RADHA GOVIND UNIVERSITY
RAMGARH, JHARKHAND

DEPARTMENT OF CHEMISTRY

NEP FYUGP CURRICULUM
CHEMISTRY HONOURS/
CHEMISTRY HONOURS WITH RESEARCH PROGRAMME
SUBJECT CODE = 14

FOR UNDERGRADUATE COURSES UNDER
RADHA GOVIND UNIVERSITY

Implemented w.e.f.
Academic Session 2025-2026 & onwards

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HIGHLIGHTS OF FYUGP CURRICULUM

PROGRAMME DURATION

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entry and multiple exit options.
- The session shall commence from the **1st of July**.

ELIGIBILITY

- The selection for admission will be primarily based on the availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in the Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if the Marks of the Major subject is not available. Reservation norms of the Government of Jharkhand must be followed as amended in times.
- UG Degree Programmes with Double Major shall be provided only to those students who secure a minimum of 75% overall marks or 7.5 CGPA or higher.
- Other eligibility criteria, including those for multiple entry, will be in light of the UGC Guidelines for Multiple Entry and Exit in Academic Programmes offered in Higher Education Institutions.

ADMISSION PROCEDURE

- The reservation policy of the Government of Jharkhand shall apply in admission and the benefit of the same shall be given to the candidates belonging to the State of Jharkhand only. The candidates of other states in the reserved category shall be treated as General category candidates. Other relaxations or reservations shall be applicable as per the prevailing guidelines of the University for FYUGP.

VALIDITY OF REGISTRATION

- Validity of a registration for FYUGP will be for a maximum of **Seven years** from the date of registration.

ACADEMIC CALENDAR

- An Academic Calendar will be prepared by the University to maintain uniformity in the UG Honours/ Honours with Research Programmes and PG Diploma Programmes, running in the colleges under the university (Constituent/Affiliated).
- **Academic Year:** Two consecutive (one odd + one even) semesters constitute one academic year.
- **Semester:** The Odd Semester is scheduled from **July to December and** the Even Semester is from **January to June**. Each week has a minimum of 40 working hours spread over 6 days.
- Each semester will include Admission, coursework, conduct of examination and declaration of results, including semester break.
- To undergo an 8-week summer internship/ apprenticeship during the summer camp, the Academic Calendar may be scheduled for academic activities as below:
  a) Odd Semester: **From the first Monday of August to the third Saturday of December**
  b) Even Semester: **From the first Monday of January to the third Saturday of May**
- An academic year comprising 180 working days in the least is divided into two semesters, each semester having at least 90 working days. With six working days in a week, this would mean that each semester will have 90/ 6 = 15 teaching/ working weeks. Each working week will have 40 hours of instructional time.
- Each year, the University shall draw out a calendar of academic and associated activities, which shall be strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavours to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change, prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry

options within this period, with appropriate certifications such as:

- UG Certificate after completing 1 year (2 semesters) of study in the chosen fields of study, provided they complete one vocational course of 4 credits during the summer vacation of the first year or internship/ Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semesters.,
- UG Diploma after 2 years (4 semesters) of study diploma provided they complete one vocational course of 4 credits or internship/ Apprenticeship/ skill based vocational courses offered during the first year or second year summer term, in addition to 9 credits from skill-based courses earned during the first, second and third semester.
- Bachelor's Degree after a 3-year (6 semesters) programme of study,
- Bachelor's Degree (Honours) after a 4-year (8 semesters) programme of study.
- Bachelor's Degree (Honours with Research) after a 4-year (8 semesters) programme of study to the students undertaking a 12-credit Research component in the fourth year of FYUGP.

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.
One credit for Theory = 15 Hours of Teaching
One credit for Practicum = 30 Hours of Practical work
One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
Hours (L) – Classroom Hours of one hour duration.
Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.
Internship – For the Exit option after any academic year of a Four-year U.G. Programme for the award of U.G. Certificate, U.G. Diploma, U.G. Degree (Level 4.5, 5 or 5.5 respectively), Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

CHANGE OF MAJOR OR MINOR COURSES

- The change of Major or Minor courses may be allowed only once after the Second Semester and before the third Semester in the FYUG Programme, depending on the provisions laid by the FYUGP and the conditions laid by the Institution. **However, the student must clear the papers (Mid Sem & End Sem both) from the previous semesters of the new subject opted in the next Examination of the coming session.**

CALCULATION OF MARKS FOR THE PURPOSE OF THE RESULT

- Students' final marks and the result will be based on the marks obtained in the Semester Internal Examination and End Semester Examination organized taken together.
- Passing in a subject will depend on the collective marks obtained in the Semester internal and End Semester University Examination. However, students must pass in Theory and Practical Examinations separately.

PROMOTION CRITERIA

First degree programme with a single major (160+4=164 credits):

i. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
ii. No student will be detained in odd Semesters (I, III, V & VII).
iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 14 papers. It is further necessary

to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum of 20 papers out of the total 26 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum of 27 papers out of the total 36 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 5 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

First degree programme with dual major (192+4=196 credits):

i. Please refer to the FYUGP Regulations for the detailed provisions of Double Major and Dual Degrees.

ii. No student will be detained in odd Semesters (I, III, V & VII).

iii. To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of the Courses in an academic year, a student has to pass in minimum 11 papers out of the total 15 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 8 papers in Semester-II.

iv. To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 20 papers out of the total 27 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 4 papers out of 7 papers in Semester-IV.

v. To get promotion from Semester-VI to Semester-VII (taken all together of Semester I, II, III, IV, V & VI) a student has to pass in minimum 28 papers out of the total 37 papers. It is further necessary to procure pass marks in minimum of 50% papers of the current semester i.e. the student has to pass in 3 papers out of 6 papers in Semester VI.

vi. However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

PUBLICATION OF RESULTS

- The examination result shall be notified by the Controller of Examinations of the University in different newspapers and the same is to be posted also on the University website.
- If a student is found indulging in any malpractice/ unfair means during an examination, the examination taken by the student for the semester will be cancelled. The candidate has to reappear in all the papers of the session with the students of the next session and his one year will be detained. However, marks secured by the candidate in all previous semesters will remain unaffected.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination to clear the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination to clear the backlog.

Regulations related to any concern not mentioned above shall be guided by the Regulations of the Radha Govind University for FYUGP.

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COURSE STRUCTURE FOR FYUGP **'HONOURS/ RESEARCH/ PG DIPLOMA'**

Table 1: Credit Framework for Four-Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 164]

Academic Level	**Level of Courses**	**Semester**	**MJ**: Discipline Specific Courses – Core or Major (80)	**AC**: Associated core courses from discipline/ Interdisciplinary/ vocational (8)		**ELC**: Elective courses may be opted from four paths [Follow table 2] (24)	**MDC**: Multidisciplinary Courses (From a pool of Courses) (9)	**AEC**: Ability Enhancement Courses (Modern Indian Language and English) (8)	**SEC**: Skill Enhancement Courses (9)	**VAC**: Value Added Courses (6)	**IKS**: (i) Indian Knowledge System (2) & **SA**: (ii) Social awareness (2)	**RC**: Research Courses (4+8)/ **AMJ**: Advanced Courses instead of Research (4+4+4)/ **PGD:** PG Diploma Level 6 (4+4+4)		**Total Credits**	**IAP**; Internship/Apprenticeship/ Project/ Vocational course/ Dissertation (4) **In between Sem I to Sem-VI**
	1	2	3 (Major- 80)	4 (Minor-32)			5	6	7	8	9	10	11	12	13
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	4	4	---	---	3	2	3	2	2	---	---	**20**	4
		II	4	---	4	---	3	2	3	2	2	---	---	**20**	
		Exit Point: Undergraduate Certificate provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4+4	---		4	3	2	3	---	---	---	---	**20**	
		IV	4+4+4	---		4	---	2	---	2	---	---	---	**20**	
		Exit Point: Undergraduate Diploma provided with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)													
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		VI	4+4+4+4	---		4	---	---	---	---	---	---	---	**20**	
		Exit Point: Bachelor's Degree with Summer Internship/ Project/ Vocational course/ Dissertation (4 credits)												**124**	
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4+4+4	---		4	---	---	---	---	---	4	4	**20**	---
		VIII	4+4	---		4	---	---	---	---	---	8	4+4	**20**	
		Exit Point: Bachelor's Degree with Honours/ Honours with Research/ PG Diploma Level 6												**164**	

Note: Honours students not undertaking research will do 3 courses for 12 credits in lieu of a Research project.

Table 2: Options for Elective Minor Courses

Path A	Path B	Path C	Path D
ELC-A; Elective courses from Interdisciplinary Subjects 1 & 2 (24)	**ELC-B**; Elective courses from discipline (24)	**ELC-C**; Elective courses from vocational (24)	**ELC-D**; Elective courses from discipline for Double Major (48)
This pathway may be recommended for students who wish to develop core competency in multiple disciplines of study. In this case, the credits for the minor pathway shall be distributed among the constituent disciplines/subjects. If students pursuing FYUGP are awarded a UG Degree in a Major discipline, they are eligible to mention their core competencies in other disciplines of their choice if they have earned 12 credits each from pathway courses of two particular disciplines. In the first three years of FYUGP, this pathway is composed of one Major discipline with 60 credits from 15 courses and two other disciplines, with 12 credits from 3 courses in each discipline. In this pathway, if the students choose one of the two disciplines for 12 credits in one discipline then they should choose a different discipline for the other 12 credits. If the students continue to the fourth year of FYUGP, the students need to earn an additional 4 credits in both disciplines.	This pathway may be recommended to those students who wish for an in-depth study in more than one discipline with a focus on one discipline (Major) and relatively less focus on the other (Minor). If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in another discipline of their choice, if they earn a minimum of 24 credits from the courses in the Minor discipline. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the Minor discipline, to be eligible for a UG Degree (Honours) with a Major and a Minor. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Minor discipline.	This pathway may be recommended to those students who wish for exposure to a vocational discipline in addition to the in-depth study in the Major discipline. The credit requirements for Major and Vocational Minor disciplines in this pathway are the same as those for Major with Minor pathway, except that the Minor courses are in a vocational discipline. If students exit at the end of the third year of FYUGP, they are awarded a Major Degree in a particular discipline and a Minor in vocational discipline of their choice, if they earn a minimum of 24 credits from the Vocational courses. If the students continue to the fourth year of FYUGP, they should earn a minimum of 32 credits in the vocational discipline. For this, in the fourth year, they should earn an additional minimum of 8 credits through 2 courses in the Vocational discipline.	To secure the required minimum credits in each discipline, students who wish to opt for a Double Major should include the credits earned by them from the Multi-Disciplinary Courses, Skill Enhancement Courses and Value-Added Courses offered by the respective Major disciplines. The Double Major pathway is extended to the fourth year. Shifting to a double major from a minor in the third semester will be allowed subject to clearance of the courses of double major (not studied earlier) in succeeding sessions. In the fourth year, the student can continue to earn the required credits in either Major A or Major B to qualify for a UG Degree (Honours)/ UG Degree (Honours with Research) in A or B. If he/she opts to continue with Major B in the fourth year, he/she should earn an additional 16 credits of 300-399 level in Major B through mandatory online courses. The institution will not provide the courses in physical mode in the fourth year of this segment.

Table 3: Credit Distribution in Elective Courses during the Four Years of FYUGP

Academic Level	Level of Courses	Semester	Path A **ELC**; Elective courses from Interdisciplinary Subjects 1 & 2 (24)		Path B **ELC**; Elective courses from the discipline (24)	Path C **ELC**; Elective courses from vocational (24)	Path D **ELC**; Elective courses from the discipline for Double Major (64)
	1	2	3A. Subject 1	3B. Subject 2	4	5	6
Level 4.5	Level 100-199: **Foundation or Introductory courses**	**I**	---	---	---	---	4+4
		II	---	---	---	---	4+4
		Exit Point: Bachelor's Degree with Hons. with Research					
Level 5	Level 200-299: **Intermediate-level courses**	**III**	4	---	4	4	4+4
		IV	---	4	4	4	4+4
		Exit Point: Bachelor's Degree with Hons.					
Level 5.5	Level 300-399: **Higher-level courses**	**V**	4	---	4	4	4+4
		VI	---	4	4	4	4+4
		Exit Point: P.G. Diploma Degree					
Level 6	Level 400-499: **Advanced courses** Hons with Research (>7.5 CGPA)/ Honours/ PG Diploma	**VII**	4	---	4	4	4+4
		VIII	---	4	4	4	4+4
		Exit Point: (A) Bachelor's Degree with Hons. with Research/ (B) Bachelor's Degree with Hons./ (C) P.G. Diploma Degree					

COURSES OF STUDY FOR FOUR-YEAR UNDERGRADUATE PROGRAMME 2025 onwards

Table 4: Semester-wise Course Code and Credit Points for Single Major during the First Three Years of FYUGP

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
I	AEC-1	Language and Communication Skills (MIL-1; Modern Indian language Hindi/ English)	2	**7 Papers** (20 credits)
	VAC-1	Value Added Course-1	2	
	IKS-1	Indian Knowledge System-I (Foundation Course)	2	
	SEC-1	Skill Enhancement Course-1	3	
	MDC-1	Multi-disciplinary Course-1	3	
	AC-1	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-1	Major paper 1 (Disciplinary/ Interdisciplinary Major)	4	
II	AEC-2	Language and Communication Skills (MIL-1; Modern Indian language English/ Hindi)	2	**7 Papers** (20 credits)
	VAC-2	Value Added Course-2	2	
	SA	Social Awareness Activities	2	
	SEC-2	Skill Enhancement Course-2	3	
	MDC-2	Multi-disciplinary Course-2	3	
	AC-2	Associated core courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-2	Major paper 2 (Disciplinary/ Interdisciplinary Major)	4	
III	AEC-3	Language and Communication Skills (MIL-2; MIL including TRL)	2	**6 Papers** (20 credits)
	SEC-3	Skill Enhancement Course-3	3	
	MDC-3	IKS as a Multi-disciplinary Course-3	3	
	ELC-1	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-3	Major paper 3 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-4	Major paper 4 (Disciplinary/ Interdisciplinary Major)	4	
IV	AEC-4	Language and Communication Skills (MIL-2; MIL including TRL)	2	**6 Papers** (20 credits)
	VAC-3	Value Added Course-3	2	
	ELC-2	Elective courses from discipline/ Interdisciplinary/ vocational	4	
	MJ-5	Major paper 5 (Disciplinary/ Interdisciplinary Major having IKS)	4	
	MJ-6	Major paper 6 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-7	Major paper 7 (Disciplinary/ Interdisciplinary Major)	4	
V	ELC-3	Elective courses from discipline/ Interdisciplinary/ vocational	4	**5 Papers** (20 credits)
	MJ-8	Major paper 8 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-9	Major paper 9 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-10	Major paper 10 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-11	Major paper 11 (Disciplinary/ Interdisciplinary Major)	4	
VI	ELC-4	Elective courses from discipline/ Interdisciplinary/ vocational	4	**5 Papers** (20 credits)
	MJ-12	Major paper 12 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-13	Major paper 13 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-14	Major paper 14 (Disciplinary/ Interdisciplinary Major)	4	
	MJ-15	Major paper 15 (Disciplinary/ Interdisciplinary Major)	4	
Total Credits, excluding one Internship (IAP) of 4 credits =			**120**	**120**

Note: It is mandatory to take One Internship of 4 credits in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Table 5A: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours with Research)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII A	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Research Methodology)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	RC-1	Research proposal – Planning & Techniques (Disciplinary/Interdisciplinary Major)	4	
VIII A	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	4 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	RC-2	Research Internship/Field Work/Project/Dissertation/Thesis	8	
Total Credits, excluding one Internship of 4 credits =			**160**	**160**

Table 5B: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (Honours)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII B	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-1	Advanced Major pape-1 (Disciplinary/Interdisciplinary Major)	4	
VIII B	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	AMJ-2 AMJ-3	Advanced Major paper-2 (Disciplinary/Interdisciplinary Major) Advanced Major paper-3 (Disciplinary/Interdisciplinary Major)	4 4	
Total Credits, excluding one Internship of 4 credits =			**160**	**160**

Table 5C: Semester-wise Course Code and Credit Points for Single Major during the Fourth Year of FYUGP for Bachelor's Degree (with Postgraduate Diploma)

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits	
	Code	Papers	Paper	Semester
VII C	ELC-5	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-16	Major paper 16 (Disciplinary/Interdisciplinary Major)	4	
	MJ-17	Major paper 17 (Disciplinary/Interdisciplinary Major)	4	
	MJ-18	Major paper 18 (Disciplinary/Interdisciplinary Major)	4	
	JOC-1	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
VIII C	ELC-6	Elective courses from discipline/ Interdisciplinary/ vocational	4	5 Papers (20 credits)
	MJ-19	Major paper 19 (Disciplinary/Interdisciplinary Major)	4	
	MJ-20	Major paper 20 (Disciplinary/Interdisciplinary Major)	4	
	JOC-2	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
	JOC-3	Skill based Job Oriented paper (Disciplinary/Interdisciplinary Major)	4	
Total Credits, excluding one Internship of 4 credits =			**160**	**160**

AIMS OF BACHELOR'S DEGREE PROGRAMME IN CHEMISTRY

The broad aims of the bachelor's degree programme in Chemistry are:

Chemistry is a pervasive subject. All the branches of science need chemistry. It is an experimental science and students need to train in practicals to get expertise in doing fine experiments and handling sophisticated instruments. Along with the data obtained its statistical analysis is also required to establish authenticity in the fields like environmental science, space chemistry and biotechnology. There is immense potential for chemistry and post-graduates to undertake advanced research or in Industries as skilled chemists.

