolean functions, Introduction to Google Scholar and accessing scholarly literature from Internet, Fake News and spotting the fake news, multimedia resources and podcasts, RSS/XML Feeds and feed subscription using a feed reader.

Unit III:Bibliographymanagement **8 Lectures**

Introducing a bibliography management software (for e.g. Endnote), Styles and Templates, Changing the bibliography style as per journal format, Citing while typing in the office application, downloading citations from Google Scholar.

Unit IV: Othersoftwareresources **7 Lectures**

Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point, Microphotography and scale calibration with ImageJ, digital image processing (Paint.net or GIMP).

Suggested Readings

1. User manual and online user manual of respective soft wares for the most updated content
2. Published books are not recommended as versions keep on updating very frequently; therefore, it is not easy tofollow.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 3	Science Communication andPopularization	Theory:2

Learning outcomes:

After the completion of this course, the learner will be able to:

- Identify the need and role of science communication in humandevelopment
- utilize visual media science communication for creating scripts anddocumentaries
- Contribute in science popularization through internet communication and public sensitization

Keywords:

Print science, Visual media, Internet communication, Blogs, Outreach talks, Public sensitization

Unit I: PrintScienceCommunication **9 lectures**

Need for Science Journalism: Science has potential for breaking news, impact on Human life, impact on technology. Role of science and technology in human development.Framing policies at national and international levels. Writing and communicating popular articles effectively, case studies of celebrated works of science communicators including Cosmos by Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley, importance for communication through regionallanguages.

Unit II: Visual MediaScienceCommunication **7 lectures**

Science outreach through visual media: Creating science documentaries, creating the outline and expanding, scripts, citing authentic sources, case study: Famous documentaries of Carl Sagan, David Attenborough and Prof. Yashpal

Unit III: InternetScienceCommunication **7 lectures**

Science outreach through internet: Social media, Websites, Blogs, Youtube, Podcast etc.

Unit IV: Science Outreach Talks andPublicSensitization **7lectures**

Tactics for providing a charismatic and effective public talk, use of metaphors, speaking in context, Science outreach for biodiversity conservation sensitization of public

Suggested Readings

1. Selected works of Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and MattRiddley.
2. Gigante, E. Marie (2018). Introducing Science Through Images: Cases of Visual Popularization (Studies in Rhetoric/Communication), University of South CarolinaPress.

Semester	Course	Name of the course	Credits
I,II,III,IV	SEC 4	Biofertilizers (Practical based course)	Theory: 2

Learning outcomes:

On the completion of this course, the students will be able to;

- Develop their understanding on the concept ofbio-fertilizer
- Identify the different forms of biofertilizers and theiruses
- Compose the Green manuring and organicfertilizers
- Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers

Keywords:

Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost

UnitI **9 Lectures**

General account about the microbes used as biofertilizer – Rhizobium – isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis. *Azospirillum:* isolation and mass multiplication – carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics – crop response to *Azotobacter* inoculum, maintenance and massmultiplication.

Unit II **7 Lectures**

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

UnitIII **7 lectures**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit IV **7 lectures**

Organic farming – Green manuring and organic fertilizers, Recycling of bio- degradable municipal, agricultural and Industrial wastes – biocompost making methods, types and method of vermicomposting – field Application.

Suggested Readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, NewDelhi.
2. John Jothi Prakash, E. (2004). Outlines of PlantBiotechnology.Emka Publication, NewDelhi.
3. Kumaresan, V.(2005). Biotechnology, Saras Publications, NewDelhi.
4. NIIR Board. (2012). The complete Technology Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project ConsultancyServices.
5. Sathe, T.V. (2004) Vermiculture and Organic Farming. Dayapublishers.
6. Subba Rao N.S. (2017). Biofertilizers in Agriculture and Forestry. Fourth Edition. Medtech.
7. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizersandorganicFarming Akta Prakashan,Nadiad.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 5	Herbal Science & Technology	Theory: 2

Learning outcomes:

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

- Develop their understanding on HerbalTechnology
- Define and describe the principle of cultivation of herbalproducts.
- List the major herbs, their botanical name and chemicalconstituents.
- Evaluate the drug adulteration through the biologicaltesting
- Formulate the value added processing / storage / quality control for the better use of herbalmedicine
- Develop the skills for cultivation of plants and their value added processing / storage / quality control

Keywords:

Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites

UnitI

7 lectures

Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products.

