P. D. E. A's

Prof. Ramkrishna More Arts, Commerce and Science College Akurdi Pune-411044

Affiliated to

Savitribai Phule Pune University [SPPU]

B.Sc. Chemistry / B.Sc. Honors Chemistry

(Three Years B. Sc. and Four Years B. Sc. Honors Program)

Choice Based Credit System [CBCS]

Under

Autonomy and NEP-2024 Pattern

Syllabus

Third Year Graduate (T.Y. B. Sc.)
Chemistry

From Academic Year

2026-2027

Board of Studies in Chemistry

Rules and Regulations

1. **National Credit Framework (NCrF):** For creditisation and integration of all higher education qualifications leading to a certificate/ diploma/ degree with multiple entry and exit options, college will refer to National Credit Framework (NCrF) which encompasses the qualification frameworks for higher education, vocational and skill education and school education, namely National Higher Education Qualification Framework (NHEQF), National Skills Qualification Framework (NSQF) and National School Education Qualification Framework (NSEQF) respectively.

2. **Structure of Four years multidisciplinary UG Programme and Five Years Integrated Multidisciplinary Master's Degree Programmes with Multiple Entry and Exit Options at Different Levels:**

   (i) Students will have the flexibility to enter four years multidisciplinary Under Graduate Programme in odd semesters and exit a programme after the successful completion of even semesters as per their future career needs.

   (ii) Students will get a Certificate after a One year programme (minimum 40 Credits), a Diploma after two years (minimum 80 Credits), a Bachelor's degree after three years (minimum 120 Credits), and a Bachelor's degree with Research or Honours after Four years (minimum 160 Credits).

3. **Qualification Type and Credit Requirements of Four Years Multidisciplinary Degree Programme with Multiple Entry and Exit Options**

   (i) Details of qualifications, minimum credit requirements, exit credit courses, year and semester are as under:

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	UG Certificate	40	44	2	1
5.0	UG Diploma	80	88	4	2
5.5	Three Years Bachelor's degree	120	132	6	3
6.0	Bachelor's degree Honour's with Major	160	176	8	4
	Bachelor's degree Honour's with Major	160	176	8	4
7.0	Master's Degree	200	220	10	5
8.0	Ph. D.	----	-----	-----	----

   (ii) An exit 6-credit bridge course(s) lasting two months, including at least 6-credit job specific internship/apprenticeship that will help the graduates acquire job-ready competencies required to enter the workforce will be an additional requirement for the award of the undergraduate Certificate/ Diploma/ three year Bachelor's Degree.

   (iii) On exit, the students will have the option to re-enter the programme in the college, or in a different higher education institution. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in the Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records.

   (iv) Eligibility for admission to the fourth year of four-year **Honours with Research Degree Programmes** as per UGC guidelines: Minimum CGPA of 7.5 or minimum 75% at three-year degree.

(v) PG curriculum, as illustrated below, have flexibility a) One-year Post-Graduate Diploma (PGD), b) Two year Post-graduate Programme and c) 5 Years Master's degree programmes with multiple Entry and Exit options at different levels.

(a) Post-Graduate Diploma (PGD): Programme duration- One year (2 semesters) after any bachelor's degree, min. 40 credits

(i) UGC: 1-Year (2 semesters) Post-Graduate Diploma (PGD) after 3-years Bachelor's degree: Level 6.0

(ii) UGC: 1-Year (2 semesters) PGD after 4 years Bachelor's degree (Honors/ Research): Level 6.5

(b) Master's Degree:

(i) UGC: 2-Years (four semesters) Master's Degree after obtaining a 3-years Bachelor's degree, Minimum 40 credits/year, second year devoted entirely to research, PG – 2nd year: Level 6.5

OR

(i) 1-Year (two semesters) Master's Degree after obtaining a 4-year Bachelor's degree (Honours/Research): Minimum 40 credits: Level 6.5

(c) Level 8 represents Ph. D. Research Degree.

(d) A 5-year Integrated Bachelor's and Master's programme shall have a minimum of 220 credits.

(e) Master's and doctoral programmes, while providing rigorous research-based specialization, should also provide opportunities for multidisciplinary work, in academia, government, research institutions, and industry.

4. Lateral Entry/ Re-entry at higher Levels after exit from lower levels of four years multidisciplinary UG degree programme:

(i) The credit points earned and accumulated shall be used to determine the eligibility for taking admission to various programs at multiple levels, subject to fulfilment of the broad principles laid down under NCrF. Students who leave with a Certification, Diploma, or a Basic Bachelor's Degree will be eligible to re-enter the programme at the exit level to complete or progress to the next level through lateral entry mode. Depending upon the academic and physical facilities available, the State Universities/ Autonomous Colleges (Higher Education Institutions or HEI) may earmark specific seats/ intake for lateral entry into the second year/ third year/ fourth year of a four years multidisciplinary UG degree programme as approved by Professional Standard Setting Bodies (PSSB/Govt. of Maharashtra/ statutory council of affiliating University plus any consequential vacancies caused by exits to an ongoing programme (four-year Degree Programme and Integrated Master's or second year Master's). Lateral entry or Re-entry is open to those students if he/she has either –

(a) successfully completed the first year/second year/third year of the particular four years multidisciplinary degree programme in any ABC registered HEI with valid credits in ABC and re-entering into the second year/third year/fourth year, respectively of the same four years degree programme of any ABC registered HEI, within stipulated/ permissible period of years as decided by Statutory Councils of that HEI

OR

(b) Already successfully completed a multidisciplinary four-year first-degree programme and is desirous of and academically capable of pursuing another multidisciplinary four years first-degree programme in an allied subject.

(ii) A student will be allowed to enter/re-enter only at the odd semester. Re-entry at various levels for lateral entrants in academic programmes should be based on the earned and valid credits as deposited and accumulated in Academic Bank of Credits (ABC) through Registered Higher Education Institutions (RHEI) and proficiency test records. However, in terms of the admission eligibility requirements, the student shall belong to the same faculty/ discipline in terms of Major Subject i.e., the Major subject of his earlier Programme and the

Major subject of the new Programme for which he is seeking admission must be from the same faculty/discipline. Reservation for lateral entry will be executed as per the Government of Maharashtra norms.