(i) Broad and balanced knowledge in chemistry in addition to an understanding of key chemical concepts, principles and theories.

(ii) To develop students' ability and skill to acquire expertise in solving both theoretical and applied chemistry problems.

(iii) To provide knowledge and skill to the students' thus enabling them to undertake further studies in chemistry in related areas or multidisciplinary areas that can be helpful for self-employment/entrepreneurship.

(iv) To provide an environment that ensures cognitive development of students in a holistic manner. A complete dialogue about chemistry, chemical equations and its significance is fostered in this framework, rather than mere theoretical aspects

(v) To provide the latest subject matter, both theoretical as well as practical, such a way to foster their core competency and discovery learning. A chemistry graduates as envisioned in this framework would be sufficiently competent in the field to undertake further discipline-specific studies, as well as to begin domain-related employment.

(vi) To mold a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication.

(vii) To enable the graduate, prepare for national as well as international competitive examinations, especially UGC-CSIR NET and UPSC Civil Services Examination.

PROGRAM LEARNING OUTCOMES

The broad learning outcomes of bachelor's degree programme in Chemistry are:

The student graduating with the Degree B.Sc. (Honours/Research) in Chemistry should be able to understand:

(i) **Core competency:** Students will acquire core competency in the subject Chemistry and in allied subject areas.

(ii) Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.

(iii) Students will be able to understand and use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.

(iv) The students will be able to understand the characterisation of materials.

(v) Students will be able to understand the basic principles of equipment, instruments used in the chemistry laboratory.

(vi) Students will be able to understand and demonstrate the experimental techniques and methods of their area of specialization in Chemistry.

(vii) **Disciplinary knowledge and skill:** A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry, etc. Further, the student will be capable of using of advanced instruments and related software for in-depth characterisation of materials/chemical analysis and separation technology.

(viii) **Skilled communicator:** The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

(ix) **Critical thinker and problem solver:** The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

(x) Sense of inquiry: It is expected that the course curriculum will develop an inquisitive characteristic among the students through appropriate questions, planning and reporting experimental investigation.

(xi) **Team player:** The course curriculum has been designed to provide an opportunity to act as a team player by contributing in laboratory, field-based situations and industry.

(xii) **Skilled project manager:** The course curriculum has been designed in such a manner as to enable a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.

(xiii) **Digitally literate:** The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools and use of chemical simulation software and related computational work.

(xiv) **Ethical awareness/reasoning:** A graduate student is required to understand and develop ethical awareness/reasoning, which the course curriculum adequately provides.

(xv) **Lifelong learner:** The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT techniques and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunities.

SEMESTER WISE COURSES IN CHEMISTRY HONOURS **2025 onwards**

Table 6: Semester-wise Course Code and Credit Points of Major Courses in Chemistry

Semester	Courses		Examination Structure			
	Code	Courses in NEP FYUGP Syllabus of Chemistry Session 2025-26 & onwards	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Chemistry-I	4	25	75	---
	SEC-1	Fuel & Pharmaceutical Chemistry	3	---	75	---
II	MJ-2	Chemistry-II	4	25	75	---
	SEC-2	Green Chemistry	3	---	75	---
III	MJ-3	Chemistry-III	4	25	75	---
	MJ-4	Practical-I	4	---	---	100
	SEC-3	Elementary Computer Application Softwares	3	---	75	---
IV	MJ-5	Chemistry-IV (IKS in Chemistry)	4	25	75	---
	MJ-6	Chemistry-V	4	25	75	---
	MJ-7	Practical-II	4	---	---	100
V	MJ-8	Chemistry-VI	4	25	75	---
	MJ-9	Chemistry-VII	4	25	75	---
	MJ-10	Chemistry-VIII	4	25	75	---
	MJ-11	Practical-III	4	---	---	100
VI	MJ-12	Chemistry-IX	4	25	75	---
	MJ-13	Chemistry-X	4	25	75	---
	MJ-14	Chemistry-XI	4	25	75	---
	MJ-15	Practical-IV	4	---	---	100
VII	MJ-16	Chemistry-XII (Research Methodology)	4	25	75	---
	MJ-17	Chemistry-XIII	4	25	75	---
	MJ-18	Practical-V	4	---	---	100
	AMJ-1/	Advanced Chemistry-I OR	4	25	75	---
	RC-1	Research Planning & Techniques	4	25	75	---
VIII	MJ-19	Chemistry-XIV	4	25	75	---
	MJ-20	Practical-VI	4	---	---	100
	AMJ-2	Advanced Chemistry-II	4	25	75	---
	AMJ-3/	Practical-VII (Advanced Chemistry)	4	---	---	100
	RC-2	Project Dissertation/ Research Internship/ Field Work	8	50	---	150

***** It is mandatory to take Either One Internship of 4 credits or Two Internships of 2 credits each in any one of the semesters during the first three years in FYUGP or before exit at any of the exit points if a student wishes to opt for the same.

Topics in each course of the Chemistry Major are as follows:

1. **MJ-1** **Chemistry-I**
   Structure of Atom, Periodicity of Elements, Chemical Bonding & Molecular Structure, Basics of Organic Chemistry, Elementary concepts of Stereo Chemistry
2. **SEC-1** **Fuel & Pharmaceutical Chemistry**
   Energy Resources & Fuel, Pharmaceuticals
3. **MJ-2** **Chemistry-II**
   Gaseous State, Liquid State, Solid State, Hydrocarbons
4. **SEC-2** **Green Chemistry**
   Introduction to Green Chemistry, Principles of Green Chemistry and Designing a Chemical Synthesis, Examples of Green Synthesis/ Reactions, Future Trends in Green Chemistry
5. **MJ-3** **Chemistry-III**
   Hydrogen & its Compounds, S-block Elements, Redox Reactions, general principle of metallurgy, Chemistry of Halogenated Hydrocarbons, Functional Group containing Oxygen-I
6. **MJ-4** **Practical-I**
7. **SEC-3** **Elementary Computer Application Softwares**
   Basic Concept of Computer, Concepts of Hardware, Operating System, Concept of Software, Internet & its uses, Microsoft Word, Microsoft Excel, Microsoft PowerPoint, Digital Education
8. **MJ-5** **Chemistry-IV (IKS in Chemistry)**
   Principles of Indian Knowledge System in Chemistry, Relevant Topics of IKS in Chemistry, Application of IKS in Chemistry, Case Study, p-block Elements
9. **MJ-6** **Chemistry-V**
   Thermodynamics-I & Thermochemistry, Thermodynamics-II, Functional Group containing Oxygen-II
10. **MJ-7** **Practical-II**
11. **MJ-8** **Chemistry-VI**
    Chemical Equilibria-I, Chemical Equilibria-II, Ionic Equilibria, Phase Equilibria, Chemical Kinetics
12. **MJ-9** **Chemistry-VII**
    d-block Elements, f-block Elements, Coordination Chemistry
13. **MJ-10** **Chemistry-VIII**
    Functional Group containing Nitrogen, Aromatic Heterocyclic Compounds, Active Methylene groups, Carbohydrates
14. **MJ-11** **Practical-III**
15. **MJ-12** **Chemistry-IX**
    Electrolytic Conductance, Electrochemistry, Surface Chemistry, Catalysis, Dilute Solution
16. **MJ-13** **Chemistry-X**
    Organometallic Compounds, Synergic effects, Ferrocene & Zeise's salt, Metal Clusters, Inorganic Polymers.
17. **MJ-14** **Chemistry-XI**
    Classification & Characterisation of Polymers, Properties of Polymers, Frontier areas of polymer science and technology, Amino acids, Peptides & Proteins, Nucleic acids, Lipids
18. **MJ-15** **Practical-IV**
19. **MJ-16** **Chemistry-XII**
    Research Methodology: Introduction to Research, Research Design and Sampling, Data Collection Methods, Data Analysis and Interpretation, Report Writing and Research Ethics
20. **MJ-17** **Chemistry-XIII**
    Microwave Spectroscopy, Vibrational Spectroscopy: Infrared Spectroscopy, Raman Spectroscopy, UV Spectroscopy, NMR Spectroscopy, Mass Spectroscopy
21. **MJ-18** **Practical-V**
22. **AMJ-1** **Advanced Chemistry-I**
    Stereochemistry and Bonding in Main Group Compounds, Metal-Ligand Bonding, Metal-Ligand Equilibria in Solution, Acids, Bases, Electrophiles, Nucleophiles and Catalysis, Nature of Bonding in Organic Molecules, Stereochemistry, A Mathematical Approach to MO Theory, Unifying Principles.

    Or RC-1 **Research Planning & Techniques (Instead of AMJ1):**

Research Planning and Design based on objectives, Research Methods and Techniques, Synthesis, Purification & Sampling, Instrumentation Techniques and their Relevance, Interpretation of Results, Project Work and Practical Application

23. **MJ-19** **Chemistry-XIV**
Quantum Chemistry, Nuclear Chemistry
24. **MJ-20** **Practical-VI**
25. **AMJ-2** **Advanced Chemistry-II**
General Mechanism in Organic Chemistry, Aliphatic Nucleophilic Substitution, Aliphatic Electrophilic Substitution, Addition to Carbon-Carbon Multiple Bonds, Addition to Carbon-Hetero Multiple Bonds, Aromatic Electrophilic & Nucleophilic Substitution, Free Radical Reactions & Organic Reagents
26. **AMJ-3** **Practical-VII (Advanced Chemistry)**
Or RC-2 **Project Dissertation/ Research Internship/ Field Work (Instead of AMJ2 & AMJ3)**

Table 7: Semester-wise Course Code and Credit Points of Minor Courses in Chemistry

Courses		Examination Structure			
Code	**Minor Courses in NEP FYUGP Syllabus of Chemistry** Session 2025-26 & onwards	**Credits**	**Mid Semester Theory (F.M.)**	**End Semester Theory (F.M.)**	**End Semester Practical/ Viva (F.M.)**
MN-A	Chemistry Minor A	4	15	60	25
MN-B	Chemistry Minor B	4	15	60	25
MN-C	Chemistry Minor C	4	15	60	25
MN-D	Chemistry Minor D	4	15	60	25
MN-E	Chemistry Minor E	4	15	60	25
MN-F	Chemistry Minor F	4	15	60	25
MN-G	Chemistry Minor G	4	15	60	25

Topics in each course of Chemistry as Minor are as follows:

1. **MN-A** Atomic Structure, Periodicity of Elements, Chemical Bonding and Molecular Structure, Fundamentals of Organic Chemistry:
Practical-MN A
2. **MN-B** Kinetic Theory of Gases, Liquids, Solids, Aliphatic hydrocarbons, Aromatic hydrocarbons, Polynuclear Hydrocarbons
Practical-MN B
3. **MN-C** Equilibrium, MO Approach, Oxidation-Reduction and general principle of metallurgy, Alkyl and Aryl Halides
Practical-MN C
4. **MN-D** First Law of thermodynamics, Chemical Energetics, Chemical Kinetics, *s*- and *p*-Block Elements, Metallurgy, Compounds of p-Block Elements
Practical-MN D
5. **MN-E** Conductance, Electrochemistry, Application of EMF measurements, Transition Elements, Lanthanides and Actinides, Coordination Chemistry
Practical-MN E
6. **MN-F** Dilute solutions, Surface chemistry, Alcohols, Ethers, Aldehydes and ketones
Practical-MN F
7. **MN-G** Second & Third Law, Free Energy Functions, Introduction of Polymers, Carboxylic Acids and their Derivatives, Nitrogen Containing Functional Groups
Practical-MN G

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INSTRUCTIONS TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

There will be Only One Semester Internal Examination in Major, Minor and Research Courses, which will be organized at college/institution level. However, Only One End semester evaluation in other courses will be done either at College/ Institution or University level depending upon the nature of course in the curriculum.

A. (SIE 10+5=15 marks):

There will be two group of questions. **Question No.1 will be very short answer type in Group A** consisting of five questions of 1 mark each. **Group B will contain descriptive type** two questions of five marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks, (b) Class Attendance Score (CAS) of 5 marks.

B. (SIE 20+5=25 marks):

There will be two group of questions. **Group A is compulsory** which will contain two questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 will be short answer type** of 5 marks. **Group B will contain descriptive type** two questions of ten marks each, out of which any one to answer.

The Semester Internal Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESE):

1. (ESE 50 marks):

There will be two group of questions. **Group A is compulsory** which will contain one question. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

2. (ESE 60 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No.2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type five questions of fifteen marks each, out of which any three are to answer.

3. (ESE 75 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of five questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of fifteen marks each, out of which any four are to answer.

4. (ESE 100 marks):

There will be two group of questions. **Group A is compulsory** which will contain three questions. **Question No.1 will be very short answer type** consisting of ten questions of 1 mark each. **Question No. 2 & 3 will be short answer type** of 5 marks. Group B will contain descriptive type six questions of twenty marks each, out of which any four are to answer.

FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **15 Marks**:

Subject/ Code

F.M. =15 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [10]
3. ..... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time** = 1 Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [10]
4. ..... [10]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **50 Marks**:

Subject/ Code

F.M. =50 **Time** = 1.5 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....

Group B

2. ..... [15]
3. ..... [15]
4. ..... [15]
5. ..... [15]
6. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **75 Marks**:

Subject/ Code

F.M. =75 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]
9. ..... [15]

Note: There may be subdivisions in each question asked in the Theory Examination.

Question format for **100 Marks**:

Subject/ Code

F.M. =100 **Time** = 3 Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer-type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all subparts of a question in one place.
v. Numbers in the right indicate full marks for the question.

Group A

1. [10x1=10]
   i. ..... vi. .....
   ii. ..... vii. .....
   iii. ..... viii. .....
   iv. ..... ix. .....
   v. ..... x. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [20]
5. ..... [20]
6. ..... [20]
7. ..... [20]
8. ..... [20]
9. ..... [20]

Note: There may be subdivisions in each question asked in the Theory Examination.