UnitII

7 lectures

Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmeticals and biopesticides, their Botanical names, plant parts used, major chemicalconstituents.

UnitIII

8 lectures

Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, *Catharanthus roseus*, *Withania somnifera*, *Centella asiatica*, *Achyranthes aspera*, Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.

UnitIV

8 lectures

Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation. of some medicinal plants (*Withania somnifera*, neem andtulsi),

Suggested Readings

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario ofHerbal Technology worldwide: An overview. *Int J Pharm Sci Res*; 4(11):4105-17.
2. Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications,Jaipur.

3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 :88.

4. Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17:987-1000.

5. Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp218.

6. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.* New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government ofIndia.

7. Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition,SAUNDERS/ Elsevier.

8. Sivarajan,V.V.andIndia,B.(1994).AyurvedicDrugsandTheirPlantSources..*Oxford&IBH Publishing Company*, 1994 - Herbs - 570 pages.

9. Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. *Motilal Banarsidass,;Fourth edition.*

10. Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan,Pune.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 6	Fermentation Science and Technology	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to:

- Employ the process for maintenance and preservation ofmicroorganisms
- Analyze the various aspects of the fermentation technology and apply for Fermentative production
- Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio productrecover

UnitI **8 Lectures**

Preparation of microbial culture, Preparation and sterilization of fermentation media.Isolation and improvement of industrially important microorganisms.

UnitII **8Lectures**

Maintenance and preservation of microorganisms, Metabolic regulations and overproduction of metabolites. Kinetics of microbial growth and product formation.

UnitIII **8 Lectures**

Scope and opportunities of fermentation technology. Principles of fermentation: Submerged, solid state, batch, fed-batch and continuous culture. Fermentative production of vinegar, alcohol (ethanol, wine, beer), acids (citric acid and gluconic acid), amino acids (lysine and glutamic acid) and antibiotics (penicillin and streptomycin).

UnitIV **6Lectures**

Microbial production of enzymes: Amylase and Protease. Bioproduct recovery.

Suggested readings

1. Waites M.J. (2008). Industrial Microbiology: An Introduction, 7th Edition, Blackwell Science, London,UK.
2. Prescott S.C., Dunn C.G., Reed G. (1982). Prescott & Dunn's Industrial Microbiology, 4th Edition, AVI Pub. Co.,USA.
3. Reed G. (2004). Prescott & Dunn's industrial microbiology, 4th Edition, AVI Pub. Co., USA.
4. JR Casida L.E. (2015). Industrial Microbiology, 3rd Edition, New Age International (P) Limited Publishers, New Delhi,India.
5. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) Industrial Microbiology: An Introduction. 1st Edition, Blackwell Science, London,UK.
6. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, NewDelhi.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 7	Environmental impact analysis (Practical based)	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to;

- Have critical understanding of environmentalimpact
- Learn important steps of EIAprocess
- Interpret the environmental appraisal and procedures inIndia.

Unit I: OriginandDevelopment **8 Lectures**

Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.

Unit II:EIAProcess **8 Lectures**

Components of EIA, EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.

Unit III: Main participants inEIAProcess **7 Lectures**

Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA.Public participation.

Unit IV: Environmental Appraisal and Procedures in India and EIA **7 Lectures**

Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.

Practical

1. Prepare a Matrix of every environmental existing resource of your college or your hostel/mohalla or any defined area and evaluate each component using established methods and make auditanalysis.
2. Prepare a case report of Environmental impact of any area underdevelopment.