5. Distribution of Credits across Multidisciplinary Four Years Degree Programme:

(i) Four-year multidisciplinary degree programme with Honours/ Specialization Degree will have Internship and Core /Major Courses with a minimum of 22 credits per sem. in the Fourth Year.

(ii) Four-year multidisciplinary degree programme with Research will have Research Projects, Seminars, Dissertations and Internships with a minimum of 22 credits per Sem. in the Fourth Year.

(iii) Students shall select a 'Major or Core Subject/ Discipline' and a '**Minor Subject/Discipline' from the lists of various Subject Combinations and Options provided the Colleges.** In general, for the four years multidisciplinary bachelor's degree programme, the distribution of credits will be as follows:

(a) Disciplinary/interdisciplinary Major/ Core Subject (minimum of 68 credits)- Mandatory and Elective Courses

(b) Disciplinary/interdisciplinary Minor Subject (maximum of 22 credits)

(c) Skill based/Vocational studies corresponding to the Major/ Core Subject (8 credits)

(d) Field projects/internship/apprenticeship/community engagement and service corresponding to the Major/ Core Subject (14-22 credits) with a maximum of six credits per Semester

(e) Generic/ Open Electives through Baskets of Elective Courses (12 credits),

(f) Ability Enhancement Courses including Languages, Literature and Environmental Studies (12 credits),

(g) In-built modules on the Indian Knowledge System (IKS) in Major/ Core Subject at Level 4.5 – 2 credits

(h) Value-based Education, Life Skills and Professional Ethics: Co-curricular Courses such as Sports and Culture, NSS/NCC and Fine/ Applied/Visual Arts (8 credits).

Student can earn some credits (SEC/VSC/GE/OE) in the form of online from-

(i) The National Skills Qualifications Framework (NSQF) organizes qualifications for Vocational and Skill Courses in a series of 8 levels based on professional knowledge, professional skills, core skills and responsibilities, in the increasing order of complexity and competency.

(ii) University Grants Commission (Credit Framework For Online Learning Courses through Study Webs of Active-Learning for Young Aspiring Minds) Regulations, 2021, **permits up to 40 per cent of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM) platform**.

6. Examination and Assessment Process:

(i) The basic principle of the credit framework is that credits are a function of the successful completion of a program of study/ vocational education/ training and assessment. No credit can be earned by the student unless the student is assessed for the achievement of the desired competencies and outcome of a program.

(ii) Exit options are provided with certification, diploma and basic Bachelor's degrees to the students at the end of the second, fourth and sixth semesters of a four years multidisciplinary degree programme. Students will receive a Bachelor's degree with Honours/ Research on successfully completing of all eight semesters of the UG Program either at a stretch or with opted exits and re-entries.

(iii) For the smooth success of four-year multidisciplinary degree programme with multiple entry and exit systems, the examination mode will be based on the combination of innovative trends in formative (informal and formal tests administered during the learning process) and summative (evaluation of students learning at the end of an instructional unit) examination modes. This is in line with the UGC Report on 'Evaluation Reforms in Higher Educational Institutions (2019)'.

(iv) Evaluation of each students in each course will be done as follows

a. Each theory may be 2 or 4 credits and practical course will be of 2 credits. 2 credit course examination will be of 50 mark and for 4 credits 100 marks.
b. Internal evaluation 30% weightage
c. External evaluation 70% weightage
d. Students should secure 40% marks in each type of evaluation for successful completion of a course.

(v) Evaluation Pattern.

a. Internal evaluation – Question paper should be designed so that evaluation of CO, PO, PSO can be performed. Internal evaluation should include written tests, seminars, orals, poster presentation, open book challenging tests, surprise test, objective test on whole syllabus of the course (at least 40 questions of objective type must be designed), etc. for 5 marks at least three different types technique must be utilized.

b. External Evaluation - Question paper should be designed so that evaluation of CO, PO, PSO can be performed. External evaluation will be done at the end of semester. Time for examination - 2 credits 2 hour time and 4 credit 3 hour time.

7. Declaration of Results:

(i) Declaration of result is based on the Semester Grade Point Average (SGPA) earned towards the end of each semester or the Cumulative Grade Point Average (CGPA) earned at the completion of all eight semesters of the programme and the corresponding overall alpha-sign or letter grades as given in Table 2. If some candidates exit at the completion of the first, second or third year of the four years Undergraduate Programmes, with Certificate, Diploma or Basic Degree, respectively, then the results of successful candidates at the end of the second, fourth or sixth semesters shall also be classified on the basis of the CGPA obtained in the two, four, six or eight semesters, respectively. Successful candidates at the end of the tenth semester of the integrated Master's Degree Programmes shall also be classified on the basis of CGPA obtained in the ten semesters of the Programmes. Likewise, the successful candidates of one year or two semesters Master's Degree Programme are also classified on the basis of the CGPA of two semesters of the Master's Degree Programme.

Table-2: Grades on degree certificate/mark sheet will be assigned to the students as per the following table

Semester GPA/ Program CGPA Semester/Program	% of Marks	Alpha-Sign / Letter Grade Result
9.00-10.00	90-100	O (outstanding)
8.00 - <9.00	80.00 – <90.00	A+ (Excellent)
7.00 - <8.00	70.00-<80.00	A (Very Good)
6.00 - <7.00	60.00-<70.00	B+ (Good)
5.50 - <6.00	55.00-<60.00	B (Above Average)
5.00 - <5.50	50.00-<55.00	C (Average)
4.00 - <5.00	40.00-<50.00	P (Pass)
Below 4.00	< 40	F (Fail)
Ab	----------	Absent

(ii) A student obtaining Grade F shall be considered failed and will be required to reappear in the examination. For non-credit courses 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

8. Award of Major and Minor Degree:

(i) A student pursuing four-year multidisciplinary UG programme will be awarded an appropriate Honours/ Research degree in Major/ Core Subject on completion of VIII Semester with the minimum of 176 credits if he secures in that Subject at least 50% of the total credits for that programme. He shall thus study the specific number of Mandatory Core Courses, Core

Electives, Vocational and Skill Courses and Field projects/ Internships connected to Core Subjects in eight semesters so as to cover at least 50% of the total credits.