SEMESTER I

I. MAJOR COURSE –MJ 1:
CHEMISTRY-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Atomic theory and its evolution.
2. Learning scientific theory of atoms, concept of wave function.
3. Elements in periodic table, physical and chemical characteristics, periodicity.
4. To predict the atomic structure, chemical bonding and molecular geometry based on accepted models.
5. Atomic theory of matter, composition of atom.
6. Hybridisation and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
7. Valence bond theory incorporating concepts of hybridisation predicting geometry of molecules.
8. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
9. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
10. Reactivity, stability of organic molecules, structure, stereochemistry.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Electronic configuration of various elements in periodic table
2. Predicting the structure of molecules
3. How hydrogen bonding and metallic bonding are important in common materials' scientific applications to material fabrication
4. Design and syntheses of organic molecules.
5. Stereochemistry of organic molecules – conformation and configuration, asymmetricmolecules and nomenclature.
6. Correlation of Reactivity, stability of organic molecules, structure and stereochemistry.

Course Content:

UNIT I: Structure of Atom (10 Lectures)

Bohr's theory, its limitations and the atomic spectrum of the hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalised and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for the hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Aufbau's principle. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity.

UNIT II: Periodicity of Elements (10 Lectures)

s, *p*, *d*, *f* -block elements, the Long form of the Periodic Table. Detailed discussion of the following properties of the elements.

a. Atomic radii (van der Waals)
b. Ionic and crystal radii.
c. Covalent radii (octahedral and tetrahedral)
d. Ionisation enthalpy, Successive ionisation enthalpies and factors affecting ionisation energy. Applications of ionisation enthalpy.
e. Electron gain enthalpy, trends of electron gain enthalpy.
   Electronegativity, Pauling, Mullikan, Allred Rochow scales, electronegativity and bond order, partial charge, hybridisation, group electronegativity.
f. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

UNIT III: Chemical Bonding & Molecular structure (12 Lectures)

(i) *Ionic bond:*

General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation, Madelung constant, expression for lattice energy, Born-Haber cycle and its application, Solvation energy.

(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). Hybridisation 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: N_2, O_2, C_2, B_2, F_2, CO, NO and their ions. Covalent character in ionic compounds; polarization, polarizing power and polarizability. Fajan rules. Ionic character in covalent compounds: Bond moment and dipole moment, ionic character from dipole moment and electronegativities.

(iii) *Weak Chemical Forces:*
Van der Waals, ion-dipole, dipole-dipole (Keesom forces), dipole-induced dipole interactions (Deby forces or induction forces), transient dipole interactions (London Forces or Dispersion forces), hydrogen bond.

UNIT IV: Basics of Organic Chemistry (16 Lectures)
Organic Compounds: Classification and Nomenclature, Hybridisation, shape of molecules, influence of hybridisation on bond properties. Electron Displacement Effects: inductive, electromeric, resonance and mesomeric effects. Tautomerism, 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 stability of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, annulenes, anti-aromaticity, Y-aromaticity, homo-aromaticity, bonding in fullerenes, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

Elementary idea of Organic reactions: Addition, Elimination, Substitution reactions and Rearrangement reactions.

UNIT V: Elementary concepts of Stereo Chemistry (12 Lectures)
Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions, Geometrical isomerism: cis–trans & syn-anti isomerism and E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation. Elements of symmetry, chirality, molecules with more than one chiral center, Threo and Erythro isomers, Chirality/Asymmetry, Enantiomers, Diastereomers, Meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S configurations.

Reference Books:

1. Chandra, A. K. Introductory Quantum Chemistry, Tata McGraw-Hill (2001).
2. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
3. Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edn.
4. Douglas, B.E., McDaniel, D.H., Alexander J.J., Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 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. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
8. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
10. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
11. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
12. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publishers, (2000).

II. SKILL ENHANCEMENT COURSE- SEC 1: FUEL & PHARMACEUTICAL CHEMISTRY

Marks: 75 (ESE: 3Hrs) = 75	**Pass Marks: Th (ESE) = 30**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. Fuels and their Calorific Value.
2. Fractionation of coal tar
3. Refining and different types of petroleum products.
4. The difference between Medicine and Drugs.
5. The importance of Pharmaceuticals.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. About renewable and non-renewable energy resources.
2. Uses of Petrochemicals and Lubricants.
3. Synthesis of the representative drugs.
4. The types of Fermentation and their uses.

Course Content:

UNIT I: Energy Resources & Fuel: (25 Lectures)

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonisation of 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.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids) and clean fuels.

Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

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

UNIT II: Pharmaceuticals: (20 Lectures)

Drugs & Pharmaceuticals: Drug discovery, design and development; Basic Retrosynthetic approach.

Synthesis of the representative drugs of the following classes:

Analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, ibuprofen); Antibiotics (Chloramphenicol); Antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); Antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), Antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation.

Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics: Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
3. B.K. Sharma: *Industrial Chemistry,* Goel Publishing House, Meerut.
4. G.L. Patrick: *Introduction to Medicinal Chemistry*, Oxford University Press, UK.65
5. Harkishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi.
6. William O. Foye, Thomas L., Lemke, David A. William: *Principles of Medicinal Chemistry*, B.I. Waverly Pvt. Ltd. N. Delhi.

SEMESTER II

I. MAJOR COURSE- MJ 2:
CHEMISTRY-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

On successful completion of this course, the student should be able to understand:

1. Familiarisation with various states of matter.
2. Physical properties of each state of matter and laws related to describing the states.
3. Understanding the Kinetic model of gas and its properties.
4. Maxwell distribution, mean-free path, kinetic energies.
5. Liquid state and its physical properties related to temperature and pressure variation.
6. Solids, lattice parameters – application of symmetry, solid characteristics of simple salts.
7. Calculation of lattice parameters.
8. Variety of hydrocarbons and their properties.

Learning outcomes

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

1. Appreciate the stages of development of gas laws.
2. Differentiate the ideal and real gases.
3. Understand the Kinetic theory of gases.
4. Appreciate the reasons for variations in the behaviour of liquids in layers.
5. Why does the presence of solute change the behaviour of liquids.
6. Determination of lattice parameters of a given salt.
7. Study of X-ray diffraction pattern.
8. Differentiate aliphatic, aromatic and alicyclic hydrocarbons.
9. Appreciate the change in behaviour w.r.t. the nature of unsaturation in a compound.
10. Understand the mechanism of electrophilic substitution on aromatic rings.
11. Understand the Addition and Cleavage reactions of Unsaturated hydrocarbons

Course Content:

UNIT I: Gaseous State (15 Lectures)

Deviation from ideal gas behaviour, compressibility factor and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour. Boyle's temperature. Isotherms of real gases and their comparison 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, 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 temperature dependence. Effect of addition of various solutes on surface tension, cleansing action of detergents.

UNIT III: Solid State (8 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, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices, X-ray diffraction, Bragg's law, a simple account of the 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.

Qualitative idea of free electron model, Semiconductors, Insulators.

UNIT IV: Hydrocarbons:

A. Alkanes: (6 Lectures)

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Corey House Synthesis, Kolbe's Synthesis, Free radical substitutions: Halogenation - relative reactivity and selectivity. Lengthening and shortening of the carbon chain in alkanes.

B. Alkenes & Alkynes: (10 Lectures)

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cB reactions. Saytzeff and Hofmann eliminations, Pyrolytic eliminations. Reactions of alkenes: Electrophilic additions, their mechanisms (Markownikov/ Anti Markownikov 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. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Conversions involving π-bonds.

C. Aromatic Hydrocarbons (10 Lectures)

Aromaticity: 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.

D. Polynuclear Hydrocarbons: (6 Lectures)

Reactions of naphthalene and anthracene: Structure, preparation and important derivatives of naphthalene and anthracene.

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
3. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
4. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
5. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw-Hill (Fifth Edition) (2007)
6. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
7. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
8. Acheson, R.M. Introduction to the Chemistry of Heterocyclic Compounds, John Welly & Sons (1976).
9. Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc. (2009).
10. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
11. Kalsi, P. S. Organic reactions and their mechanisms, New Age Science (2010).
12. Clayden, J., Greeves, N., Warren, S., Wothers, P., Organic Chemistry, Oxford University Press Inc., New York (2001)

II. SKILL ENHANCEMENT COURSE- SEC 2: GREEN CHEMISTRY

Marks: 75 (ESE: 3Hrs) = 75	**Pass Marks: Th (ESE) = 30**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. The importance of green synthesis and its need.
2. The methods involving green synthesis and the economy associated with it.
3. The concept of Atom economy. The importance of green solvents
4. The methods in use in Green Synthesis.
5. The scope of green chemistry.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Goals and outcomes of green chemistry. Selection of nonconventional energy sources.
2. Microwave-assisted reactions in water and their applications.
3. The innovative methods for organic synthesis.
4. The alternative sources of starting materials for green synthesis. The alternative paths for a few known-name reactions.

Course Content:

UNIT I: Introduction to Green Chemistry (4 Lectures)

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

UNIT II: Principles of Green Chemistry and Designing a Chemical Synthesis (15 Lectures)

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids.

Energy requirements for reactions- use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

UNIT III: Examples of Green Synthesis/ Reactions (18 Lectures)

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

2. Microwave-assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols).
Microwave-assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Johnson-Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.

3. Microwave-assisted solid-state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2-dihydrotriazine derivatives; benzimidazoles.

UNIT IV: Future Trends in Green Chemistry (8 Lectures)

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

Books Suggested:

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

SEMESTER III

I. MAJOR COURSE- MJ 3:
CHEMISTRY-III

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Unique nature of the Hydrogen atom.
2. Concept of Redox Reactions and their applications.
3. Chemistry of Alkali and Alkaline Earth Metals.
4. Anomalous behaviour of Lithium and Beryllium.
5. Different mechanisms of substitution reactions of Halogenated hydrocarbons.
6. Different nature of Alkyl and Aryl halides.
7. The behaviour of alcohols and ethers.

Course Learning Outcomes:

After completing this course, the students will be able to

1. Appreciate the compounds of hydrogen
2. Balance the redox reactions
3. Know the biological importance of Alkali and Alkaline earth metals.
4. Familiarisation with classes of organic compounds and their methods of preparation.
5. Name reactions, uses of various reagents and the mechanism of their action.
6. Know the methods of preparation of Organometallic compounds of Magnesium and Lithium.
7. Use of reagents in various organic transformation reactions.
8. Decide the path of transformation of one compound to another.
9. Differentiate the acidic character of phenols from that of alcohols.

Course Content:

UNIT I: Hydrogen & its Compounds (06 Lectures)

Position of Hydrogen in the Periodic Table, Dihydrogen - Preparation & Properties.

Compounds of Hydrogen: Stoichiometric (Metallic & Non-metallic) and Non-Stoichiometric Hydrides, Preparation, Properties, Uses and Structure of Hydrogen Peroxide (H_2O_2), Heavy Water (D_2O). Water- Physical State, Structure, Hardness of water and its removal. Dihydrogen as a Fuel.

UNIT II: s-block Elements (12 Lectures)

Group 1 Elements: Alkali Metals, General Characteristics of the Compounds of the Alkali Metals, Diagonal Relationship, Anomalous Properties of Lithium, Some Important Compounds of Sodium (NaCl, NaOH, Na_2CO_3, $NaHCO_3$), Biological Importance of Sodium and Potassium

Group 2 Elements: Alkaline Earth Metals, General Characteristics of Compounds of the Alkaline Earth Metals, Diagonal Relationship, Anomalous Behaviour of Beryllium, Some Important Compounds of Calcium (CaO, $Ca(OH)_2$, $CaCO_3$, $CaOCl_2$), Biological Importance of Magnesium and Calcium.

UNIT III: Redox Reactions and general Principles of metallurgy: (15 Lectures)

Redox equations, Balancing by ion-electron method & Oxidation number method. Disproportionation Reaction. Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for the reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Pyrometallurgy, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel de Boer process and Mond's process, Zone refining.

UNIT IV: Chemistry of Halogenated Hydrocarbons: (12 Lectures)

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

Aryl halides: Preparation from diazonium salts. nucleophilic aromatic substitution, S_NAr, 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 V: Functional Group containing Oxygen-I (Alcohols, Phenols, Ethers and Epoxides) (15 Lectures)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3°- alcohols, Bouveault-Blanc Reduction, Preparation and properties of glycols and glycerol. Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties, Acidic nature and factors affecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Kolbe-Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reaction with acids. Reaction of epoxides with alcohols, ammonia derivatives and $LiAlH_4$, Cleavage of ethers with HI.

Reference Books:

1. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
2. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry Fourth Ed., Pearson, 2010
3. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
4. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
5. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., *Organic Chemistry*, 7th Edn., Pearson.
6. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic Compounds,* John Welly & Sons(1976).
7. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc. (2009).
8. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,2013.
9. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science (2010).
10. Clayden, J., Greeves, N., Warren, S., Wothers, P., *Organic Chemistry,* Oxford University PressInc., New York (2001).

II. MAJOR COURSE- MJ 4:
PRACTICAL-I

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

I. Acquaintance with Chemistry Laboratory

1. Common Symbols of Laboratory Concerns:
   Biohazard, Highly Flammable, Oxidizing, Corrosive, Harmful/Irritant, Radioactive, Explosive, Toxic, Dangerous for the Environment etc.
2. Common Laboratory Reagents:
   Common Acids, Common Bases, Common Inorganic/Organic Salts, Organic Compounds, Common Solvents, Difference between Dilute/Concentrated/Fuming liquids, Diluting a solution to a known strength. Safe storage of chemicals.

II. Common Procedures

1. Heating/Boiling with and without a condenser, Filtration techniques, Separation techniques, Crystallisation techniques.
2. Purification of organic compounds
   (say naphthalene & others) by crystallisation using the following solvents:
   a. Water b. Alcohol c. Alcohol-Water d. Acetone e. Hexane f. Toluene
3. Determination of the melting points
   a. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
   b. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
   c. Determination of the boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method).

III. Volumetric Analysis

1. Acid-Base Titrations
   a. Estimation of oxalic acid present in the supplied sample.
   b. Estimation of sodium hydroxide present in given sample.
   c. Estimation of the amount of acetic acid in vinegar solution.
   d. Estimation of carbonate and hydroxide present together in mixture.
   e. Estimation of carbonate and bicarbonate present together in a mixture.
   f. Estimation of free alkali present in different soaps/detergents.
2. Oxidation-Reduction Titrimetry
   a. Estimation of Fe(II) in supplied solution using standardized $KMnO_4$ solution.
   b. Estimation of oxalic acid using standardized $KMnO_4$ solution.
   c. Estimation of the percentage of Fe(II) in Iron fillings with standard $K_2Cr_2O_7$

Note:

- You must wear **Safety goggles & Lab Apron** in the laboratory at all times.
- Only CO_2 and dry-chemical fire extinguishers should be used on chemical or electrical fires.
- Water faucets at sinks may be used to wash skin exposed to corrosive chemicals.
- Most importantly, make any **Emergency inform** as soon as possible to a Teacher or staff member.

Reference Books

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
3. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: N. Delhi (2011).
4. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).

III. SKILL ENHANCEMENT COURSE- SEC 3:
ELEMENTARY COMPUTER APPLICATION SOFTWARES

Marks: 75 (ESE: 3Hrs) = 75	**Pass Marks: Th (ESE) = 30**

A Common Syllabus for FYUGP (Credits: Theory-03) **45 Hours**

Instructions to Question Setter
*There will be **objective type test** consisting of **Seventy-five questions of 1 mark each**. Students are required to mark their answer on **OMR Sheet** provided by the University.*

Course Objectives:
The objective of the course is to generate qualified manpower in the area of Information Technology (IT) and Graphic designing which will enable such person to work seamlessly at any Offices.