Suggested readings:

a. Kulkarni V and Ramachandra TV, (2006). Environmental Management, Capital Pub. Co. NewDelhi.

b. Petts, J. (2005) Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers,UK.

c. Glasson, J. Therivel, R. and Chadwick, (2006) A. Introduction to Environmental Impact Assessment. Routledge,London.

d. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, NewYork;

e. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL

Press,London;

f. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science,Oxford;

g. Therivel, R. and Partidario, M. R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan,London;

h. Vanclay, F. and Bronstein, D. A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons,Chichester.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 8	Skill Enhancement Course: IT skills for chemists	Theory: 2

Learning outcome

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

- Have understanding of fundamental mathemarical functions
- Understand uncertainty in experimental techniques
- Develop computer programmes using various programs.

UNIT-I: IT Skills for Chemists

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

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities. Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors.Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression). Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary–bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations). Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

UNIT-II: Computer programming:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions.Elements of the BASIC language.BASIC keywords and commands.Logical and relative operators.Strings and graphics.Compiled versus interpreted languages.Debugging.Simple programs using these concepts.Matrix addition and multiplication.Statisticalanalysis. BASIC/FORTRAN programs for curve fitting, numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method).

Recommended books/References:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005). 3.Steiner, E. The Chemical Maths Book Oxford University Press (1996). 4.Yates, P. Chemical calculations. 2nd Ed. CRC Press(2007).
5. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.
6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487pages.

7. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co.(1985).
8. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi(1996).

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 9	Intellectual property right (IPR) and business skills forchemists	Theory: 2

Learning outcome

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

- Know History, types and important of intellectual property.
- Have understanding about different types of trademarks.
- Know about Patent and copyright transfer system
- Learn about registration, Industial design and trade secrets and different international agreements about IPR

Introduction to Intellectual Property:

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

Copyrights

Introduction, How to obtain, Differences from Patents.

Trade Marks

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

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

Geographical Indications

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

Industrial Designs

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

Layout design of integrated circuits

Circuit Boards, Integrated Chips, Importance for electronic industry.

Trade Secrets

Introduction, Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

Different International agreements

(a) World Trade Organization(WTO):

(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade related Services (GATS) (iii) Madrid Protocol (iv) Berne Convention (v) Budapest Treaty.

(b) ParisConvention

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity

IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Intellectual Property in the Indian Context – Various laws in India Licensing and

technology transfer.

Business Basics

Key business concepts: Business plans, market need, project management and routes to market.

Chemistry in Industry

Current challenges and opportunities for the chemistry-using industries, role of chemistry in India and globaleconomies.

Financial aspects

Financial aspects of business with case studies.

Recommended Books/References:

1. Acharya, N.K. Textbook on intellectual property rights, Asia Law House(2001).
2. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications(2003).
3. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw- Hill(2001).
4. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers(2000).
5. Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, NewDelhi.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 10	Analytical Clinical Biochemistry	Theory: 2

Learning outcome

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

- Identify among various biological molecules
- Understand primary, secondary and tertiary structures of proteins.
- Indentify structures of DNA, RNA, Lipids etc.
- Know about nomenclature, Classification of Enzymes

Structure, properties and functions of carbohydrates, lipids and proteins:

Carbohydrates:Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides.

Proteins:Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins.

Enzymes:Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Lipids:Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.

Structure of DNA(Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

***Enzymes*:** Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition.

A diagnostic approach to biochemistry:

Blood:Composition and functions of blood, blood coagulation. Blood collection and preservation of samples.Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol andbilirubin.

Urine:Collection and preservation of samples. 6. Formation of urine. Composition and estimation of constituents of normal and pathological urine.

Recommended books/references:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry.* Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry,* Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.