(ii) In case of Research Degree, a student shall pursue research project and write dissertation in that Major in the VII and VIII semesters.

On the basis of above rules and regulations under NEP-2020 following course frame work is adopted by the Prof. Ramkrishna More Arts, Commerce and Science College, Akurdi, Pune-411044 for the completing of four years honours degree in Major and Minor subjects.

9. Distribution of Credits across Four Years Degree Programmes:

In general, for the four years' bachelor's degree programme, the distribution of credits will be as follows:

(a) Major (Core) Subject comprising Mandatory and Elective Courses:

i. Minimum 50% of total credits corresponding to Three/Four - year UG Degree- Mandatory Courses offered in all Four years;

ii. 2 credit course on Major Specific IKS shall be included under Major;

iii. Elective courses of Major will be offered in the third and/or final year.

iv. Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects connected to Major first to fourth year.

(b) Minor Subject: 18-20 Credits

i. The Minor subjects may be from the different disciplines of the same faculty of DSC Major (Core) or they can be from different faculty altogether.

ii. The credits of Minor subjects shall be completed in the first three years of UG Programme.

(c) Generic/ Open Elective Courses (OE): 10-12 credits

i. It is to be offered in I and/or II year

ii. Faculty-wise baskets of OE shall be prepared by University/ Autonomous Colleges.

iii. OE is to be chosen compulsorily from faculty other than that of the Major.

(d) Vocational and Skill Enhancement Courses (VSEC): 14-16 credits

Vocational Skill Courses (VSC): 8-10 credits, including Hands on Training corresponding to the Major and/or Minor Subject:

i. To be offered in first to three years;

ii. Wherever applicable vocational courses will include skills based on advanced laboratory practicals of Major

 # Skill Enhancement Courses (SEC): 06 credits

i. To be offered in I and II year;

ii. To be selected from the basket of Skill Courses approved by University/ Autonomous Colleges

(e) Ability Enhancement Courses (AEC), Indian Knowledge System (IKS) and Value Education Courses (VEC): 14 Credits

- **AEC: 08 credits**

i. To be offered in I and II year

ii. English: 04 Credits

iii. Modern Indian Language: 04 credits

iv. To be offered from the Basket approved by the College;

The focus for both languages should be on linguistic and communication skills.

o IKS: 2 Credits

i. To be offered in I Year

ii. Courses on IKS to be selected from the basket of IKS courses approved by the Colleges

o VEC: 04 Credits

i. To be offered in I year

ii. Value Education Courses (VEC) Environmental Science Education (Compulsory), Understanding India, and Digital and Technological Solutions.

(f) Field Projects/ Internship/ Apprenticeship/ Community Engagement and Service corresponding to the Major (Core) Subject, Co-curricular Courses (CC) and Research Project

o Internship/Apprenticeship corresponding to the Major (Core) Subject: 8 Credits

o Field Projects/Community Engagement and Service corresponding to the Major (Core) Subject: minimum 4-6 credits

To be offered in II, and III years of UG Degree Programmes.

o Co-curricular Courses (CC) such as Health and Wellness, Yoga education sports, and fitness, Cultural Activities, NSS/NCC and Fine/ Applied/ Visual/ Performing Arts: 8 credits. To be offered in I and/or II year

o Research Projects: 10 to 12 credits

To be offered in the final year for 4-year Honours with Research UG Degree

The UGC Regulations, 2021 permit up to 40% of the total courses being offered in a particular programme in a semester through the Online Learning Courses offered through the SWAYAM platform and/or other State Level Common Platforms which can be developed in due course with the participation of different Universities/ HEIs.

Abbreviations: Generic/ Open Electives: **GE**/**OE**; Vocational Skill and Skill Enhancement Courses: **VSEC**; Vocational Skill Courses: **VSC**; Skill Enhancement Courses**: SEC**; Ability Enhancement Courses: **AEC**; Indian Knowledge System: **IKS**; Value Education Courses: **VEC; OJT**: On Job Training: Internship/ Apprenticeship; Field projects: **FP**; Community engagement and service: **CEP**; Co-curricular Courses: **CC**; Research Methodology**-RM**; Research Project: **RP** Note: The Credit Distribution Table given above is illustrative only. The Universities/ Autonomous Colleges may suitably modify within the broader framework of credit distribution across six verticals.

Definitions:

1. One semester = 15 weeks

2. 1-credit theory = 15 hours i.e. for 1 credit, 1 hour per week teaching is to be performed.

15 hours of 1-credit are splinted as 12 hours actual teaching + 3 hours Tutorial (practice problem solving sessions, repeated discussion on difficult topics, discussion on student's difficulties, questions discussion and internal evaluation)

3. 1-credit practical = 30 hours. Thus, 1 credit practical = 2 contact hours in laboratory per week. 30 hours splinted as 24 hours actual table work and 6 hours for journal competition, oral on each practical and other internal evaluation.

4. Each theory course of any type (major, minor, VSC, VEC, OE/GE, VEC, SEC, CC, etc.) **is of 2 credits**.

a. Theory per semester: Contact hours per credi t= 15h (12 teaching + 3 tutorials include problem solving sessions, repeated discussion on difficult topics, solution difficulty, questions discussion and internal evaluation).

b. Each course will be of two or four modules, one module = 15 hours

c. Each module may consist of one or more than one chapter.

5. Each practical course of any course is of 2 credits = 60 hours per semester

a. Each laboratory sessions will be of 4 hours.

b. Minimum 12 laboratory sessions of 4 hour should be conducted in one semester. This time include completion practical report of the session.