1. Basic Concept of Computer: What is a Computer, Applications of Computer, Types of Computer, Components of a Computer System, Central Processing Unit (CPU) **(3 Hours)**

2. Concepts of Hardware: Input Devices, Output Devices, Computer Memory, Types of Memory, Processing Concept of Computer **(4 Hours)**

3. Operating system: Operating System, Functions of Operating System (Basic), Introduction to Windows 11, Working on Windows 11 environment, Installation of Application Software, My Computer, Control Panel, searching techniques in Windows environment, Basic of setting **(6 Hours)**

4. Concept of Software: What is Software, Types of Software, Computer Software- Relationship between Hardware and Software, System Software, Application Software, some high-level languages **(4 Hours)**

5. Internet & its uses: Basic of Computer networks; LAN, WAN, MAN, Concept of Internet, Applications of Internet; connecting to internet, what is ISP, World Wide Web, Web Browsing software's, Search Engines, URL, Domain name, IP Address, using e-governance website, Basics of electronic mail, getting an email account, Sending and receiving emails. **(6 Hours)**

6. Microsoft Word: Word processing concepts, Creation of Documents, Formatting of Documents, Formatting of Text, Different tabs of Word 2016 environment, Formatting Page, Navigation of Page, Table handling, Header and footer, Page Numbering, Page Setup, Find and Replace, Printing the documents **(7 Hours)**

7. Microsoft Excel (Spreadsheet): Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Worksheets, Formatting worksheet, Excel Formula, Concept of charts and Applications, Pivot table, Goal Seek, Data filter, data sorting and scenario manager, printing the spreadsheet **(6 Hours)**

8. Microsoft PowerPoint (Presentation Package): Concept and Uses of presentation package, Creating, Opening and Saving Presentations, working in different views in PowerPoint, Animation, slide show, Master Slides, Creating photo album, Rehearse timing and record narration **(5 Hours)**

9. Digital Education: Introduction & Advantages of Digital Education, Concept of e-learning, Technologies used in e learning **(4 Hours)**

Reference Books

1. Nishit Mathur, *Fundamentals of Computer*, APH Publishing Corporation (2010)
2. Neeraj Singh, *Computer Fundamentals (Basic Computer),* T Balaji, (2021)
3. Joan Preppernau, *Microsoft PowerPoint 2016 step by step*, Microsoft press (2015)
4. Douglas E Corner, *The Internet Book* 4th Edition, prentice –Hall (2009)
5. Wallace Wang, *Microsoft Office 2019*, Wiley (January 2018)
6. Noble Powell, *Windows 11 User Guide For Beginners and Seniors*, ASIN, (October 2021)

SEMESTER IV

I. MAJOR COURSE- MJ 5:
CHEMISTRY-IV (IKS IN CHEMISTRY)

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. To introduce students to the foundational principles and holistic worldview of Indian Knowledge Systems (IKS) in the domain of chemical sciences.
2. To explore traditional Indian approaches to classification of matter, chemical transformation, metallurgy and alchemy through ancient texts and practices.
3. To familiarize learners with indigenous technologies such as dyeing, fermentation, perfumery and preservation methods as practiced in historical India.
4. To examine the role of Ayurveda and Rasashastra in the development of natural drug synthesis and eco-friendly chemical processes.
5. To promote comparative understanding between ancient Indian and modern chemistry for sustainable and culturally-rooted scientific thinking.
6. To integrate IKS-based knowledge with NEP 2020 reforms, encouraging students to recognize its interdisciplinary applications and field-based learning.
7. To know the Chemistry of p-block elements.

Course Learning Outcomes:

On successful completion of this course, the student should:

1. Understand the foundational principles of Indian Knowledge Systems with relevance to chemical sciences.
2. Identify and relate significant IKS contributions in the domain of chemistry.
3. Analyze ancient Indian methods in metallurgy, alchemy and drug formulation.
4. Compare traditional and modern chemical knowledge for sustainable solutions.
5. Apply IKS-based practices in chemical education and research.
6. Align chemical concepts of IKS with NEP 2020 and interdisciplinary innovations.
7. Bonding of various p-block elements.
8. Important Trends and Anomalous Behaviour among p-block elements.

Course Content: **(30 Lectures)**

UNIT I: Principles of the Indian Knowledge System in Chemistry

1. Introduction to Indian Knowledge Systems and their holistic philosophy
2. Concepts of Panchamahabhutas, Tridoshas, Rasa and Dravya
3. Indigenous classification of substances (Dhatu, Rasa, Upadhatu)
4. Ancient Indian worldview of matter and energy
5. Concept of atomic structure (Anu, Paramanu) in Vaisheshika Darshan

UNIT II: Relevant Topics of IKS in Chemistry

1. Contributions of Acharyas: Nagarjuna, Charaka, Sushruta & P.C. Ray in chemical knowledge
2. Chemistry in Ayurveda: Bhasma, Rasayana, Parada
3. Indigenous technologies in dyeing, tanning, perfumery and Ceramics
4. Metallurgical heritage: Iron Pillar of Delhi, Dhar, Zinc distillation at Zawar
5. Chemistry in temple rituals and material preservation

UNIT III: Application of IKS in Chemistry

1. Alchemy (Rasashastra): Objectives, principles and health-related applications
2. Role of traditional lab practices: Puta, Bhavana, Swedana
3. Applications of Plant-based Chemicals, Glass in ancient times
4. Ayurvedic pharmacy and natural drug synthesis
5. Sustainability in ancient chemical practices: eco-friendly materials and processes
6. Case studies: Ayurvedic formulations and their modern validations

UNIT IV: Case Study: Field-Based Learning through Indian Knowledge System Heritage Sites in Jharkhand.

Case Study Located in Jharkhand:

1. **Tanginath Dham (Gumla)**
    a. Highlight: Ancient iron tangi (axe) that doesn't rust.

b. IKS Link: Tribal metallurgy, temple science, Vedic symbolism.

2. **Maluti Temples (Dumka)**
   a. Highlight: Cluster of 72 temples with terracotta art.
   b. IKS Link: Art, architecture, historical water drainage system, tantric science.
3. **Parasnath Hills (Giridih)**
   a. Highlight: Jain pilgrimage site; ancient stone inscriptions.
   b. IKS Link: Jain philosophy, early documentation techniques, nature-spiritual synergy.

UNIT V: p-block Elements **(30 Lectures)**

Group 13 Elements: The Boron Family, Important Trends and Anomalous Properties of Boron, Diagonal Relationship. Some Important Compounds of Boron ($Na_2B_4O_7.10H_2O$, H_3BO_3, B_2H_6, $B_3N_3H_6$), Uses of Boron. Aluminium- Extraction and Compounds.

Group 14 Elements: The Carbon Family, Important Trends and Anomalous Behaviour of Carbon, Allotropes of Carbon, Some Important Compounds of Carbon (CO & CO_2) and Silicon (Silica, Silicates & Silicones).

Group 15 Elements, Dinitrogen, Ammonia, Oxides of Nitrogen, Nitric Acid, Phosphorus – Allotropic Forms, Phosphine, Phosphorus Halides, Oxoacids of Phosphorus

Group 16 Elements: Dioxygen, Simple Oxides, Ozone, Sulphur – Allotropic Forms, Sulphur Dioxide, Oxoacids of Sulphur, Sulphuric Acid,

Group 17 Elements, Chlorine, Hydrogen Chloride, Oxoacids of Halogens, Interhalogen Compounds,

Group 18 Elements: Noble gases, Occurrence & uses, rationalisation 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), Shape of noble gas compounds (VSEPR theory)

Reference Books:

1. R. Balasubramaniam – *New Insights on the Iron Pillar of Delhi*
2. P.V. Sharma – *Rasashastra: The Science of Indian Alchemy and Medicine*
3. Debiprasad Chattopadhyaya – *Science and Society in Ancient India*
4. Lokesh Chandra – *Cultural Horizons of India*
5. Dharampal – *Indian Science and Technology in the 18th Century*
6. Kapil Kapoor – *Text and Interpretation: The Indian Tradition*
7. IGNOU – *Indian Culture and Heritage (Chemistry)*
8. Ministry of Education (AICTE-IKS Division) – IKS Portal
9. Acharya Suresh Chandra – *Rasashastra Vigyan* (Hindi)
10. Subhash Kak – *The Astronomical Code of the Rigveda*
11. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
12. Douglas, B.E., McDaniel, D.H., & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.,* John Wiley Sons, N.Y. 1994.
13. Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
14. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.

Case Study:

1. IGNCA – *Indian Cultural Heritage Studies*
2. Kapil Kapoor – *Text and Interpretation in Indian Traditions*
3. Michel Danino – *The Lost River & Indian Roots of Science*
4. Dharampal – *Indian Science & Technology in the 18th Century*
5. Subhash Kak – *The Astronomical Code of the Rigveda*
6. Ministry of Tribal Affairs – *Tribal Culture and Practices*
7. Jharkhand Tourism Board – *Heritage and Culture Booklets*
8. Prof. R. Balasubramaniam – *Studies on Iron and Metallurgy in Ancient India*
9. ASI (Eastern Circle) Reports – *Jharkhand Archaeological Survey*
10. IKS Division, AICTE – *Field Visit Guidelines and Learning Tools*

II. MAJOR COURSE- MJ 6:
CHEMISTRY-V

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. First & second laws of thermodynamics.
2. Concept of enthalpy & resonance energy.
3. The use of thermochemistry to calculate Bond energy.
4. Second & Third laws of thermodynamics.
5. Entropy and its significance.
6. Concept and applications of Free energy.

Course Learning Outcomes:

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

1. Use of thermochemistry to calculate Bond energy.
2. The factors affecting the solubility of compounds.
3. Organic chemistry reactions and reaction mechanisms.
4. Use of reagents in various organic transformation reactions.
5. The Chemistry of carbonyl compounds and carboxylic acids.
6. Predicting the structure of molecules
7. Appreciate the behaviour of oxygen-containing functional groups.
8. Differentiate the nature of various carbonyl derivatives.

Course Content:

UNIT I: Thermodynamics-I

Introduction & First Law of thermodynamics: (6 Lectures)

Intensive and extensive properties, thermodynamic variables, state and path functions, isolated, closed and open systems, reversible, irreversible and cyclic processes. Zeroth law of thermodynamics. *First law of Thermodynamics:* Concept of heat, *q*, work, *w*, internal energy, enthalpy, relation between heat capacities, calculations of *q*, *w*, *U and H* for reversible and irreversible processes. Expression for work done under free expansion of gases for isothermal and adiabatic conditions.

Thermochemistry: (8 Lectures)

Heat of reactions: standard states, enthalpy of formation of molecules and ions. Hess's Law, Enthalpy of reactions (combustion, neutralisation, solution etc) and its applications, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

UNIT I: Thermodynamics-II

Second & Third Law: (10 Lectures)

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

Third Law: Statement of the third law, concept of residual entropy, calculation of absolute entropy of molecules.

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 equations of state.

Partial molar quantities: (8 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 IV: Functional Group containing Oxygen-II (Aldehydes, Ketones, Acids and Derivatives)

Carbonyl Compounds: (16 Lectures)

Structure, reactivity and preparation of Carbonyl compounds. Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism. 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.

Carboxylic Acids and their Derivatives: (6 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, Hofmann bromamide degradation and Curtius rearrangement.

Reference Books:

1. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics. Wiley, 2001. 6 Commonly Asked Questions in Thermodynamics. CRC Press, 2011.
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw-Hill (Fifth Edition) (2007)
4. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
5. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
6. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
7. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
8. Laideler K. J. and Meiser J. M. Physical Chemistry, Third Edition (International)1999
9. Levine I. N., Physical Chemistry, Fourth Edition, McGraw-Hill (International), 1995.
10. McQuarrie D. A. and Simon J. D. Physical Chemistry- A Molecular Approach, University Science Books, 1998.
11. J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
12. F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
13. D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
14. Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.
15. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
16. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
17. I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
18. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
19. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

III. MAJOR COURSE- MJ 7:
PRACTICAL-II

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

I. Green Synthesis: Diels-Alder reaction in water

a. Reaction between furan and maleic acid in water at room temperature rather than in benzene, which requires refluxing.

II. Thermochemistry

1. Determination of the heat capacity of a calorimeter.
2. Determination of the heat capacity of the calorimeter and the enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionisation of ethanoic acid.
4. Determination of the heat capacity of the calorimeter and the integral enthalpy (endothermic and exothermic) solution of salts.

III. Organic Chemistry

1. Detection of hetero elements in organic compounds.
2. Functional group test for nitro, amine and amide groups
3. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups.
4. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)
5. Organic preparations:
   a. Benzolyation of aniline.
   b. Oxidation of Benzaldehyde to Benzoic Acid.
   c. Hydrolysis of amides and esters.
   d. Preparation of Semicarbazone derivatives of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

Reference Books

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; American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph, International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN 978-93-81141-55-7 (2013).
5. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).
6. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).
7. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
8. Vogel, A.I. *A text book of Quantitative Analysis*, ELBS 1986.
9. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
10. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. *Practical Organic Chemistry,5th Ed.,* Pearson (2012)

SEMESTER V

I. MAJOR COURSE- MJ 8:
CHEMISTRY-VI

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. The basics of chemical kinetics: determination of order, molecularity and understanding theories of reaction rates.
2. Phases, components, Gibbs' phase rule and its applications, construction of phase diagrams of different systems and the application of phase diagrams.

Course Learning Outcomes:

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

1. The concept of equilibria and its applications. The concept of pH.
2. Recognise the acidic and basic behaviour of a compound not having protons or the hydroxyl group.
3. Understand Phases, components, Gibbs phase rule, Phase diagrams and applications.
4. Chemical kinetics: types of reactions, determination of rate, theories of reaction rate, steady state approximation.
5. Catalyst – mechanism, acid-base catalysis, enzyme catalysis.
6. Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory and significance.
7. Determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics and Steady-state approximation.

Course Content:

UNIT I: Chemical Equilibria-I: (6 Lectures)

Concept of Equilibrium. Le Chatelier's principle and its applications. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases (Kinetic derivation). Equilibrium between ideal gases and a pure condensed phase.

UNIT II: Chemical Equilibria-II (16 Lectures)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases and the concept of fugacity. Thermodynamic derivation of the relation between the Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx.

UNIT III: Ionic Equilibria: (16 Lectures)

Strong, moderate and weak electrolytes, Arrhenius theory of electrolytic dissociation. Degree of ionisation, factors affecting the degree of ionisation, ionisation constant and ionic product of water. Ionisation of weak acids and bases, pH scale, common ion effect. Dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, calculation of hydrolysis constant, degree of hydrolysis and pH for different salt solutions. Buffer solutions. Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Applications of the solubility product principle.

Bronsted-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) and applications of HSAB principle.

Qualitative treatment of acid–base titration curves (calculation of pH at various stages). Theories of indicators, selection of indicators and their limitations.

UNIT IV: Phase Equilibria: (12 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 non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its thermodynamic derivation and applications.

UNIT V: Chemical Kinetics: (12 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, pseudo-unimolecular 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 and Activated Complex theories of reaction rates, Unimolecular reaction, qualitative treatment of the theory of absolute reaction rates. Lindemann mechanism.

Reference Books:

1. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
2. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
4. Metz, C.R. *2000 Solved Problems in Chemistry*, Schaum Series, 2006.
5. Zundhal, S.S. *Chemistry concepts and applications.* Cengage India, 20116 Ball, D. W. *Physical Chemistry.* Cengage India, 2012.
6. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.
7. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.