5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Analytical Clinical Biochemistry Practical

Identification and estimation of the following:

1. Carbohydrates – qualitative andquantitative.
2. Lipids –qualitative.
5. Determination of cholesterol using Liebermann- Burchardreaction.
6. Proteins –qualitative.
7. Isolation of protein.
8. Determination of protein by the Biuretreaction.
9. Determination of nucleicacids.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry*. Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry*, Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 11	Mushroom Culture Technology	Theory: 2

Learning outcomes:

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

- Recall various types and categories ofmushrooms.
- Demonstrate various types of mushroom cultivatingtechnologies.
- Examine various types of food technologies associated with mushroomindustry.
- Value the economic factors associated with mushroomcultivation
- Device new methods and strategies to contribute to mushroomproduction.

Keywords:

Edible mushrooms, Poisonous mushrooms, Cutivation technology, Mushroom bed, Mushroom unit, Storage and Nutrition

UnitI **7Lectures**

Introduction, History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus*.

UnitII **9 Lectures**

Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low-cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparations of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low-cost technology, Composting technology in mushroomproduction.

UnitIII **7 Lectures**

Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

UnitIV **7 Lectures**

Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and regional level. Cost benefit ratio - Marketing in India and abroad, ExportValue.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore -560018.
3. Tewari, Pankaj and Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol.II.

CERTIFICATE COURSEs/VALUE ADDED COURSES

Semester	Course	Name of the course	Credits=02
I-VI	VAC-3	Fuel Chemistry	Theory+ Practical

1. **Department** Chemistry
2. **Name of the Course:** Certificate Course in Fuel Chemistry
   Nature of Course(Certificate/ Value Added): Certificate
3. **Mode of Course:** Hybrid Mode (Online + Offline)
   Online / Offline / Physical
4. **Number of Seats:** 20
5. **Eligibility Criteria for Admission:** 12th Pass, Ongoing B Sc in any discipline with Chemistry as a paper.
6. **Introduction and relevance of Course**:

In the present scenario energy are first and foremost requirement for the socio-economic development of the society and nation as well which is also recognized by United Nations (UN) as one of the very important and inevitable common goals for the sustainable development goals (SDGs). This course will enable the scientific knowledge, skill and hands-on experience about the most non-renewable energy sources fossil fuels (coal, petroleum, and natural gas) to meet out the energy demand of the country. This will assist them to be industry ready to contribute effectively in the field of coal, petroleum chemistry and technology. In the Bilaspur city the regional research centre of CSIR-Central Institute of Mining and Fuel Research (CIMFR) is located where they recruit the project assistant and project fellow having the knowledge and experience on fuel chemistry, therefore, this course will provide job opportunities too.

7. **Objectives of the course**: The course will have the following objectives
   - To know about the sources of energies.
   - To study the fuel as the main source of energy particularly fossil fuels.
   - To know the chemical compositions of different fuels
   - To study Domestic and industrial applications of coal.
   - To understand about petroleum and petrochemical industry.
   - Various prospects of lubricants
8. **Learning outcome of the course**:
   - Understand both conventional based fuels, and alternative & renewable fuels.

- Understand the chemistry that underpins coal and petroleum fuel science and technology.
- They will understand the refining processes used to produce fuels and lubricants and will know how differences in chemical composition affect properties of fuels and their usage in different applications.
- Understand the fuel product specifications, various test methods used to qualifydifferent types of fuels as well characterization methods.
- They will get experimental experience on fossil fuels like coal, petroleum, and natural gas)
- Students can get job opportunities in various projects of of CSIR-Central Institute of Mining and Fuel Research (CIMFR).

9. Number of lectures: 2 hour per week (02 Credit)

10. Number of practical's (if any): 2 hour per week (01 Credit)

11. List of experiments (If any)-

- Determination of flash point & fire point of given fuel sample.
- Determination of viscosity index, cloud point, pour point of given fuel sample.
- Determination of calorific value of given fuel sample/coal sample using bomb calorimeter. Proximate analysis of given coal sample.
- Determination of the iodine number of oil.
- Determination of the saponification number of oil.

12. Syllabus:

Credits: 02 **30 Lectures**

Unit 1

Review of energy sources (renewable and non-renewable). Energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission.Classification of fuels and their calorific value. Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel

Unit II

Coal as Fuel: Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point. Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit III

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining anddifferent types

of petroleum products and their applications Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit IV

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (flash point, fire point, viscosity index, cloud point, pore point) and their determination.