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Prof. Ramkrishna More College, Akurdi, Pune 411044
Graduate and Honors Degree Course Framework under Autonomy as per NEP-2020; Pattern-2023; With Major Chemistry

Level / Difficulty	Sem	Subject-1				Subject-2	GE/OE	SEC	IKS	AEC	VEC	CC	Total
Certificate													
4.5 / 100	I	4T + 2P/T				4T + 2P/T	2T	2T/P	2T (General)	2T	2T	0	22
	II	4T + 2P/T				4T + 2P/T	2T/P	2T/P	0	2T	2T	2T/P	22
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor **Continue option:** Student will select one subject among the (subject 1, subject 2 and subject 3) as major and another as minor and third subject will be dropped.													
Diploma													
Level / Difficulty	**Sem**	**Credits Related to Major**				**Subject-2**	**GE/OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP / CEP / OJT**								
5.0 / 200	III	4T + 2P/T	0	2T/P	2 FP	2T+ 2T/P	2T	0	2T (Major Specific)	2T	0	2	22
	IV	4T + 2P/T	0	2T/P	2 CEP	2T + 2P/T	2T/P	2T/P	0	2T	0	2	22
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor													
Three years Graduation Degree													
5.5 /300	V	8T + 4P/T	4T + 2P/T	2T/P	2 FP/RP	0	0	0	0	0	0	0	22
	VI	8T + 4P/T	2T + 2P/T	2T/P	4 OJT	0	0	0	0	0	0	0	22
	Total Credits UG Degree	**48**	**10**	**8**	**10**	**20**	**8**	**6**	**4**	**8**	**4**	**6**	**132**
Four Years Graduate Degree with Honours (Major and Minor subjects)													
6.0 /400	VII	10T + 4P/T	2T + 2P/T	0	0	4T+P RM	0	0	0	0	0	0	22
	VIII	10T + 4P/T	2T + 2P/T	0	4 OJT	0	0	0	0	0	0	0	22
	Total Credits Honours Degree	**76**	**18**	**8**	**14**	**24**	**8**	**6**	**4**	**8**	**4**	**6**	**176**
Four Years Graduate Degree with Honours (Research)													
6.0 /400	VII	8T + 2P/T	2T + 2P/T	0	4 RP	4T+P RM	0	0	0	0	0	0	22
	VIII	10T + 2P/T	2T + 2P/T	0	6 RP	0	0	0	0	0	0	0	22
	Total Credits Honours Degree	**68**	**18**	**8**	**22**	**24**	**8**	**6**	**4**	**8**	**4**	**6**	**176**

Table-1: Courses at T. Y. B. Sc. NEP-2020; Pattern-2024

Sr No.	Course Type	Course Code and Title	Credits
Semester-V			**2**
1	Major	CHMAT-351: Physical Chemistry-III	**2**
2	Major	CHMAT-352: Inorganic Chemistry-III	**2**
3	Major	CHMAT-353: Organic Chemistry-III	**2**
4	Major	CHMAT-354: Medicinal Chemistry	**2**
5	Major	CHMAP-355: Practical Physical and Analytical Chemistry	**2**
6	Major	CHMAP-356: Practical Inorganic and Analytical Chemistry	**2**
7	Major Elective	CHMET-351A: Solid State Chemistry	**2**
8	Major Elective	CHMET-352A: Agrochemicals	**2**
9	Major Elective	CHMET-353A: Environmental Chemistry	**2**
10	Major Elective	CHMEP-351B: Practical Organic and Medicinal Chemistry	**2**
11	Major Elective	CHMEP-352B: Practical Organic and Argo Chemistry	**2**
12	VSC Theory	CHVST-351: Pharmaceutical Analysis-III	**2**
13	Project	CHRPP-351: Research Project	**2**
Semester-VI			
1	Major	CHMAT-361: Physical Chemistry-IV	**2**
2	Major	CHMAT-362: Inorganic Chemistry-IV	**2**
3	Major	CHMAT-363: Organic Chemistry-IV	**2**
4	Major	CHMAT-364: Analytical Chemistry-II	**2**
5	Major	CHMAP-365: Practical Physical and Analytical Chemistry	**2**
6	Major	CHMAP-366: Practical Inorganic and Analytical Chemistry	**2**
7	Major Elective	CHMET-361A: Polymer Chemistry	**2**
8	Major Elective	CHMET-362A: Dyes and Drug chemistry	**2**
9	Major Elective	CHMEP-361B: Practical Organic and Polymer Chemistry	**2**
10	Major Elective	CHMEP-362B: Practical Organic, Dyes and Drug	**2**
11	VSC Practical	CHVSP-361: Practical Pharmaceutical Analysis-IV	**2**
12	On Job Training	CHOJP-361: On Job Training	**4**

Semester-V: Course Wise Syllabus

CHMAT-351: Physical Chemistry-III [Theory, 2 Credit paper, 30L]

Module-I	Quantum Mechanics and Atomic Structure	8 L
	Properties of Diatomic Molecules	2 L
	Properties of Electromagnetic Radiations and Interaction with Diatomic Molecules.	3 L
	Microwave Spectroscopy	3 L
Module-II	Infra-Red Spectroscopy	3 L
	Raman Spectroscopy	3 L
	Photochemistry	9 L

1: Quantum Mechanics and Atomic Structure [8 L]

The Wave Theory of Light, Planck's Quantum Theory, The Photoelectric Effect, Bohr's Theory of the Hydrogen Emission Spectrum, de Broglie's Postulate, The Heisenberg Uncertainty Principle, The Schrodinger Wave Equation, Particle in a One-Dimensional Box, Electronic Spectra of Polyenes, Quantum-Mechanical Tunnelling, The Schrodinger Wave Equation for the Hydrogen Atom, Problems. (**Ref-1** Pages-383-433)

2: Properties of Diatomic Molecules [2 L]

Dipole moment, Polar and Non-polar Molecules, Determination of Dipole moment, Rotational Motion, Vibrational Motion, Reduced Mass of molecules, Problems. **(Ref-1, 2 and 3 page 482-528).**

3: Properties of Electromagnetic Radiations and Interaction with Diatomic Molecules. [2 L]

Electromagnetic Radiations: Wave nature, wavelength, frequency, energy. Interaction of Electromagnetic Radiations with Diatomic Molecules: Absorbance, Transmittance, Types of Interaction of Diatomic Molecules with Electromagnetic Radiations (Rotational, Vibrational and Electronic excitation), Representation of Spectra, Problems. **Ref-2:** 1-39 (Relevant points), Supplementary **Ref-1, 3, 4**: Relevant Pages

4: Microwave Spectroscopy [3 L]