II. MAJOR COURSE- MJ 9:
CHEMISTRY-VII

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. The Chemistry of d-block & f-block elements.
2. Lanthanides, Actinides – separation, colour, spectra and magnetic behaviour
3. Coordination compounds – their nomenclature, theories, d-orbital splitting in complexes and chelate.
4. Valence bond theory and Molecular orbital theory to explain the bonding in complexes.
5. The nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes and chelate effects.
6. The transition metals' stability in reactions, origin of colour and magnetic properties.

Course Learning Outcomes:

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

1. Appreciate the Anomalous behaviour of representative elements in the periodic table.
2. General group trends with special reference to d-block elements.
3. Appreciate the postulates of Werner's theory of coordination compounds;
4. learn the rules of nomenclature of coordination compounds; write the formulas and names of mononuclear coordination compounds; define different types of isomerism in coordination compounds.
5. Understand the nature of bonding in coordination compounds in terms of the Valence Bond and
6. Crystal Field theories; learn the stability of coordination compounds;
7. Appreciate the importance and applications of coordination compounds in our day-to-day life.
8. IUPAC nomenclature of coordination compounds/complexes.
9. Prediction of the structure of complexes using various theories, colour and magnetic properties of different complexes.

Course Content:

UNIT I: d-block Elements-Transition Elements (3d series) (20 Lectures)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states. 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 II: f-block Elements (Lanthanides and Actinides) (5 Lectures)

Electronic configuration, oxidation states, colour, spectra and magnetic behaviour of lanthanides and actinides. Lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT III: Coordination Chemistry (35 Lectures)

IUPAC nomenclature of coordination compounds, Werner's theory, Sidgwick theory, EAN rule and Valence bond theory (VBT), Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu. Chelate effects, Structural and stereoisomerism in complexes with coordination numbers 4 and 6, Chelate effect. Drawbacks of VBT. Colour, Magnetic properties and Factors affecting the Stability of Complexes. Mononuclear and Polynuclear complexes.

Crystal Field Theory (CFT), Crystal field effect, octahedral symmetry. Crystal field stabilisation energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D (Δ). Spectrochemical series. Comparison of CFSE for O_h and T_d complexes. tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar complexes, d-orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE. Limitations of CFT.

Introduction to Ligand Field Theory (LFT) & Molecular Orbital Theory (MOT), octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

Reference Books:

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. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010
6. Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press(2010).
7. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co,1977. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
8. Basolo, Fand Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.

III. MAJOR COURSE- MJ 10:
CHEMISTRY-VIII

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Nitrogen-containing functional groups and their reactions.
2. The existence and importance of heterocyclic compounds.
3. Carbohydrate chemistry and interconversion of carbohydrates.
4. Elementary idea of Polysaccharides. Terpenes and their importance.
5. Stereogenic features of naturally occurring and synthetic organic compounds.

Course Learning Outcomes:

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

1. Elucidating reaction mechanisms for organic reactions.
2. Use of benzene diazonium salt in organic synthesis.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Design and syntheses of organic molecules.
5. Appreciate the differences among the geometrical and optical isomers.

Course Content:

UNIT I: Functional Group containing Nitrogen (15 Lectures)

Nitrogen Containing Functional Groups, Preparation and important reactions of nitro 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 their synthetic applications.

UNIT II: Aromatic Heterocyclic compounds (15 Lectures)

Heterocyclic Compounds, 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

UNIT III: Active methylene groups: (10 Lectures)

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

UNIT IV: Carbohydrates (20 Lectures)

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

Reference Books:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., *Organic Chemistry*, 7th Edn., 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 reactions and their mechanisms*, New Age Science (2010).
6. Clayden, J., Greeves, N., Warren, S., Wothers, P., *Organic Chemistry,* Oxford University PressInc., New York (2001).
7. Nasipuri, *Stereochemistry of Organic Compounds*, New Age international.
8. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic Compounds,* John Welly & Sons(1976).

IV. MAJOR COURSE- MJ 11: PRACTICAL-III

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

I. Equilibria:

1. Determination of critical solution temperature (CST) of the phenol-water system.
2. Determination of the effect of impurity (NaCl) on the CST of the phenol-water system.
3. Distribution of acetic/ benzoic acid between water and cyclohexane.
4. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
5. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) $I_2(aq) + KI \rightarrow KI_3$ (aq)
   (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow [Cu(NH_3)_n]^{2+}$
6. *Any other experiment carried out in the class.*

II. Ionic equilibria & pH measurements

1. Preparation of buffer solutions of different pH
   i. Sodium acetate-acetic acid
   ii. Ammonium chloride-ammonium hydroxide
2. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
3. Determination of the dissociation constant of a weak acid.
4. 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 a pH-meter.

III. Inorganic Preparations:

1. Tetraamminecopper(II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
2. Potassium tris(oxalate)ferrate(III)
3. Preparation of Aluminium potassium sulphate $K_2SO_4Al_2(SO_4)_3.12H_2O$ (Potash alum)
4. Preparation of Chrome alum.

IV. Organic Practicals:

1. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
2. Separation of a mixture of two sugars by ascending paper chromatography
3. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin-layer chromatography (TLC).

Reference Books

1. J. A. Kent: *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
2. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
3. A. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
4. S. M. Khopkar, *Environmental Pollution Analysis*: New Age Int. Publisher, New Delhi.
5. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
6. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
7. Khosla, B.D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
8. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry.* New Age International: New Delhi (2001).

SEMESTER VI

I. MAJOR COURSE- MJ 12: CHEMISTRY-IX

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Basic principle of electrochemistry, chemical cells and their function, EMF measurement, potentiometric titrations and their applications.
2. Basic principle of laws of electrochemistry.
3. Understanding about chemical cells and their function
4. Understanding about electrodes, EMF measurement.
5. Understanding of potentiometric titrations and their applications.
6. Chemical kinetics: types of reactions, determination of rate, theories of reaction rate, steady state approximation.
7. Catalyst – mechanism, acid-base catalysis, enzyme catalysis.
8. The concept of solution.
9. The properties of dilute solutions and the ways to correlate them with some of the physical parameters.

Course Learning Outcomes:

After successfully completing the course, the students will be able to

1. Phases, components, Gibbs phase rule, Phase diagrams and applications.
2. Chemical kinetics: types of reactions, determination of rate, theories of reaction rate, steady state approximation.
3. Catalyst – mechanism, acid-base catalysis, enzyme catalysis.
4. Phases, components, Gibbs' phase rule and its applications, construction of phase diagrams of different systems, the application of phase diagrams.

Course Content:

UNIT I: Electrolytic Conductance: (12 Lectures)

Resistance/Conductance of solutions, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch's law of independent migration of ions. 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) hydrolysis constants of salts etc.

Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; Debye-Huckel-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. ionic equilibria; conductometric and potentiometric titrations.

UNIT II: Electrochemistry: (10 Lectures)

Quantitative aspects of Faraday's law. Applications of electrolysis in metallurgy and industry. Half-cell potential, 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: (8 Lectures)

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 without transference, liquid junction potential, determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Electroanalytical methods: (5 Lectures)

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

Principles of Corrosion: (5 Lectures)

Introduction to corrosion, homogenous theory, electrolytic theory of corrosion, forms of corrosion, special attention to rusting and its influence on the economy of the world, corrosion monitoring and prevention methods.

UNIT III: Surface chemistry: (6 Lectures)

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Langmuir adsorption isotherms), BET theory of multilayer adsorption (Excluding derivation), Adsorption in solution. Colloids and crystalloids. Classification of colloids. Preparation of colloids. Lyophobic and Lyophilic colloids. Brownian movement. Coagulation of colloidal solutions. Optical properties of colloidal solutions. Protective colloids and gold number.

UNIT IV: Catalysis: (6 Lectures)

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

UNIT V: Dilute Solution (8 Lectures)

Dilute solutions, lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Colligative properties of solutions, abnormal colligative properties, Van't Hoffs factor. Thermodynamic derivation using chemical potential to derive relations between the (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. Azeotropes.

Reference Books:

1. Castellan, G. W. *Physical Chemistry* 4th Ed., Narosa (2004).
2. Mortimer, R. G. *Physical Chemistry* 3rd Ed., Elsevier: NOIDA, UP (2009).
3. Barrow, G. M., *Physical Chemistry* 5th Ed., Tata McGraw-Hill: New Delhi (2006).
4. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed., Prentice-Hall (2012).
5. Rogers, D. W. *Concise Physical Chemistry.* Wiley (2010).
6. Silbey, R. J., Alberty, R. A. & Bawendi, M. G. *Physical Chemistry* 4th Ed., John Wiley &Sons, Inc. (2005).

II. MAJOR COURSE- MJ 13:
CHEMISTRY-X

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Types of organometallic compounds based on bond type.
2. EAN rule as applied to carbonyls.
3. The differences of aromaticity and reactivity of Zeise's salt with that of benzene.
4. Synergic effect and its role in stability.

Course Learning Outcomes:

After completing the course, the students will be able to

1. Organometallic compounds and their uses.
2. Understand the stability of metal carbonyls.
3. Explain the nerve conduction through the sodium-potassium pump.

Course Content:

UNIT I: Organometallic Compounds: (15 Lectures)

Definition and classification of organometallic compounds based on 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 the 3d series.

UNIT II: Synergic effects: (20 Lectures)

EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. pi-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes: tertiary phosphine as ligand. 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 the extent of back bonding.

Definition and Classification with appropriate examples based on the nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures, properties and reactions of organometallic compounds of Mg, Al, Sn and Li – Use in the synthesis of organic compounds.

UNIT III: Ferrocene & Zeise's salt: (12 Lectures)

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

Preparation & structure of Zeise's salt. Evidence of synergistic effect and comparison with that in carbonyls.

UNIT IV: Metal Clusters (8 Lectures)

Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

UNIT V: Inorganic Polymers: (5 Lectures)

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

Reference Books:

1. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry,* Wiley-VCH, 1999
2. Basolo, F and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY,1967.
3. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997
4. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
5. Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
6. Spessard, Gary O., &Gary L. Miessler. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.
7. Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry*. Mill Valley, CA: University Science Books, 1987.

III. MAJOR COURSE- MJ 14:
CHEMISTRY-XI

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. The mechanism of polymer material formation. Characterisation of polymers
2. The association of amino acids to form the polyamides i.e. proteins.
3. The role and importance of Fertilisers.

Course Learning Outcomes:

After completing the course, the students will be able to

1. Appreciate the importance of alkaloids as medicines.
2. Classification, structure and mechanism of reactions of few selected alkaloids.
3. Differentiate the protein from nylons even they contain common amide groups.
4. Understand the building blocks of the nucleic acids.

Course Content:

UNIT I: Classification & Characterisation of Polymers: (10 Lectures)

Introduction and classification of Polymers, Biopolymers, Synthetics polymers. polymerisation process, degree of polymerisation, condensation and addition polymers, kinetics of addition polymerisation process.

UNIT II: Properties of Polymers (Physical, thermal, Flow & Mechanical Properties). **(12 Lectures)**

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly (vinyl chloride) and related polymers, poly (vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol-formaldehyde resins, polyurethanes, silicone polymers, polydienes, Polycarbonates.

UNIT III: Frontier areas of polymer science and technology: (15 Lectures)

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, soya protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, polyvinyl 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.

UNIT IV: Amino Acids, Peptides & Proteins (10 Lectures)

Classification of Amino Acids, Zwitterion structure and Isoelectric point, Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of the 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.

UNIT V: Nucleic Acids (07 Lectures)

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

UNIT VI: Lipids (06 Lectures)

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

Reference Books:

1. J.E. Mark Ed. AIP, *Physical Properties of Polymers Hand Book*, Williston, VT, 1996.
2. D.W. Van Krevelen and P.J. Hoftyzen, Properties of Polymers, 3rd Edition Elsevier Scientific Publishing Company, Amsterdam - Oxford - New York. 1990.
3. Odian, George, *Principles of Polymerisation*, McGraw-Hill Book Co., New York (1970).
4. W. Billmeyer, *Textbook of polymer science*, 3rd Edn., 2007, Wiley.
5. Singh, J., Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).
6. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, ThirdEdition (1999).

IV. MAJOR COURSE- MJ 15: PRACTICAL-IV

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:
Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

I. Measuring Physical parameters

1. **Surface tension measurements.**
   a. Determine the surface tension of the supplied liquid solution.
   b. Study the variation of surface tension of detergent/ supplied solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**.
   a. Determination of the coefficient of viscosity of supplied solutions
   b. Study the variation of the coefficient of viscosity of a sucrose solution with the change in concentration of solute.

II. Conductometry

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:
   a. Strong acid vs. strong base
   b. Weak acid vs. strong base
   c. Mixture of strong acid and weak acid vs. strong base
   d. Strong acid vs. weak base
   e. Construction of a Daniell cell and measurement of EMF.

III. Biomolecules:

1. Saponification value of an oil or a fat.
2. Determination of the Iodine number of an oil/ fat.
3. Extraction of caffeine from tea leaves.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups.

IV. Reference Books:

1. Vogel, A.I. *A textbook of Quantitative Analysis*, ELBS 1986.
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).
6. Khosla, B. D.; Garg, V. C. & Gulati, *A. Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
7. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry* 3rd Ed.; W.H. Freeman & Co.: New York (2003).

SEMESTER VII

I. MAJOR COURSE- MJ 16:
CHEMISTRY-XII (RESEARCH METHODOLOGY)

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. To introduce students to the basics of research and scientific inquiry
2. To enable students to identify and define research problems
3. To familiarize students with various research methods, tools and ethical practices
4. To develop basic skills in data collection, analysis and reporting

Course Learning Outcomes:

Students would be able to understand:

1. Characteristics of good research viz; a comprehensive study of research reviews, gaps, objective, methodology, results, discussion and conclusion with future scope.
2. How to keep ethical considerations and stay away from plagiarism.

Course Content:

UNIT I: Introduction to Research (12 Lectures)

Definition and objectives of research, Types of research: basic, applied, qualitative, quantitative
Steps in the research process, Research questions and hypothesis formulation, Characteristics of good research

UNIT II: Research Design and Sampling (12 Lectures)

Research design: exploratory, descriptive, experimental, Variables and control groups, Sampling methods: probability and non-probability, Sample size determination, Limitations and delimitations

UNIT III: Data Collection Methods (12 Lectures)

Primary and secondary data, Techniques: questionnaires, interviews, observation, case studies
Survey tools and fieldwork, online and offline data collection, Validity and reliability of data

UNIT IV: Data Analysis and Interpretation (16 Lectures)

Basics of data organization, Introduction to descriptive statistics: mean, median, mode, standard deviation
Graphical representation: tables, charts, graphs, Introduction to inferential statistics
Use of software tools (e.g., MS Excel, SPSS/R/PAST – demo-based)

UNIT V: Report Writing and Research Ethics (8 Lectures)

Structure of a research report/thesis, Referencing and citation styles (APA/MLA)
Plagiarism and how to avoid it, Intellectual property rights and copyright
Ethical issues in research (including human and animal ethics)

Practical / Project Work

Framing a research question and writing a short proposal
Designing a sample questionnaire or data collection tool
Collecting mock data and presenting it using graphs or basic stats
Referencing using software like Zotero, Mendeley
Writing a mini-report based on collected data

Reference Books:

1. Kothari, C. R. – Research Methodology: Methods and Techniques.
2. Online resources: SWAYAM, NPTEL and Google Scholar.
3. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New age International.
4. Breakwell, Glynis M. Hammond, S. Fifeschaw, C., Smith, J.A. Research Methods in Psychology, Sage Publication.
5. Kerlinger, Fred N., Foundation of Behavioral Research, Hort, Rinehart and Winston publishing.
6. Ahuja, Ram., Research Methods, Rawat Publications.