13. Suggestive Readings:

- Industrial Chemistr by Stocchi, E. Vol-I, Ellis Horwood Ltd. UK (1990).
- Engineering Chemistry by Jain, P.C. & Jain, M. Dhanpat Rai & Sons, Delhi.
- A Text Book of Engineering Chemistry S. S. Dara S Chand & Company
- Industrial Chemistry by Sharma, B.K. & Gaur, H. Goel Publishing House, Meerut (1996).
- Chemistry of Fossil Fuels and Biofuels by Harold Schobert , Cambridge University Press 2013.
- The Chemistry and Technology of Coal by James G. Speight, CRC Press Boca Raton (2012)
- Water for Energy and Fuel Production, Yatish T. Shah, CRC Press Boca Raton (2014)
- Process Chemistry of Coal Utilization: Impacts of Coal Quality and Operating Conditions by Stephen Niksa, Elsevier 2019
- Chemistry of Coal Conversion by Richard H. Schlosberg Springer (1985).
- The Chemistry and Technology of Petroleum by James G. Speight CRC, Boca Raton (2014).
- Lubricants and Lubrication by Wilfried Dresel, Wiley (2017).

14. Course Coordinator (Name & Designation)

Dr S S Thakur, Assistant Professor

Prof G, K Patra, Professor

15. Evaluation Criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	**20**	**20**	**60**	**100**

16. Infra Structure requirements (if any): Basic laboratory with small instrument like flash and fire point apparatus, Bomb Calorimeter, viscometer, consumables chemicals etc.

17. Financial Requirement (if any): Rs. 50,000/- for instrument and chemicals

18. Proposed fee for the Course (if any): 5000/- (or as per direction of the university)

19. Budgetary provisions : 50, 000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-5	POLYMER CHEMISTRY	Theory+ Practical

1. **Department:** Chemistry
2. **Name of the Course:** Certificate Course in Polymer Chemistry
3. **Nature of Course:** Certificate or Value Added Course: Certificate
4. **Mode of Course:** Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5. **Number of Seats:** 20
6. **Eligibility Criteria for Admission:** Intermediate/ B Sc in any discipline with Chemistry as a paper
7. **Introduction and relevance of Course**: Polymer is a natural or artificial chemical compound consisting of large molecules which are made up of smaller, joined-together molecules called monomers. Due to their broad spectrum of properties, both synthetic and natural polymers play essential and versatile roles in everyday life.Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. This course will provide the opportunity to the learner to get job in polymer industries. Learner can start own small level work based on polymer Processing that are one of the part of Syllabus
8. **Objectives of the course:**
   - To study the methods for preparation of variety of Polymers
   - To study the utilization of polymer in the preparation of different industrial articles along with other important compounds.
9. **Learning outcome of the course:** This course will educate the students on the subject of polymers that constitute one of the most important materials used presently. The course will include fundamentals of synthesis, characterization, properties and also include discussion on the applications of polymers, as well as challenges pertaining to contemporary polymer research.
10. **Number of lectures (I hour =1 credit per week):**2 (02 hour)
11. **Number of practical's (if any)(2 hours = 1 Credit per week):** 1(2 Hour)
12. **List of experiments (If any)-** attached with annexure I
13. **Syllabus:** See annexure 1
14. **Suggestive Readings:** See annexure 1
15. **Course Coordinator (Name & Designation):** Dr Arti Srivastava, Assistant Professor

16. **Evaluation Criteria** (to be decided by HOD and Course Teacher) by Written examination of theory and practical.
17. **Infra Structure requirements (if any):** Available in the department, 01 instrument required
18. **Financial Requirement (if any):**
19. **Proposed fee for the Course (if any):** 5000/-
20. **Budgetary provisions** – See annexure II

Syllabus on Polymer Chemistry (Certificate Course)

Credits: 02 **30 Lectures**

Unit 1

Introduction: Background, Nomenclature, Classifications, Examples and Applications, Principles of Polymerization

Unit II

Synthesis of Polymers: Step-Growth Polymerization, Radical Chain Polymerization, Controlled Radical Polymerization, Copolymerization Ionic Chain Polymerization, Coordination Polymerization, Ring-Opening Polymerization, Polymerization techniques.