Rotational Motion of Diatomic Molecules, Rotational Excitation, Energy of Diatomic Molecule in J^{th} Rotational Level, Quantization of Rotational Energy Levels, Selection rule for rotational excitation, Rotational Spectra of Diatomic Molecule and its interpretation, Problems. **Ref-2:** Relevant Pages, Supplementary **Ref-1, 3, 4:** Relevant Pages

5: Infra-Red Spectroscopy [3 L]

Vibrational Motion of Diatomic Molecules, Vibrational Excitation, Energy of Diatomic Molecule in ν^{th} Rotational Level, Quantization of Vibrational Energy Levels, Selection rule for Vibrational Excitation, Vibrational Spectra of Diatomic Molecule and its interpretation. Vibrational-Rotational Spectra of diatomic Molecules, Problems. **Ref-2:** Relevant Pages, Supplementary **Ref-1, 3, 4**: Relevant Pages

6: Raman Spectroscopy [3 L]

Raman Scattering, Theory of Raman Scattering (classical and quantum mechanical), Raman Spectra of Molecule and its Interpretation, Problems.

7: Photochemistry [9 L]

Part-I Basics of Photochemistry: Photochemical Reactions, Difference between Photochemical and Thermochemical Reactions, Thermopile, Photoelectric Cell, Chemical Actinometer, Laws of Photochemistry, Grothus Draper Law, Stark-Einstein Law of Photochemical Equivalence, Quantum Yeild (or Quantum Efficiency), Calculation of Quantum Yield, Photosensitized Reactions, Photophysical Processes, Fluorescence, Phosphorescence, Chemiluminescence. (Ref-3: PP 1043-1062)

Part-B: Photoflurimetry: General discussion, Instruments for fluorimetric analysis, Some applications of fluorimetry, EXPERIMENTAL – Quinine, Riboflavin, Zinc, Determination of codeine and morphine in a mixture. (Ref-5: pp- 731-740)

Ref-1: Physical chemistry for the chemical sciences, Raymond Chang, Jr. Thoman John W, University Science Books (2014).

Ref-2: Fundamentals of Molecular Spectroscopy, C. N. Banwell, Tata-McGraw Hill Publication.

Ref-3: Essentials of Physical Chemistry, Arun Bahl, B.S. Bahl, G.D. Tuli, Publisher S. Chand

Ref-4: Physical Chemistry, P. W. Attkins

Ref-5: Vogels Text Book of Inorganic quantitative analysis, 5th Ed, Longman Scientific Tecnical

Course Outcomes: Physical Chemistry-III

CO1: Explain the fundamental principles of quantum mechanics, including wave–particle duality, Planck's quantum theory, photoelectric effect, Bohr's model, de Broglie's hypothesis, Heisenberg's uncertainty principle, and the Schrödinger wave equation, with applications to simple systems such as the particle in a box and hydrogen atom.

CO2: Apply quantum mechanical concepts to interpret electronic spectra of polyenes, tunneling phenomena, and energy quantization in atomic and molecular systems.

CO3: Analyze the properties of diatomic molecules by evaluating dipole moments, rotational and vibrational motions, reduced mass, and their role in molecular spectroscopy.

CO4: Interpret the interaction of electromagnetic radiation with diatomic molecules, including rotational, vibrational, and electronic excitations, and represent spectra for different transitions.

CO5: Evaluate the principles and applications of molecular spectroscopy techniques—microwave, infrared, and Raman spectroscopy—by understanding selection rules, quantization of energy levels, and spectral interpretation.

CO6: Demonstrate knowledge of photochemistry by distinguishing photochemical and thermochemical reactions, applying laws of photochemistry, calculating quantum yield, and exploring photophysical processes (fluorescence, phosphorescence, chemiluminescence) along with practical applications in fluorimetric analysis.

CHMAT-352: Inorganic Chemistry III [Theory, 2 Credit paper, 30L]

Chapter No	Name of the Chapter	Lectures Assigned
Module-I	Molecular orbital Theory of covalent bonding	10
	Structure and Reactivity	05
Module-II	Reactions of Coordination Compounds	07

	Organometallic Compounds and homogeneous catalysis	08

Module I **[15 L]**

1. Molecular Orbital Theory of Covalent Bonding [10 L]

Introduction to Molecular Orbital Method (MOT) and postulates of MO theory, LCAO approximation, s-s combination of orbitals, s-p combination of orbitals, p-p combination of orbitals, p-d combination of orbitals, d-d combination of orbitals, nonbonding combination of orbitals, Rules for linear combination of atomic orbitals, example of molecular orbital treatment for homonuclear diatomic molecules: Explain following molecules with respect to MO energy level diagram, bond order and magnetism: H_2^+ molecule ion, H_2 molecule, He_2^+ molecule ion, He_2 molecule, Li_2 molecule, Be_2 molecule, B_2 molecule, C_2 molecule, N_2 molecule, O_2 molecule, O_2^- and O_2^{2-} ion, F_2 molecule, Heteronuclear diatomic molecules: NO, CO, HF. Triaromic molecules CO_2, NO_2, Structure and bond properties: Bond lengths and bond strength. (Ref.-1:89-112, Ref-5: 213-235 (recommended), Ref-2: 278-305, Ref-3: 117-164, Ref-4: 42-59)

2. Structure and Reactivity [5 L]

An Over View of Chemical Reactivity: Acid–Base Reactions, Arrhenius, Bronsted and Lewis Definition of Acids and Bases, Conjugate Acid Base Pairs, HSAB Principle; Frontier Molecular Orbital Theory; Oxidation–Reduction Reactions (**Ref-3**: pp 453-474, Ref-2 and 4 relevant pages).

Module II **[15 L]**

3. Reactions of Coordination Compounds [5L]

Kinetics Overview (Labile and Inert Complexes), Octahedral Substitution Reactions, Associative (A) Mechanism, Interchange (I) Mechanism, Dissociative (D) Mechanism, Square Planar Substitution Reactions and Trans Effect, Trans Effect Series (Reference-3 pp - 573-592; 2, and 4 respective pages)

4. Organometallic Compounds and Homogeneous Catalysis [10 L]

Par-A: Introduction to Organometallic Chemistry, Electron Counting and the 18-Electron Rule, Carbonyl Ligands, Nitrosyl Ligands, Hydride and dihydrogen ligands, Phosphine Ligands, Ethylene and Related Ligands (Ref-2). Bonding modes of CO and Structure of some metal carbonyl compounds and their synthesis (Ref-3 492-493).