II. MAJOR COURSE- MJ 17:
CHEMISTRY-XIII

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

This course is designed:

1. To expose the students to the basic principles of spectroscopic theory.
2. Application of spectroscopic techniques in organic chemistry. Interaction of electromagnetic radiations and matter.
3. Applications of spectroscopic analysis to elucidate the structure of organic compounds.

Course Learning Outcomes:

On successful completion of this course, the student should be able to understand:

1. Correlate theory and experimental findings to explore structural features of chemicals.
2. Apply the concept to establish structures of unknown compounds.

Course Content:

UNIT I: Microwave Spectroscopy (08 Lectures)

Interaction of electromagnetic radiation with molecules & various types of spectra and Born-Oppenheimer approximation. Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities and non-rigid rotor. Stark effect, nuclear and electron spin interaction and the effect of external field. Applications.

UNIT II: Vibrational Spectroscopy (10 Lectures)

A. Infrared Spectroscopy

Linear harmonic oscillator, vibrational energies of diatomic molecules, zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P, Q, R branches. Breakdown of Oppenheimer approximation; vibrations of polyatomic molecules. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities.

Applications of IR Spectroscopy: (14 Lectures)

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). Effect of H-bonding, conjugation, resonance and ring size on IR absorptions, Fingerprint region and its significance, application in functional group analysis.

B. Raman Spectroscopy

Classical & quantum theories of the Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Rule of the mutual exclusion principle. Resonance Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy (CARS).

UNIT II: UV Spectroscopy: (10 Lectures)

Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption, Application of Woodward - Fieser rules for calculation of λ_{max} for the following systems: α, β-unsaturated aldehydes, ketones, carboxylic acids and esters, Conjugated dienes: alicyclic, homoannular and heteroannular and extended conjugated systems (aldehydes, ketones and dienes). Distinction between cis and trans isomers.

UNIT III: NMR Spectroscopy: (10 Lectures)

Basic principles of Proton Magnetic Resonance, factors influencing chemical shift, Spin–Spin coupling, coupling constant, Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

UNIT IV: Mass Spectroscopy: (8 Lectures)

Basics of fragmentations in organic compounds. Discussion of molecular ion peak, base peak and metastable ions, McLafferty rearrangement. Nitrogen rule, Index of hydrogen deficiency. Application of fragmentation in the characterisation of organic compounds. Problems in the structure elucidation of organic compounds based on spectral data. Applications of IR, UV, NMR and Mass spectra for the identification of simple organic molecules.

Reference Books:

1. William Kemp, Organic Spectroscopy, 3rd Edition ELBS, 2022
2. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,* UniversityScience Books, 1998
3. Rohatgi-Mukherjee K. K. *Fundamentals of Photochemistry*, New Age (revised secondedition).
4. Banwell C.N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
5. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of OrganicCompounds*, John Wiley & Sons.
6. John R. Dyer, *Applications of absorption spectroscopy of organic compounds*, Prentice Hall India (2012).

III. MAJOR COURSE- MJ 18:
PRACTICAL-V

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

List of Practical

I. Organic Preparations

i. 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 the Schotten-Baumann reaction.
ii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
iii. Nitration: (any one)
   a. Acetanilide/nitrobenzene by conventional method
   b. Salicylic acid by the green approach (using ceric ammonium nitrate).
iv. Selective reduction of meta-dinitrobenzene to m-nitroaniline.
v. Reduction of p-nitrobenzaldehyde by sodium borohydride.
vi. Hydrolysis of amides and esters.

II. Estimations

a. Estimation of the amino group by the brominating method.
b. Estimation of the Phenolic group by the brominating method.
c. Estimation of glucose by the Fehling solution method.
d. Estimation of glucose by the Benedict's solution method.
e. Estimation of amino acid.
f. Estimation of Formaldehyde.

III. Separation and identification

a. Separation and identification of organic compounds from the following mixture.
   i. Benzoic acid + β – naphthol.
   ii. ρ – toludine + naphthalene.

Reference Book:

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).

IV. ADVANCED MAJOR COURSE- AMJ 1: ADVANCED CHEMISTRY-I

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Objectives:

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

1. Reaction Mechanism and factors related to Structure and Reactivity in inorganic reactions.
2. Different types of substitution reactions of complexes.
3. Electronic spectra of inorganic molecules.

Course Learning Outcomes:

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

1. Explain the labile and inert behaviour of complexes.
2. Explain the kinetic application of valence bond and crystal field theories
3. Appreciate one-electron transfer reactions.

Course Content:

UNIT I: Stereochemistry and Bonding in Main Group Compounds (05 Lectures)

VSEPR, Walsh diagrams (tri-atomic molecules of type AH_2), dπ-pπ bonds, Bent rule and energetic of hybridisation, some simple reactions of covalently bonded molecules, Atomic Inversion, Berry Pseudorotation.

UNIT II: Metal-Ligand Bonding (05 Lectures)

Limitations of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, p-bonding and molecular orbital theory.

UNIT III: Metal-Ligand Equilibria in Solution (05 Lectures)

Step-wise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

UNIT IV: Acids, Bases, Electrophiles, Nucleophiles and Catalysis (09 Lectures)

Acid-base dissociation. Electronic and structural effects, acidity and basicity. Acidity functions and their applications. Hard and soft acids and bases. Nucleophilicity scales. Nucleofugacity. The α-effect. Ambivalent nucleophiles. Acid-base catalysis- specific and general catalysis. Bronsted catalysis. Nucleophilic and electrophilic catalysis. Catalysis by non-covalent: binding-micellar catalysis.

UNIT V: Nature of Bonding in Organic Molecules (10 Lectures)

Delocalized chemical bonding: conjugation, cross-conjugation, resonance, hyperconjugation, bonding in fullerenes, tautomerism.

Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of 7-molecular orbitals, annulenes, anti-aromaticity, Y-aromaticity, homo-aromaticity, PMO approach.

Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

UNIT VI: Stereochemistry (10 Lectures)

Cycloalkanes and stability, Baeyer strain theory. Conformation analysis and Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms. Conformational analysis of decalins, effect of conformation on reactivity, conformation of sugarsand steric strain due to unavoidable crowding.

Methods of resolution of chiral compounds, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape.

Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

UNIT VII: A Mathematical Approach to MO Theory (6 Lectures)

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 wave functions, detailed solution not required) and their limitations. Average and most probable distances of the electron from the nucleus. Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.

UNIT VIII: Unifying Principles (10 Lectures)

Electromagnetic radiation, interaction of electromagnetic radiation with matter: absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, results of the time-dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.

Books Suggested:

1. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
2. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
3. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
4. Quantum Chemistry, Ira N. Levine, Prentice Hall.
5. Chemical Applications of Group Theory, F. A. Cotton.
6. Physical Methods in Chemistry, R.S. Drago, Saunders College.
7. Introduction to Molecular Spectroscopy, Q.M. Barrow, McGraw Hill.

OR

RESEARCH COURSES- RC 1: (In lieu of AMJ 1)

RESEARCH PLANNING & TECHNIQUES

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	**Pass Marks: Th (SIE + ESE) = 40**

(Credits: Theory-04) **60 Hours**

(Only for Hons with Research Degree)

Course Objectives:

1. To equip the students with the ability to understand the philosophy and ethics of research.
2. Foster critical and analytical thinking aligned with NEP's emphasis on inquiry-based learning.
3. They could frame the questions in research and structure the hypothesis to find the gap in any research matter.

Course Learning Outcomes:

1. They will be able to identify and define a research problem.
2. Able to conduct literature reviews using digital tools.
3. Form basic research questions and a hypothesis.
4. Design research methodology along with the given protocols.
5. Able to present research proposals.

Course Content:

UNIT I: Research Planning and Design based on objectives

Research should be designed.
Review of literature and its importance
Preparing a research proposal

UNIT II: Research Methods and Techniques

Data collection methods: Observation, survey, interviews, experiments, if lab techniques are required
Sampling techniques
Introduction to data analysis: Quantitative and qualitative
Use of tools (questionnaires, spreadsheets, basic statistical software)

UNIT III: Synthesis, Purification & Sampling

General method of preparation of Samples
Purification & Isolation Techniques
Sample Preparation for Analysis

UNIT IV: Instrumentation Techniques and their Relevance

Classical vs Instrumental Techniques
Gravimetric Analysis
Volumetric Analysis
Instrumentation Techniques & their relevance
Selection of Analytical Techniques

UNIT V: Interpretation of Results

Structuring a research report
Selection of Experimental Tools
Interpretation of Experimental Reports

UNIT VI: Project Work and Practical Application

Mini project on a chosen research topic
Preparing a report and delivering a presentation
Peer review and feedback

Reference Books:

1. Kothari, C. R. – Research Methodology: Methods and Techniques
2. Online resources: SWAYAM, NPTEL and Google Scholar
3. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New age International
4. Kerlinger, Fred N., Foundation of Behavioral Research, Hort, Rinehart and Winston publishing
5. Ahuja, Ram., Research Methods, Rawat Publications

SEMESTER VIII

I. MAJOR COURSE- MJ 19:
CHEMISTRY-XIV

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

Course Objectives:

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

1. Black body radiation
2. The concept of wave function and its importance.
3. The Schrodinger wave equation
4. Applications of the variation method and perturbation theory
5. The concept of Angular momentum
6. The theories governing bonding in chemical substances.
7. The instability of nuclei and nuclear disintegration
8. The difference between Nuclear Fission and Fusion.
9. The Nuclear Reactor Theory.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Elucidating the Black body radiation and the Photoelectric effect.
2. To apply the Schrodinger wave equation
3. About spin-orbit coupling and Zeeman splitting
4. Comparison of LCAO-MO and VB treatments of H_2
5. About nuclear radiations and nuclear reactions and reactor theory.

Course Content:

UNIT I: Quantum Chemistry

Introduction to Quantum Chemistry (10 Lectures)

Introduction to black-body radiation and distribution of energy, photoelectric effect, concept of quantization, wave-particle duality (de-Broglie's hypothesis), Planck's Quantum theory. 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 eigen values.

The Schrodinger wave equation (10 Lectures)

Postulates of quantum mechanics, the Schrodinger wave equation. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in one-dimensional box, three-dimensional box, the harmonic oscillator, the rigid rotor and the hydrogen atom. Schrodinger equation in spherical polar coordinates and separation of $R_{(r)}$, $\Theta_{(\theta)}$ & $\Phi_{(\phi)}$ (radial and angular parts), degeneracies, spherical harmonics of the hydrogen atoms.

Approximate Methods for multi-electron system (6 Lectures)

The variation method, Perturbation theory (first order and non-degenerate) and the W.K.B. method. Applications of variation method and perturbation theory to the Helium atom.

Angular momentum (8 Lectures)

Ordinary angular momentum, generalised angular momentum (quantum mechanical approach), communication relation, eigen functions for angular momentum, eigen values of angular momentum. Operators: Ladder operators, raising and lowering operator, addition of angular momenta, spin, antisymmetric and Pauli Exclusion Principle.

Electronic Structure of Atoms (8 Lectures)

Electronic configuration, Microstate, Term symbols, Russell- Saunders coupling schemes, Slater-Condon parameters, term separation energies for the d^n configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self -consistent field, the virial theorem.

UNIT II: Nuclear Chemistry (18 Lectures)

Systematic of alpha, beta and gamma decays

Alpha decay, energy curve, spectra of alpha particles, Giger-Nuttal law, theory of alpha decay, penetration of potential barrier, beta decay, range of energy relationship, beta spectrum, sergeants curve, Fermi theory of beta decay, matrix

elements, allowed and forbidden transitions, curie plots, gamma decay, Nuclear energy levels, selection rule, isomeric transitions, Internal conversion, Auger effect.

Nuclear Structure and Stability

Nuclear Fission & Fusion, Binding energy, empirical mass equation, The nuclear models, the liquid drop model, the shell model, the Fermi gas model & collective nuclear model, nuclear spin, parity & magnetic moments of odd mass numbers nuclei. Symmetric and asymmetric fission, decay chains. Heavy water manufacturing.

Reference Books:

1. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
2. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
3. Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed.,* Oxford University Press (2011).
4. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
6. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
7. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999
8. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill (International), 1995.
9. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, University Science Books, 1998.
10. Banwell C.N. & Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).
11. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
12. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice–Hall,
13. Overman R. T., Basic Concepts of Nuclear Chemistry, Chapman & Hall.
14. A. N. Nesmeyanov, Radiochemistry, MIR Publication, Moscow.
15. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry, Wiley
16. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, Second Edition.

II. MAJOR COURSE- MJ 20:
PRACTICAL-VI

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

List of Practical

I. Analysis of water

a. Determination of temporary hardness in the supplied sample of water.
b. Determination of permanent hardness in the supplied sample of water.
c. Determination of total hardness of water by Complexometry.
d. Determination of dissolved oxygen in water.
e. Determination of Chemical Oxygen Demand (COD)
f. Determination of Biological Oxygen Demand (BOD)
g. Percentage of available chlorine in bleaching powder.
h. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
i. Measurement of dissolved CO_2.

II. Cosmetics

a. Preparation of Face Cream.

III. Gravimetric Analysis:

a. Estimation of nickel (II) using Dimethylglyoxime (DMG).
b. Estimation of barium as $BaSO_4$
c. Estimation of magnesium in pyrolusite
d. Estimation of iron in Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

Reference Book:

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).

III. ADVANCED MAJOR COURSE- AMJ 2: ADVANCED CHEMISTRY-II

Marks: 25 (5 Attd. + 20 SIE: 1Hr) + 75 (ESE: 3Hrs) = 100	Pass Marks: Th (SIE + ESE) = 40

(Credits: Theory-04) **60 Hours**

(Only for Hons Degree)

Course Objectives:

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

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Understanding hybridisation and geometry of atoms, 3-D structure of organic molecules and identifying chiral centers.
5. Reactivity, stability of organic molecules, structure and stereochemistry.
6. Electrophiles, nucleophiles, free radicals, electronegativity, resonance and intermediates along the reaction pathways.
7. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

Course Learning Outcomes:

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

1. Understand the Mechanistic path of Organic reactions.
2. Decide the formation of reaction products other than the expected one.
3. Compare the stability of various intermediates formed in a chemical reaction.
4. Learn about the methods of Analysis of common useful substances.

Course Content:

UNIT I: General Mechanism in Organic Chemistry (10 Lectures)

Structure and Reactivity, Types of mechanisms, types of reactions. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity, resonance and field effects, steric effect.

UNIT II: Aliphatic Nucleophilic Substitution (12 Lectures)

The SN_2, SN_1, mixed SN_1 and SN_2 and SET mechanisms. Structural and electronic effects on SN_1 and SN_2 reactivity. Solvent effects. Kinetic isotope effects. Intramolecular assistance: Electron transfer nature of SN_2 reaction.
The neighbouring group mechanism, neighbouring group participation by R and π-bonds, anchimeric assistance.
Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The SNi mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and ambident nucleophile.

UNIT III: Aliphatic Electrophilic Substitution (05 Lectures)

Electrophilic reactivity, general mechanism. Bimolecular mechanisms- SE_2 and SE_i. The SE_1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity. Kinetics of SE_2-Ar reaction. Structural effects on rates and selectivity.

UNIT IV: Addition to Carbon-Carbon Multiple Bonds (5 Lectures)

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemo-selectivity, orientation and reactivity. Addition to the cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

UNIT V: Addition to Carbon-Hetero Multiple Bonds (05 Lectures)

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, Organozinc and Organolithium reagents to carbonyl and unsaturated carbonyl compounds. Mechanism of condensation reactions involving enolates- Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

UNIT VI: Aromatic Electrophilic & Nucleophilic Substitution (08 Lectures)

The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack and orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeier reaction, Gattermann-Koch reaction.
The SN_{Ar}, SN_1, benzyne and SRN_1 mechanisms. Reactivity - effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser and Smiles rearrangements.