Unit III

Characterization of Polymers: Determination of Molecular Weight, Frictional Properties of Polymers in Solution, Hydrodynamic Size, DSC, TGA and SEM.

Unit IV

Polymer Properties: Crystallinity in polymers, Glass transition temperature, Rheological properties, Mechanical, Optical, Electrical, Surface and Other Industrially Relevant Properties Degradation of polymers.

Unit V

Some industrially important Polymer reactions, Polymer Processing: Polymer additives, compounding and processing techniques

21. Books recommended:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.

2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.

3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore

4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)

5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar , Polymer Sciences, Wiley Eastern, New Delhi

(1986).

A Visit to Polymer Industry

Suggested list of Experiments (based on availability of the resources)

1. Purification of monomer
2. Radical polymerization vinyl monomers.
3. Determination of molecular weight of polymer by viscometric method.
4. Determination of molecular weight of polymer by GPC method
5. Synthesis of Nylon.
6. Synthesis of Hydrogel and its application

Annexure II

Amount of Minimum Proposed Budget: Rs 50,000/-

Amount required for Chemical: Rs 40,0000/-

Miscellaneous budget: Rs 10,000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-4	COSMETIC FORMULATION	Theory+ Practical

Total Credit: 02 **Total hours: 30**

Course Objective:

This course is intended to provide a comprehensive survey of ingredients fundamental to the cosmetic industry. The course will emphasize current trends in the selection of cosmetic ingredients. The chemistry and technology of cosmetic raw materials will be related to their behavioral properties as utilized in the construction of stable functional systems. In this way, it is intended to generate a better understanding of the contributions of ingredients to the performance of finished product formulations. Emphasis will be placed on recognizing and dealing with problem areas associated with the use of various ingredients. Safety considerations and other pertinent matters which can influence ingredient selection will be included in these discussions.

Course Content:

UNIT - I: Classification of raw materials and raw materials used in the cosmetic industry for the manufacture of finished products. Method of sampling, Indian Standard specification laid down for sampling and testing of various cosmetics in finished form by the bureau of Indian standards. Factors affecting stability of a formulation, ICH guidelines, Methods of stabilizations and Methods of stability testing.Concept of development of stability indicating analytical methods.

UNIT - II: Determination of physical and chemical constants such as extractive values, moisture content, alcohol content, volatile oil content, ash values, bitterness values, foreign matters, and physical constants applicable to the lipid containing drugs.

UNIT III: Brief introduction of the following cosmetic preparation and a detailed study on their quality control: Shampoo, Tooth paste, skin powder, skin creams, hair creams, nail polish, after shave lotion, bath and toiletries, lipstick and hair dyes, perfumes, depilatories.

UNIT- IV: Packaging of cosmetics –Filling of solids, semisolids & liquids. Materials used for cosmetic packaging Rules & regulations and legal provisions for packaging & labeling.

UNIT-V: Experiments: Nano-Formulation of Gels, Shampoos, Hair-conditioners; Color cosmetics

Examination Scheme:

Components	**Class Test**	**Hands on Experiment**	**End Semester**	**Total**
Weightage (%)	**20**	**20**	**60**	**100**

Text & References:

1. Comprehensive Pharmacy Review 5th Edition by Leon Shargel, Alan H. Mutnick, Paul F. Souney, Larry N. Sawnson – 2004.
2. Applied Biopharmaceutics and Pharmacokinetics, 4th Edition by Leon Shargel / Andrew B.C., Yu – 1999.
3. A. H. Beckett and J. B. Stenlake Practical Pharmaceutical Chemistry, Part I and Part II, 4th Edition.
4. G. H. Jeffery, J. Basset, J. Mendham, R. C. Denny (Rev. by) Vogels Text Book of Quantitative Chemical Analysis, 5th Edition 1989, ELBS.
5. The Controller of Publications; New Delhi, Govt. of India, Indian Pharmacopoeia, Vol. I and Vol. II - 1996.
6. J. B. Wilkinson and R. J. Moore: Herry's Cosmeticology; Longman Scientific and Technical Publishers, Singapore.
7. P.D. Sethi; Quantitative Analysis of Drugs in Pharmaceutical Formulations, 3rd Edition - 1997,
8. ICH guideline for impurity determination and stability studies.
9. Practical HPLC method development by Lloyd R. Snyder, Joseph J. Kirkland, Joseph I. Glajch, John Wiley and Sons 2nd Edition – 1997
10. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
11. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Edited by M. S. Dresselhaus,G. Dresselhaus, P. Avouris, Springer-Verlag, 2000.
12. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
13. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

14. Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.

How is Cosmetic Formulation Course Beneficial?

- They can also work in hospitals by training patients how to take care of their skin after surgery.
- They can also have jobs related to manicure and pedicure such as to beautify the hands and nails by cleaning and shaping the nails; decorate nails with paintings or designs or even with imitation jewels.

Cosmetic Technology Employment Areas

- Advertisement Industries
- Beauty Clinics
- Beauty parlour
- Food & Cosmetic Industries
- Resorts
- Skin Clinics
- Spa Centers
- Star Hotels

Semester	Course	Name of the course	Credits=02
I-VI	VAC-1	**EFFICIENT TECHNOLOGIES FOR FOOD PROCESSING AND SHELF LIFE EXTENSION**	Theory+ Practical

1. Department: Chemistry
2 Name of the Course: Certificate Course in
3 Nature of Course: Certificate or Value Added Course: Certificate
4 Mode of Course: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5 Number of Seats: 20
6 Eligibility Criteria for Admission: B Sc in any discipline with Chemistry as a paper
7. **Introduction and relevance of Course**: Food processing which includes both fresh and packaged food involves handling of foods, preparation and storage through the subsequent stages so that the pathogens and toxic components present in food are destroyed and deactivated making the food safer and hygienic. Food preservation techniques combines science-based knowledge with technologies, to prevent spoilage and extend shelf-life and ensure consumers free of pathogenic microorganism food. Deterioration of food leads to loss of quality including color, texture, taste as well as nutritive value.By preserving food, food waste can be reduced, which is an important way to decrease production costs and increase the efficiency of food systems, improve food security and nutrition and contribute towards environmental sustainability.For instance, it can reduce the environmental impact of food production
8. **Objectives of the course:**
   - ✓ To impart knowledge in the area of food science and technology
   - ✓ To aware with the recent technologies used in food preservation and processing
   - ✓ To understand the quality control of different food items
   - ✓ To understand the importance of food safety and food management

1. Learning outcome of the course:

After completing this certificate course the learner will be able to:

- ✓ understand the food processing and technology, its history,development and present status
- ✓ explain the significance and basic concepts of the subject
- ✓ aware of the skills required to be a professional food technologist
- ✓ aware of the career opportunities available and educational
- ✓ qualifications required for specific careers in the industry
- ✓ know the scope for self employment as small, medium or large scaleentrepreneurs.

10. Number of lectures (I hour =1 credit per week): 1 (01 hour)
11. Number of practical's (if any) (2 hours = 1 Credit per week) 1(2 Hour)
12. List of experiments (If any)- attached with annexure I
13 Syllabus:

Credits: 02 **30 Lectures**

Unit I

Introduction: Food Constituents & Functions, Quality and Safety Aspects of Food, Factors Affecting Quality during Processing and Storage, Role of Water in Food and its Shelf Life, Browning Reactions

Unit II

Technologies in Food Preservation: Principles of Food Preservation, Traditional Food Preservation Technologies, High Pressure Processing of Food, Membrane Technology, Food Irradiation, Hurdle Technology.