Part-B: Terms involved homogeneous Catalysis: In brief explanation for: Substitution Reaction Oxidative Addition and Reductive Elimination, Organometallic Reactions Involving Changes at the Ligand, Metathesis Reactions, **Definitions**: Catalyst, catalysis, homogeneous catalysis, how catalyst works?

Part-C: Examples of Homogeneous Catalysis: Zigler Natta catalyst and polymerization of Alkenes, Commercial Catalytic Processes: Catalytic Hydrogenation, Hydroformylation, Wacker–Smidt Process, Monsanto Acetic Acid Process, [References-3 pp for part-A 527-645; for Part-B and C: 655-678, 2, 4 Relevant pages].

Ref-1: Concise Inorganic Chemistry by J.D. Lee - 5th Edn.

Ref-2: Inorganic Chemistry Gary L. Miessler Paul J. Fischer Donald A. Tarr 5th Ed, Pearson

Ref-3: Principles of Inorganic Chemistry, Brian W. Pfennig, Wiley, 2015 Ed.

Ref-4: Inorganic Chemistry Duward Shriver, Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong and P.W. Atkins, 6th Edn, W. H. Freeman and Company, 2014.

Ref-5: Essentials of physical Chemistry by Bahl, Bahl and Tuli, S. Chand Publication

Course Outcomes (COs)

1. **Explain the principles of Molecular Orbital Theory (MOT):** Describe the LCAO method, orbital combinations (s-s, s-p, p-p, p-d, d-d), and rules for orbital mixing. Interpret MO diagrams for homonuclear and heteronuclear diatomic molecules, and relate them to bond order and magnetism.
2. **Analyze bonding and reactivity using modern theoretical frameworks:** Apply acid–base theories (Arrhenius, Brønsted, Lewis) and HSAB principle to predict chemical reactivity. Use Frontier Molecular Orbital Theory to explain oxidation–reduction reactions and reactivity trends.
3. **Evaluate substitution mechanisms in coordination compounds:** Differentiate between labile and inert complexes. Compare associative, interchange, and dissociative mechanisms in octahedral complexes, and explain square planar substitution and the trans effect.
4. **Demonstrate understanding of organometallic chemistry concepts:** Apply electron counting and the 18-electron rule to organometallic complexes. Explain bonding modes of ligands such as CO, NO, hydrides, phosphines, and olefins, and analyze structures of metal carbonyls.
5. **Assess the role of organometallic compounds in homogeneous catalysis:** Explain key processes such as substitution, oxidative addition, reductive elimination, and metathesis. Evaluate catalytic cycles in industrial processes (Ziegler–Natta polymerization, hydrogenation, hydroformylation, Wacker–Smidt, Monsanto acetic acid process).
6. **Correlate molecular structure with chemical properties and applications:** Relate bond lengths, bond strengths, and electronic structures to stability and reactivity. Integrate theoretical knowledge with practical examples in catalysis, coordination chemistry, and industrial applications.

CHMAT-353: Organic Chemistry -III; [Theory, 2 Credits Paper, 30 L]

Module	Chapter No.	Title of Topic/Chapter	No. of lecture
I	1	Reagents in Organic Synthesis	05
	2	Introduction to Spectroscopy	02
	3	Ultra Violet and Visible Spectroscopy	04
	4	Infra-Red Spectroscopy	05
II	5	Nuclear Magnetic Resonance Spectroscopy (PMR)	10
	6	Combined problems based on U.V., I.R. and PMR spectroscopy	05

1. Reagents in Organic Synthesis [05 L]

Reagents- Preparation and Applications of following reagents.

Reducing Reagents: Ref 1 Pages Nos. 226, 828, 131-132, 26, 39, 537

Lithium aluminium hydride LiAlH4, NaBH4, DIBAL-H, Li(tBuO)3AlH & Raney Nickel.

Oxidizing Reagents: Ref. 1 Page Nos. 545, 1123-1126, 919, 764 1.

DMSO either with DCC or Ac2O, Dess Martin reagent, Osmium tetroxide, Selenium dioxide-(SeO2), DDQ.

2. Introduction to Spectroscopy [02 L]

Introduction, meaning of spectroscopy, Types of spectroscopy, nature of electromagnetic radiation and regions of electromagnetic spectrum, Terms used in spectroscopy; wavelength, amplitude, frequency, wavenumber, energy and their relations and conversions Ref 4: Page Nos. 43-55 Chapter

3. Ultra Violet and Visible Spectroscopy [04 L]

Introduction, Electromagnetic radiations, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts, Application of visible, ultraviolet spectroscopy in organic molecules. Application of electronic spectroscopy and Woodward rules for calculating l max of conjugated dienes and α, β – unsaturated compounds. Ref 5: Page Nos.367-398

4. Infra-Red Spectroscopy [05 L]

Introduction, Infrared radiation and types of molecular vibrations, functional group and fingerprint region. Infra-red spectroscopy in organic molecules, 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). Ref 5: Page Nos 26-93

5. Nuclear Magnetic Resonance Spectroscopy (PMR) [10 L]

Introduction, Principles, Magnetic and nonmagnetic nuclei, nuclear resonance, chemical shift, shielding, & deshielding effect. Measurement of chemical shift, TMS as reference and its advantages, peak area, integration, spin-spin coupling, coupling constants, J-value , problems based on NMR. Ref 5: Page Nos.108-175 and 225-366

6. Combined Problems Based on U.V., I.R. and PMR Spectroscopy [05 L]

Ref 5: Page Nos. 501 to 567

References:

1. E. S. Gould: Mechanism and Structure in Organic Chemistry

2. S. N. Sanyal: Reactions, Rearrangements and Reagents

3. Jagdamba Singh, Jaya Singh: Photochemistry and Pericyclic reactions.3rd edition

4. Silverstein and Basallar: Spectroscopic Identification of Organic Compounds.

5. Pavia D.L.; Lampman G.M. Kriz G. S.; Vyvyan J.R. Spectroscopy, First Indian Reprint 2008: Brooks/Cole CENGAGE Learning.