UNIT VII: Free Radical Reactions **(10 Lectures)**

Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate and neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

UNIT VIII: Organic Reagents

1. Oxidizing Agents **(10 Lectures)**

OsO_4, $KMnO_4$, SeO_2, DDQ, PCC, PDC, TEMPO, NaOCl, MnO_2, Jones reagent, Collins reagent.

2. Reducing Agents **(08 Lectures)**

$NaBH_4$, $LiAlH_4$, DIBAL-H, BH_3, N_2H_2, BINAL, Wilkinson catalyst, Lindlar catalyst, Rosenmund catalyst.

Reference Books:

1. Reactions and Reagent, O.P. Agrawal.
2. UGC Advanced Organic Chemistry, Jagdamba Singh and LDS Yadav, Pragati Prakashan
3. Modern Methods of Organic Synthesis, W. Carruthers, Iain Coldham.
4. Organic Name Reactions: A unified approach, Goutam Brahmachari.
5. A Guidebook to Mechanism in Organic Chemistry, Peter Stykes.
6. Name Reactions: A Collection of Detailed Reaction Mechanisms, Jie Jack Li.
7. Strategic Applications of Named Reactions in Organic Synthesis, Laszlo Kurti, Barbara Czakó.
8. Organic Reaction Mechanisms, Raj K. Bansal.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh.
10. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, Michael G. Ellerd, Frank G. Favaloro, Jr.
1. Jerry March, *Advanced Organic Chemistry-Reactions, Mechanism and Structure*, John Wiley.
2. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).
3. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, Longman.
4. C. K. Ingold, *Structure and Mechanism in Organic Chemistry*, Cornell University Press.
5. R. T. Morrison and R. N. Boyd, *Organic Chemistry*, Prentice-Hall.
6. H. 0. House, *Modern Organic Reactions*, Benjamin.
7. R. 0. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, Blackle Academic & Professional.
8. S. M. Mukherji, *Pericyclic Reactions*, Macmillan, India.
9. S. M. Mukherji and S. P. Singh, *Reaction Mechanism in Organic Chemistry*, Macmillan.
10. D. Nasipuri, *Stereochemistry of Organic Compounds*, New Age International.
11. P.S. Kalsi, *Stereochemistry of Organic Compounds*, New Age International.

IV. ADVANCED MAJOR COURSE- AMJ 3:
PRACTICAL-VII (ADVANCED CHEMISTRY)

Marks: Pr (ESE: 6Hrs) =100	**Pass Marks: Pr (ESE) = 40**

(Credits: Practicals-04) **120 Hours**

(Only for Hons Degree)

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 60 marks
Practical record notebook = 15 marks
Viva-voce = 25 marks

Practicals:

I. Separation Techniques

1. Chromatography:
   a. Separation of mixtures
      (i) Paper chromatographic separation of Fe^{3+}, Al^{3+} and Cr^{3+}.
      (ii) Paper chromatographic separation of Cd^{2+} and Pb^{2+}.
      (iii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
      (iv) Separation of a mixture of two amino acids by paper chromatography.

II. Estimations

a. Estimation of Magnesium and Calcium in a mixture by Complexometry.
b. Estimation of Copper & Zn in mixture by Gravimetry.
c. Estimation of Cu & Ni carbohydrate in a mixture by Gravimetry.

III. Spot Analysis

a. Identification of chemicals by Spot tests.
b. Spot analysis of following Acid & Basic Radicals: CO_3^{2-}, Cl^-, NO_3^-, SCN^-, SO_4^{2-}, PO_4^{3-}, NH_4^+, Co^{2+}, Ni^{2+}, Fe^{3+}

IV. Qualitative semi-micro analysis

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

Cations: NH_4^+, Pb^{2+}, 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+}

Anions: CO_3^{2-}, NO_2^-, CH_3COO^-, Cl^-, Br^-, NO_3^-, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$

(Spot tests should be carried out wherever feasible)

Mixtures should preferably contain:

a. one interfering anion, **or**
b. insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$) **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^-.

Reference Book:

1. Vogel, A.I. *A textbook of Quantitative Analysis*, ELBS 1986.
2. Vogel, A.I. *Qualitative Inorganic Analysis*, ELBS

V. RESEARCH COURSES- RC 2: (In lieu of AMJ 2 & AMJ 3)
RESEARCH/ PROJECT DISSERTATION/ RESEARCH INTERNSHIP/ FIELD WORK

Marks: 50 (SIE: 25 Synopsis + 25 Viva on Synopsis: 1Hr) + 100 (ESE Pr: 6Hrs) + 50 (Viva) = 200	**Pass Marks = 80**

(Only for Hons with Research Degree)

Guidelines to Examiners for Semester Internal Examination (SIE):
Evaluation of project dissertation work may be as per the following guidelines:
Project Synopsis = 25 marks
Project Synopsis presentation and viva-voce = 25 marks

Guidelines to Examiners for End Semester Examination (ESE):
Evaluation of project dissertation work may be as per the following guidelines:
Project model (if any) and the Project record notebook = 70 marks
Project presentation and viva-voce = 30 marks

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organisation*
- *Application of the Research technique in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Research Project
Research project under a Supervisor of the Department/Institution may be allocated to the eligible and qualifying candidate.

Project Dissertation/ Research Internship/ Field Work
The students of Graduation must work Thirty-Six (36) days as Interns under Any Organisation having an MoU with the Radha Govind University, which may include Government organisations/judiciary/ Health Care Sectors/ Educational Institutions/ NGOs etc.

- The nature and the place of working must be informed in writing, seeking permission from the head of the department or the institution before undertaking the Project dissertation.

Submission of the Project Work
Each student has to submit two copies of the dissertation work duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the Department/Institution for evaluation at least seven days before the seminar.

The Project Report will consist of:

a. Field work/Lab work related to the project.
b. Preparation of the dissertation based on the work undertaken.
c. Presentation of project work in the seminar on the assigned topic & open viva there on.
d. At least one Research paper must be presented at a conference or may be published in a reputed journal.

Topics
Project work related to the Industrial/socially relevant topics may be given.
NB: Students will select topics for the project work in consultation with a teacher of the department.
The seminar will be held in the respective University Department at Radha Govind Unievrsity

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COURSES OF STUDY FOR FYUGP IN **"CHEMISTRY" MINOR**

ASSOCIATED CORE COURSE- MN A **Either may be opted in Sem-I or Sem-II**

I. ASSOCIATED CORE COURSE- MN A: INTRODUCTORY CHEMISTRY

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. To expose the students to the basic principles of Chemistry.
2. Exposure of all three major branches of Chemistry.
3. Atomic theory and its evolution.
4. Learning the scientific theory of atoms, the concept of wave function.
5. Elements in the periodic table, physical and chemical characteristics, periodicity.
6. Concept of molecular framework and chemical bonding
7. Representative elements and their chemistry.
8. Hybridisation and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
9. Valence bond theory incorporating concepts of hybridisation predicting the geometry of molecules.

Course Learning Outcomes:

1. Electronic arrangements in atoms.
2. Electronic configuration of various elements in the periodic table
3. Predicting the structure of molecules

Course Content:

Section A: Physical Chemistry

UNIT I: Atomic Structure: (15 Lectures)

What is Quantum mechanics? Time-independent Schrodinger equation and the meaning of various terms in it. Significance of ψ and ψ^2, Schrodinger equation for the hydrogen atom. Radial and angular parts of the hydrogenic wave functions (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.

Section B: Inorganic Chemistry

UNIT II: Periodicity of Elements: (10 Lectures)

s, *p*, *d*, *f* -block elements, the Long form of the Periodic Table. Detailed discussion of the following properties of the elements.

a. Effective nuclear charge, shielding or screening effect, Slater rules.
b. Atomic radii (van der Waals)
c. Ionic and crystal radii.
d. Covalent radii (octahedral and tetrahedral)
e. Ionisation enthalpy, Successive ionisation enthalpies and factors affecting ionisation energy. Applications of ionisation enthalpy.
f. Electron gain enthalpy, trends of electron gain enthalpy.
g. Electronegativity, Pauling, Mulliken, Allred Rochow scales, electronegativity and bond order, partial charge, hybridisation, group electronegativity.

UNIT III: Chemical Bonding and Molecular Structure: (12 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridisation with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

UNIT IV: Fundamentals of Organic Chemistry: (8 Lectures)

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.

Aromaticity: Benzenoids and Hückel's rule.

Reference Books:

1. J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry*, Cengage Learning India Pvt. Ltd., New Delhi (2009)
2. Lee, J. D. *Concise Inorganic Chemistry,* Wiley, 5th Edn.
3. Douglas, B.E., McDaniel, D.H., Alexander, J.J., *Concepts & Models of Inorganic Chemistry,(Third Edition)* John Wiley & Sons,1999.
4. Atkins, P. W. and De Paula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press,2014.
5. Douglas, B.E, Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry3rd Ed.*, John Wiley Sons, N.Y. 1994.
6. Peter Sykes, *A Guide Book to Mechanism in Organic Chemistry*, Longman.
7. K. Ingold, *Structure and Mechanism in Organic Chemistry*, Cornell University Press.
8. R. T. Morrison and R. N. Boyd, *Organic Chemistry*, Prentice-Hall.
9. H. 0. House, *Modern Organic Reactions*, Benjamin.
10. R. 0. C. Norman and J. M. Coxon, *Principles of Organic Synthesis*, Blackle Academic & Professional.

II. ASSOCIATED CORE COURSE- MN A PR:
CHEMISTRY MINOR-A PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

I. Acquaintance with Chemistry Laboratory

1. Common Symbols of Laboratory Concerns:
   Biohazard, Highly Flammable, Oxidising, Corrosive, Harmful/Irritant, Radioactive, Explosive, Toxic, Dangerous for the Environment etc.
2. Common Laboratory Reagents:
   Common Acids, Common Bases, Common Inorganic/Organic Salts, Organic Compounds, Common Solvents, Difference between Dilute/Concentrated/Fuming liquids. Diluting a solution to a known strength. Safe storage of chemicals.

II. Common Procedures

4. Heating/Boiling with and without a condenser, Filtration techniques, Separation techniques, Crystallisation techniques.
5. Purification of organic compounds
   (say naphthalene & others) by Crystallisation using the following solvents:
   a. Water b. Alcohol c. Alcohol-Water d. Acetone e. Hexane f. Toluene
6. Determination of the melting points
   d. Determination of the melting points of the above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
   e. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
   f. Determination of the boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method).

Reference Books:

1. Vogel's *Qualitative Inorganic Analysis*, A.I. Vogel, Prentice Hall, 7th Edition.
2. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
3. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.
4. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
5. Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry.* New Age International: New Delhi (2001).

MINOR COURSE-B

I. MINOR COURSE- MN B:
CHEMISTRY MINOR-B

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. Familiarization with various states of matter.
2. Physical properties of each state of matter and laws related to describing the states.
3. Understanding the Kinetic model of gas and its properties.
4. Maxwell distribution, mean-free path, kinetic energies.
5. Behaviour of real gases, their deviation from ideal behaviour, equation of state, isotherm and law of corresponding states.
6. Liquid state and its physical properties related to temperature and pressure variation.
7. Properties of liquid as a solvent for various household and commercial use.

Course Learning Outcomes:

1. Electronic arrangements in atoms.
2. Electronic configuration of various elements in the periodic table
3. Predicting structure of molecules
4. Properties of Aliphatic and aromatic hydrocarbons.

Section A: Physical Chemistry

UNIT I: Kinetic Theory of Gases: (10 Lectures)

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Most probable, average and root mean square velocities (no derivation). Collision number, collision frequency, collision diameter and mean free path of molecules. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

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 the van der Waals equation. Andrews' isotherms of CO_2. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

UNIT II: Liquids: (5 Lectures)

Surface tension and its determination using a stalagmometer. Viscosity of a liquid and determination of the coefficient of viscosity using the Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

UNIT III: Solids: (8 Lectures)

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.

Section B: Organic Chemistry

UNIT V: Aliphatic hydrocarbons: (10 Lectures)

Alkanes: (Upto 5 Carbons)

Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from a Grignard reagent. *Reactions:* Free radical Substitution: Halogenation

Alkenes:(Upto 5 Carbons)

Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule),
Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikov's and anti-Markownikov's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons)

Preparation: Acetylene from CaC_2 and conversion into higher alkynes, by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: Formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

UNIT VI: Aromatic hydrocarbons: (8 Lectures)

Preparation of benzene: from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions of benzene: Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene)

UNIT VII: Polynuclear Hydrocarbons: (4 Lectures)

Reactions of naphthalene and anthracene: Structure, preparation and important derivatives of naphthalene and anthracene.

Reference Books:

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

II. MINOR COURSE- MN B PR:
CHEMISTRY MINOR-B PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

I. ***Section A: Physical Chemistry***

1. Surface tension measurement (use of organic solvents excluded).
   a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
   b) Study of the variation of surface tension of a detergent solution with concentration.

2. Viscosity measurement (use of organic solvents excluded).
   a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
   b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

II. ***Section B: Organic Chemistry***

1. Purification of organic compounds by Crystallisation (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
   a. Benzoylation of amines/phenols
   b. Oxime and 2,4-dinitrophenyl hydrazone of aldehyde/ketone
4. Analysis of soaps and detergents.
5. Preparation of Nylon-6, Nylon-66
6. Preparation of face cream
7. Vitamin-C preparation.

Reference Books

1. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.
2. A.I. Vogel: *Textbook of Practical Organic Chemistry*, 5th edition, Prentice-Hall.
3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
4. Waites M.J. (2008). *Industrial Microbiology: An Introduction*, 7th Edition, Blackwell Science, London, UK.
5. Prescott S.C., Dunn C.G., Reed G. (1982). Prescott & Dunn's Industrial Microbiology, 4th Edition, AVI Pub. Co., USA.
6. Reed G. (2004). *Prescott & Dunn's Industrial Microbiology*, 4th Edition, AVI Pub. Co., USA.
7. JR Casida L.E. (2015). *Industrial Microbiology*, 3rd Edition, New Age International (P) Limited Publishers, New Delhi, India.
8. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) *Industrial Microbiology: An Introduction*. 1st Edition, Blackwell Science, London, UK.
9. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) *Microbiology*. 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi.

MINOR COURSE-C

I. MINOR COURSE- MN C:
CHEMISTRY MINOR-C

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. The concept of equilibria and its applications.
2. The concept of pH.
3. The factors affecting the solubility of compounds.
4. The acidic and basic behaviour of a compound not having protons or the hydroxyl group.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Oxidation-Reduction and their use in metallurgy.
2. Understanding redox reactions in hydrometallurgy processes.
3. The difference in the bond nature of alkyl and aryl halides.
4. Difference in the nature of substitution reactions shown by alkyl and aryl; halides.

Course Content:

Section A: Physical Chemistry

UNIT I: Equilibrium: **(15 Lectures)**

Chemical Equilibria: Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases**.** Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^{o},

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionisation, factors affecting degree of ionisation, ionisation constant and ionic product of water. Ionisation 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 the solubility product principle.

Section B: Inorganic Chemistry **(8 Lectures)**

UNIT II: 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.

UNIT III: Oxidation-Reduction and general principle of metallurgy: **(8 Lectures)**

Redox equations, Balancing by Ion-electron method & Oxidation number method. Disproportionation Reaction. Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Ellingham diagrams for the reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Pyrometallurgy, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel de Boer process and Mond's process, Zone refining.

Section C: Organic Chemistry

UNIT IV: Alkyl Halides (Upto 5 Carbons) **(8 Lectures)**

Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions.