Unit III

Nanotechnology in Food Packing: Nano encapsulation,Nanoemulsions, Nanoparticles/active packagingNanoclays in packaging, Nanocomposites in packaging, Nanosensors at the packaging and processing plant, Nanosensors in plastic film packages/ Electronic tongue/ Intelligent packaging, NanosensorsNanofibresColor changing labels: Nanocochelates/ nanodroplets, Nanofilms/ Nanolaminates

Unit IV

Food Quality enhancement and analysis: Rancidity, Natural Antioxidants,High Energy RTE Food Paste, Ozonation of Food Grains, Food Fortification: Iron Fortified Rice (IFR), Nutri Dal and Fortified Noodles, Hyper Spectral Imaging for Quality Analysis of Food Grains, Non-Destructive Methods for Analysis of Grain Quality, Detection of Spoilage in Grains using Biosensors.

Practical

- To study the effect of enzymatic browning in fruits and vegetables.
- To study different types of blanching of fruits and vegetables.
- Preservation of food by canning.
- To perform cut out analysis of caned product.
- Preservation of food by high concentration of sugar i.e. jam.
- Preservation of food by high concentration of salt/acid i.e. pickle.
- Preservation of food by addition of chemicals i.e. tomato ketchup.
- Preservation of food by drying in a cabinet drier.
- Preservation of fruits & vegetables by freezing.

- Preservation of milk by pasteurization and sterilization.

14. Suggested readings/ Text and Reference Books:

- Food Processing Technology by P.J.Fellows, Woodhead publishing ltd.
- Food Science by N.N. Potter, CBS publishing.
- Physical principles of Food Preservation. Vol. II by M. Karel, O.R. Fenema and D.B. Lurd, Maroel, Dekker Inc. New York.
- The technology of food preservation by N.W. Desrosier and J.N. Desrosier, CBS publishing

15. Course Coordinator:

a. Dr NirajKumari, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

b. Dr Arti Srivastava, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

16. Evaluation Criteria (to be decided by HOD and Course Teacher):

Components	Class-Test	Experiment	End Semester	Total Marks
Weightage (%)	**20**	**20**	**60**	**100**

17. Infrastructure requirements (if any): Basic laboratory system with pH meter, magnetic stirrer, characterization and small testing equipments.

18. Financial Requirement (if any): Approx. Rs 50,000

19. Proposed fee for the Course (if any): Rs.5000.00 (As per the University's norms).

20. Budgetary provisions: Rs.50,000.00

Minutes of BOS Meeting
Department of Chemistry, GGV
Date: 28/10/2021

As per the notification (216/*Academic/2021,* dated 08-10-2021), a meeting of the Board of Studies (BoS) for the Department of Chemistry was convened on 28-10-2021 at 12:00 noon at the Departmental meeting room. The external expert of BoS attended the meeting through online video conferencing using Google meet.

The following members were present in the meeting:

1. Dr Santosh Singh Thakur – Chairman
2. Prof. C. R. Sinha – External Expert
3. Prof. G. K. Patra – Member
4. Dr. A. K. Singh– Member
5. Dr. V. K. Rai – Member

In this meeting, the contents of each paper of learning outcome based curriculum framework (LOCF) at undergraduate (UG) level and choice based credit system (CBCS) at postgraduate level (P.G.) were thoroughly discussed and suggestions made by members (both internal and external) were considered and incorporated. The syllabus of Chemistry was thoroughly modified and restructured as per university as well as UGC guidelines. The schemes and syllabus of UG and PG course in Chemistry are attached (Annexure –I and Annexure –II) which would be submitted to the university authority for approval.

Signature of BoS Members:

1. Dr. Santosh Singh Thakur
(Chairman)

2. Prof. C. R. Sinha
(External Expert)

3. Prof. G. K. Patra
(Member)

4. Dr. A. K. Singh
(Member)

4. Dr. V. K. Rai
(Member)