Course Outcomes:

CO1: Student should understand use of rearrangement reaction.
CO2: Student should understand the basic principle of spectroscopy.
CO3: Student should identify conjugation, chromophore etc. present in the molecule.
CO4: Student should identify the functional group present in the organic compounds.
CO5: Student should identify different types of protons and evaluate the structure of the molecule.
CO6: Student should apply the knowledge and solve the problems Based on U.V., I.R. and PMR Spectroscopy

CHMAT-354: Medicinal Chemistry, [Theory, 2 Credit paper, 30L]

	Name of the Chapter	Lectures Assigned
Module-I	An Introduction to Drugs and their Action	05 L
	Physiochemical factors and drug action	10 L
Module-II	Basic Principles of Drug Action	05 L
	Classes of Drugs: Synthesis, Mechanism of Action, and Uses	10 L

1. An Introduction to Drugs, their Action (5L)

Introduction, Need of new drugs, Historical background of drug discovery and design, Sources of drugs, Classification of drugs, Introduction to drug action. **(Ref.1 Pages 37-53, Ref.2 Pages 4-11, Ref.4 Pages 4-9) Ref.2 Pages 4-11, Ref.4 Pages 4-9)**

2) Physiochemical factors and drug action (10L)

Introduction, Principle, Ionization, Solubility, Partition Coefficient, Hydrogen Bonding, Protein Binding, Complexation, Surface-Activity, Oxidation-Reduction Potential, Bio-Isomerism, Optical and Geometrical Isomerism

3) Basic Principles of Drug Action (5L)

Pharmacokinetics: Absorption, distribution, metabolism, and excretion (ADME) of drugs.

Pharmacodynamics: Mechanism of drug action, receptor theory, and drug-receptor interactions. Agonists and antagonists.

4) Synthesis and mechanism of action of important Drug Classes (10L)

Analgesics and Antipyretics: Example: Paracetamol, Aspirin.

Antibiotics: Example: Penicillins, Cephalosporins.

Antimalarial Drugs: Example: Chloroquine, Artemisinin.

Antiviral Agents: Example: Acyclovir, Zidovudine.

Anticancer Agents: Example: Cisplatin, Methotrexate.

Cardiovascular Drugs: Example: Beta-blockers, Calcium channel blockers.

References:

1. Fundamentals of Medicinal Chemistry by Gareth Thomas, University of Portsmouth, UK.
2. An Introduction to Medicinal Chemistry, Patrick, G. Oxford. University Press (Vth Edition.
3. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical, Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale.
4. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (VIIth Edition), Kluwer publication.
5. Research and Development on Therapeutic Agents and Vaccines for COVID-19 and Related Human Coronavirus Diseases, Cynthia Liu et al., ACS Cent. Sci. 2020, 6, 315−331, http://dx.doi.org/10.1021/acscentsci.0c00272
7. Medicinal Chemistry and Drug Discovery by Burger
8. Introduction to Medicinal Chemistry by Grham and Patrick

9. Introduction to Drug Design by J. R. Dimmock and S.S. Pandeya
10. The Organic Chemistry of Drug Design and Drug Action, 3rd Edition, R. B. Silverman, Academic Press, 2014
11. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed Robert F Dorge, 12th Edition, 2010
12. Chemistry of Heterocycles by T. Eicher and S. Hauptmann, Thieme. Additional Study Material: NPTEL Video lecture on Medicinal Chemistry:
1. https://youtu.be/UHEXXGiegd0 ;
2. https://youtu.be/rVN_HybZ-Vk
3. https://youtu.be/-fCXLW-jF2o
4. https://youtu.be/n5C-peu54Wk
5. https://youtu.be/0wx4hep1low
6. https://youtu.be/9lWrNuUzP4A
7. https://youtu.be/84-q3SAVEQk
Additional study material: NPTEL lecture: Organic Chemistry in Biology and Drug Development (full course) https://nptel.ac.in/content/syllabus_pdf/104105120.pdf)
https://nptel.ac.in/courses/104/105/104105120
Additional study material: NPTEL lecture (only 3 topics): Essentials of Biomolecules: Nucleic Acids and Peptides https://nptel.ac.in/content/syllabus_pdf/104103121.pdf
https://nptel.ac.in/courses/104/103/104103121

Course Outcomes (CO):

CO1: Explain the concept of drugs, their need, sources, classification, and historical development of drug discovery and design.

CO2: Describe the physicochemical factors affecting drug action including ionization, solubility, partition coefficient, hydrogen bonding, protein binding, and surface activity.

CO3: Interpret the role of structural features such as bio-isomerism, optical isomerism, and geometrical isomerism in determining drug activity.

CO4: Explain the basic principles of drug action including pharmacokinetics (ADME) and pharmacodynamics (mechanism of action, receptor theory, agonists and antagonists).

CO5: Describe the synthesis and mechanism of action of important drug classes such as analgesics, antibiotics, antimalarial, antiviral, anticancer, and cardiovascular drugs.

CO6: Correlate the chemical structure of drugs like Paracetamol, Aspirin, Penicillins, Chloroquine, Acyclovir, Cisplatin, and Beta-blockers with their therapeutic action.

CHMAP-355: Practical Physical and Analytical Chemistry [Practical, 2 credit, 60L]

Total 12 experiments to be completed.

A. Solvent Extraction (any-1)

1. Determination of partition coefficient of benzoic acid in water-Benzene medium.

2. Study of effect of Solvent volume on extraction of organic substances.

3. Choice of pH for the separation of two organic substances by solvent extraction.

B. Kinetics (Any four)

1. To study the kinetic characteristics of iodination of acetone using a colorimeter.

2. To study the oxidation of iodide ions by H_2O_2 as an iodine clock reaction.

3. To determine the relative strength of HCI, and H_2SO_4 by studying the kinetics of hydrolysis of methyl acetate.

4. To determine the relative strength of mono-chloro acetic acid (4N) and trichloro-acetic acid (4N) by studying the kinetics of hydrolysis of methyl acetate.