Preparation: from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

UNIT V: Aryl Halides **(6 Lectures)**

Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

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

II. MINOR COURSE- MN C PR: CHEMISTRY MINOR-C PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:
Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

Section A: Physical Chemistry

I. Ionic equilibria pH measurements

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
2. Determine the pH of the given aerated drinks, fruit juices, shampoos and soaps.
3. Preparation of buffer solutions:
    a. Sodium acetate-acetic acid
    b. Ammonium chloride-ammonium hydroxide

Section B: Inorganic Chemistry - Volumetric Analysis

II. Acid-Base Titrations

a. Estimation of oxalic acid present in the supplied sample.
b. Estimation of sodium hydroxide present in the given sample.
c. Estimation of the amount of acetic acid in vinegar solution.
d. Estimation of carbonate and hydroxide present together in a mixture.
e. Estimation of carbonate and bicarbonate present together in a mixture.
f. Estimation of free alkali present in different soaps/detergents.

III. Oxidation-Reduction Titrimetry

a. Estimation of Fe(II) in supplied solution using standardised $KMnO_4$ solution.
b. Estimation of oxalic acid using a standardised $KMnO_4$ solution.
c. Estimation of percentage of Fe(II) in Iron fillings with standard $K_2Cr_2O_7$

Section B: Organic Chemistry

IV. Identification of Elements and Purification Methods

1. Detection of hetero elements in organic compounds.
2. Purification of organic compounds by Crystallisation (from water and alcohol) and distillation.
3. Criteria of Purity: Determination of melting and boiling points.

Reference Books
1. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.
2. A.I. Vogel: *Textbook of Practical Organic Chemistry*, 5th edition, Prentice-Hall.
3. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
4. Vogel's *Qualitative Inorganic Analysis*, A.I. Vogel, Prentice Hall, 7th Edition.
5. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
6. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.

MINOR COURSE-D

I. MINOR COURSE- MN D:
CHEMISTRY MINOR-D

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. Laws of thermodynamics and concepts. Partial molar quantities and its attributes.
2. The concept of system, variables, heat, work and laws of thermodynamics.
3. The concept of heat of reactions and the use of equations in calculations of bond energy, enthalpy, etc.
4. The concept of entropy: reversible, irreversible processes. Calculation of entropy using 3nd law of thermodynamics.
5. The application of thermodynamics: Joule-Thomson effects, partial molar quantities.
6. Theories/thermodynamics of dilute solutions.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The First Law of Thermodynamics and its applications.
2. Oxidation-Reduction and General Principles of Metallurgy
3. The concept of reaction rates and the factors affecting them.
4. Metallurgical processes and representing compounds of p-block elements.

Course Content:

Section A: Physical Chemistry

UNIT I: First Law of Thermodynamics: (10 Lectures)

Intensive and extensive properties, thermodynamic variables, state and path functions, isolated, closed and open systems, reversible, irreversible and cyclic processes. Zeroth law of thermodynamics. *First law of Thermodynamics:* Concept of heat, *q*, work, *w*, internal energy, enthalpy, relation between heat capacities, calculations of *q*, *w*, *U and H* for reversible and irreversible processes.

UNIT II: Chemical Energetics: (8 Lectures)

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation. Calculation of bond energy, bond dissociation energy from thermochemical data. Statement of the Third Law of thermodynamics and calculation of absolute entropies of substances.

UNIT III: Chemical Kinetics: (7 Lectures)

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 the determination of the order of a reaction. Concept of activation energy and its calculation from the Arrhenius equation.

Section A: Inorganic Chemistry

UNIT IV: *s*- and *p*-Block Elements: (5 Lectures)

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionisation enthalpy, electronegativity (Pauling, Mulliken and Alfred-Rochow scales). Allotropy in C, S and P.

Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of the first member of each group.

UNIT V: Metallurgy: (5 Lectures)

Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

UNIT VI: Compounds of *p*-Block Elements: (10 Lectures)

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements.

Concept of multicentre bonding (diborane). Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH); Oxoacids of P, S and Cl; Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2

Reference Books:

1. R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
2. J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
3. F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
4. D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
5. Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.

II. MINOR COURSE- MN D PR: CHEMISTRY MINOR-D PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

Section A: Physical

Thermochemistry

1. Determination of the heat capacity of the calorimeter.
2. Determination of the enthalpy of neutralisation of hydrochloric acid with sodium hydroxide.
3. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
4. Determination of the enthalpy of hydration of copper sulphate.

Section A: Inorganic Chemistry

Qualitative Semi-micro Analysis

1. Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

   Cations: NH_4^+, Pb^{2+}, 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+}

   Anions: CO_3^{2-}, NO_2^-, CH_3COO^-, Cl^-, Br^-, NO_3^-, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$

   (Spot tests should be carried out wherever feasible)

Reference Books:

1. A.I. Vogel, *Qualitative Inorganic Analysis*, Prentice Hall, 7th Edn.
2. A.I. Vogel, *Quantitative Chemical Analysis*, Prentice Hall, 6th Edn.
3. B.D. Khosla, *Senior Practical Physical Chemistry*, R. Chand & Co.

MINOR COURSE-E

I. MINOR COURSE- MN E:
CHEMISTRY MINOR-E

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. Basic principle of laws of electrochemistry.
2. Understanding about chemical cells and their function
3. Understanding about electrodes, EMF measurement.
4. Understanding of potentiometric titrations and their applications.
5. Corrosion as an electrochemical phenomenon.
6. Coordination compounds – their nomenclature, theories, d-orbital splitting in complexes, chelate.
7. Transition metals, their stability, color, oxidation states and complexes.
8. Lanthanides, Actinides – separation, color, spectra and magnetic behavior

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Theories of electrolytic dissociation.
2. Laws of electrolysis and their applications.
3. Application of emf measurements.
4. Understanding the transition metals' stability in reactions, origin of colour and magnetic properties.
5. Understanding the separation of Lanthanoids and Actinoids, its color, spectra and magnetic behaviour.

Course Content:

Section A: Physical Chemistry

UNIT I: Conductance: (10 Lectures)

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's law of independent migration of ions. Debye-Huckel-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) hydrolysis constants of salts etc.

UNIT II: Electrochemistry: (6 Lectures)

Quantitative aspects of Faraday's law. Applications of electrolysis in metallurgy and industry. Half-cell potential, 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. Electrified interfaces, overpotential and Electrocatalysis - influence of various parameters. Hydrogen electrode.

UNIT III: Application of EMF measurements: (6 Lectures)

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 without transference, liquid junction potential, determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Section B: Inorganic Chemistry

UNIT IV: Transition Elements (3d series) (6 Lectures)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states.

UNIT V: Lanthanides and Actinides: (5 Lectures)

Electronic configuration, oxidation states, colour, spectra and magnetic behaviour of lanthanides and actinides. Lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT VI: Coordination Chemistry (12 Lectures)

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Drawbacks of VBT. IUPAC system of nomenclature.

Crystal field 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.

Reference Books:

1. J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry*, Cengage Learning India Pvt. Ltd., New Delhi (2009).
2. B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
3. R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
4. J. D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
5. F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley.
6. Gary Wulfsberg: *Inorganic Chemistry,* Viva Books Pvt. Ltd.

II. MINOR COURSE- MN E PR: CHEMISTRY MINOR-E PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment	*= 15 marks*
Practical record notebook	*= 05 marks*
Viva-voce	*= 05 marks*

Practicals:

Section A: Physical Chemistry

Conductometry

4. Determination of cell constant
5. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
6. Perform the following conductometric titrations:
    a. Strong acid vs. strong base
    b. Weak acid vs. strong base
    c. Mixture of strong acid and weak acid vs. strong base
    d. Strong acid vs. weak base
    e. Construction of a Daniell cell and measurement of EMF.

Section B: Inorganic Chemistry

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.

Reference Books

1. Willard, Hobert H. et al.: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
2. Ditts, R.V. *Analytical Chemistry – Methods of separation*
3. Oser B L (1965). *Hawk's Physiological Chemistry*, 14th Ed. McGraw-Hill Book
4. Subalakshmi, G. and Udipi, SA (2006) *Food processing and preservation*, 1st Ed. New Age International (P) Ltd.
5. Srilakshmi B (2018): *Food Science*, 7th Colour Ed. New Age International (P) Lt
6. Potter NN and Hotchkiss JH (1999): *Food science*,5th Ed, Springer.
7. A.I. Vogel, *Qualitative Inorganic Analysis*, Prentice Hall, 7th Edn.
8. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
9. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

MINOR COURSE-F

I. MINOR COURSE- MN F:
CHEMISTRY MINOR-F

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. The Colligative properties and their applications.
2. Phases, components, Gibbs' phase rule and its applications, construction of phase diagrams of different systems and the application of phase diagrams.
3. Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory and significance.
4. Familiarisation with classes of organic compounds and their methods of preparation.
5. Name reactions, uses of various reagents and the mechanism of their action.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The behaviour of dilute solutions and will be able to find various physical parameters of dilute solutions.
2. Use of reagents in various organic transformation reactions.
3. The chemistry of oxygen-containing functional groups.

Course Content:

Section A: Physical Chemistry

UNIT I: Dilute solutions: (10 Lectures)

Dilute solutions, lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Colligative properties of solutions, abnormal colligative properties, Van't Hoffs factor. Thermodynamic derivation using chemical potential to derive relations between the (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. Azeotropes.

UNIT II: Surface chemistry: (6 Lectures)

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Langmuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (Excluding derivation), Adsorption in solution. Colloids: Classification, preparation, properties and stability of colloids.

Section B: Organic Chemistry

UNIT III: Alcohols: (7 Lectures)

Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation of *Diols:* (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

UNIT IV: Phenols: (7 Lectures)

Preparation: Cumene hydroperoxide method, from diazonium salts.

Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.

UNIT V: Ethers (aliphatic and aromatic): (3 Lectures)

Preparation and reaction with acids. Reaction of epoxides with alcohols, ammonia derivatives and $LiAlH_4$, Cleavage of ethers with HI.

UNIT VI: Aldehydes and ketones (aliphatic and aromatic): (12 Lectures)

(Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions– Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

Reference Books:
1. 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. T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
5. I.L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
6. Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.
7. G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
8. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
9. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., *Organic Chemistry*, 7th Edn., Pearson.
10. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic Compounds,* John Welly & Sons(1976).
11. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc (2009).
12. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,2013.
13. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science (2010).
14. Clayden, J., Greeves, N., Warren, S., Wothers, P., *Organic Chemistry,* Oxford University PressInc., New York (2001).

II. MINOR COURSE- MN F PR:
CHEMISTRY MINOR-F PRACTICAL

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for
End Semester Examination (ESE):
There will be one Practical Examination of 6Hrs duration. Evaluation of the Practical Examination may be as per the following guidelines:

Experiment	*= 15 marks*
Practical record notebook	*= 05 marks*
Viva-voce	*= 05 marks*

Practicals:

Section A: Physical Chemistry

1. **Surface tension measurements.**
   a. Determine the surface tension of the supplied liquid solution.
   b. Study the variation of surface tension of detergent/ supplied solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer**.
   c. Determination of the coefficient of viscosity of supplied solutions
   d. Study the variation of the coefficient of viscosity of a sucrose solution with the change in concentration of solute.

Section B: Inorganic Chemistry

1. **Estimations**
   a. Determination of temporary hardness in the supplied sample of water.
   b. Determination of permanent hardness in the supplied sample of water.
   c. Determination of total hardness of water by Complexometry.

Section B: Organic Chemistry

1. Differentiate between a reducing/non-reducing sugar.
2. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredients of an aspirin tablet by TLC.
3. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
4. Separation and identification of organic compounds from the following mixture.
   a. Benzoic acid + β–β-naphthol.
   b. ρ–toludine + naphthalene.

Reference Books:
1. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
2. Vogel, A.I. *A textbook of Quantitative Analysis*, ELBS 1986.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. *Practical Organic Chemistry,5th Ed.,* Pearson (2012)

MINOR COURSE-G

I. MINOR COURSE- MN G:
CHEMISTRY MINOR-G

Marks: 15 (15 SIE: 1Hr) + 60 (ESE: 3Hrs) = 75	**Pass Marks: Th (SIE + ESE) + Pr (ESE) = 40**

(Credits: Theory-03) **45 Hours**

Course Objectives:

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

1. Second law of thermodynamics.
2. Concept of enthalpy & resonance energy.
3. The use of thermochemistry to calculate Free energy
4. The mechanism of polymer material formation.
5. Polymerisation procedure and Ziegler-Natta catalysis.
6. Characterisation of polymers
7. Molecular weight and structure property relationship
8. The Chemistry of carboxylic acids and its derived compounds.
9. The Chemistry of nitrogen-containing compounds.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The Concept of entropy, the thermodynamic scale of temperature
2. Relation between Joule-Thomson coefficient and other thermodynamic parameters
3. Industrial methods of polymerisation.
4. Appreciate the behaviour of oxygen-containing functional groups.
5. Appreciate the efforts and contributions of scientists through name reactions in transforming compounds.
6. Distinction between 1°, 2° and 3°- amines
7. Preparation and synthetic applications: Diazonium salts

Course Content:

Section A: Physical Chemistry

UNIT I: Second & Third Law: (10 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.

Third Law: Statement of the third law, concept of residual entropy, calculation of absolute entropy of molecules.

UNIT II: Free Energy Functions: (7 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 equations of state.

Section B: Organic Chemistry

UNIT III: Introduction of Polymers: (6 Lectures)

Introduction and classification of Polymers, Biopolymers and Synthetic polymers. Polymerisation process, degree of polymerisation, condensation and addition polymers and kinetics of the addition polymerisation process. Ziegler-Natta, Metallocene and others.

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, Hofmann bromamide degradation and Curtius rearrangement.

UNIT V: Nitrogen-Containing Functional Groups (12 Lectures)

Preparation and important reactions of aliphatic and aromatic compounds of nitro, nitrile and isonitrile groups. 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.

Reference Books:

1. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
2. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., *Organic Chemistry*, 7th Edn., Pearson.
3. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic Compounds,* John Welly & Sons(1976).
4. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc (2009).
5. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,2013.
6. Kalsi, P. S. *Organic reactions and their mechanisms*, New Age Science (2010).
7. Clayden, J., Greeves, N., Warren, S., Wothers, P., *Organic Chemistry,* Oxford University PressInc., New York (2001).

II. MINOR COURSE- MN G PR:
CHEMISTRY MINOR-G PRACTICALS

Marks: Pr (ESE: 6Hrs) = 25	**Pass Marks: Pr (ESE) = 10**

(Credits: Practicals-01) **30 Hours**

Instructions to Question Setter for

End Semester Examination (ESE):

There will be one Practical Examination of 6Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Experiment = 15 marks
Practical record notebook = 05 marks
Viva-voce = 05 marks

Practicals:

Section A: Inorganic Chemistry

Polymer synthesis

1. Preparation of nylon 66/6
2. Preparation of Face Cream.

Estimatinons

1. Determination of temporary hardness in the supplied sample of water.
2. Determination of permanent hardness in the supplied sample of water.
3. Determination of total hardness of water by Complexometry.

Section B: Organic Chemistry

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by the formylation method.
3. Study of the titration curve of glycine
4. To determine the saponification value of an oil/fat.
5. To determine the iodine value of an oil/fat

Reference Books:

1. F. G. Mann & B. C. Saunders, *Practical Organic Chemistry*, Orient Longman (1960).
1. Vogel, Arthur I: *A Test book of Quantitative Inorganic Analysis* (Rev. by G.H Jeffery and others) 5th Ed. The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Ditts, R.V. *Analytical Chemistry – Methods of separation*
4. Malcolm P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed.
5. Harry R. Allcock, Frederick W. Lampe and James E. Mark, *Contemporary Polymer Chemistry*, 3rd ed. Prentice-Hall (2003)
6. Fred W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