5. To determine the temperature coefficient of hydrolysis of methyl acetate and its energy of activation. (Water bath to increase temp by 10 degree)

6. To study the autocatalytic reaction between MnO_4^- and $C_2O_4^{2-}$ ions catalyzed by Mn^{2+} ions.

7. Catalytic Decomposition of H_2O_2 by oxide (CuO, MnO_2, Fe_2O_3)

8) To determine the order of reaction for the oxidation of alcohol by potassium dichromate and potassium permanganate in acidic medium calorimetrically.

Part-II: instrumental Practical's

A. Colorimetry (any three)

1) To titrate Cu^{2+} ions with EDTA photometrically.

2) To determine the indicator constant of methyl red indicator

3) Determination detection limit, linearity range for the analysis of Co(II) by R-Nitroso salt. Determination of molar absorptivity of the Co(II)-R nitroso salt complex.

4) Determination of λ_{max} and molar absorptivity for Fe^{3+} ions by thiocyanate method. Quantitative analysis of Fe(III) from given sample by calibration curve method.

5) Quantitative analysis Cobalt by using R-nitroso salt method Standard addition method. Calculation by statistical method.

6) Simultaneous determination of Cu^{2+} and Ni^{2+} ions or mixture of dyes or colored organic compounds by colorimetry/spectrophotometry method.

B. Conductometry (any two)

1) To determine the velocity constant of hydrolysis of ethyl acetate by NaOH solution by conduct metric method.

2) To determine $\lambda\infty$ of strong electrolyte (NaCl and KCl) and to verify Onsager equation.

3) To determine the relative strength of monochloro acetic acid and acetic acid conductometrically

Part-III. Table work (Compulsory)

1) Interpretation of the given vibration-rotation spectrum of HCl(g), Interpretation of IR spectra of given compound.

2) UV and IR spectra of using computation chemistry software – Winmoster.

3) Construction of quantitative energy level diagram for any diatomic molecules using quantum calculation software and visualization different types of MO of these molecules.

Course Outcome:

CO-1: Apply distribution law in heterogeneous systems: Students will determine partition coefficients of solutes (e.g., benzoic acid in water–benzene), linking experimental data to concepts of solubility, equilibrium, and phase diagrams.

CO-2: Investigate chemical kinetics experimentally: Students will study reaction rates, orders, and mechanisms (e.g., iodination of acetone, iodine clock reaction, hydrolysis of esters), thereby connecting kinetic theory with practical measurements.

CO-3: Evaluate the influence of catalysts and temperature on reaction rate: Students will analyze autocatalytic and catalytic reactions (e.g., MnO_2 decomposition of H_2O_2, Mn^{2+} catalysis), and calculate activation energies, enhancing their understanding of reaction dynamics.

CO-4: Utilize instrumental methods for quantitative analysis: Students will employ colorimetry and conductometry to estimate ion concentrations, determine equilibrium constants, and verify theoretical models (e.g., Onsager equation), strengthening their analytical skills.

CO-5: Interpret spectroscopic data for molecular characterization: Students will analyze IR, UV, and vibration–rotation spectra, construct energy-level diagrams, and visualize molecular orbitals using computational tools, integrating experimental and theoretical chemistry.

CO-6: Develop problem-solving and computational chemistry skills: Students will apply chemoinformatics and quantum calculation software to optimize molecular structures, visualize HOMO–LUMO gaps, and correlate theoretical predictions with experimental observations.

CHMAP-356: Practical Inorganic and Analytical Chemistry -I
[Practical, 2 Credit paper, 60L]

Total 12 experiments to be completed.

A. Gravimetric estimations (Any 2)

1. **Quantitative separation and analysis:** Gravimetric estimation of Fe as Fe_2O_3 from mixture of Fe and Ni. Ref-1: 457
2. **Quantitative separation and analysis:** Gravimetric estimation of Nickel as Ni – DMG from mixture of Fe and Ni Ref-1: 462
3. Analysis of sodium bicarbonate from mixture of $NaHCO_3$ and Na_2CO_3 by thermal decomposition method. Ref.-6
4. Determination of K in potash fertilizer by gravimetry (Vogel Third Ed.)

B. Inorganic preparations (Any 2)

(Ref-7, 8, 9) Preparation of inorganic complexes and spot tests for metal ions and inorganic ligands:

1. Preparation of hexamminenickel(II) chloride, $[Ni(NH_3)_6]Cl_2$.
2. Preparation of Potassium trioxalatoferrate(III), $K_3[Fe(C_2O_4)_3]$.
3. Preparation of Manganese (III) acetylacetonate, $[Mn(acac)_3]$ (green Chemistry method)

C. Inorganic Qualitative Analysis (5 Expts.)

1. Inorganic Qualitative analysis (**5** mixtures) [1 simple water-soluble mixture, [2 mixtures containing borates and 2 mixtures containing phosphates] (DST manual green chemistry monograph procedure must be followed strictly]

2. **Compulsory:** Qualitative and confirmatory tests of inorganic toxicants of any four ions (Borate, copper, hypochlorite or nitrate or nitrite, Sb or Bi, Iodate, H_2O_2). Reference-3

Pard-D: Any two

1. Synthesis of amine complexes of Ni(II) and its ligand exchange reaction (bidentate ligands like acac, DMG, Glycine) by substitution method.

2. Homogeneous catalysis - Fenton reaction: Degradation of organic dye / pollutants using Fenton reagent i.e. H_2O_2 –Fe(III) catalyst. (Ref-6).

3. Study of 1) redox reactions of metals, 2) HSAB principle, 3) Strength of weak and strong acids and bases by pH measurement and determination of Ka and pk_a of acids.

References:

1: Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney, 5th Ed, Longman Scientific Technical, USA (copublished with John Wiley Sons)

2: Green Chemistry Practical Manual by DST Task Force (India)

3: Basics of Analytical toxicology, World Health Organization

Course Outcomes (COs)

CO-1: Perform gravimetric estimations with accuracy and precision: Apply quantitative separation techniques to estimate Fe, Ni, Na, and K from mixtures and fertilizers. Demonstrate proficiency in handling gravimetric methods and interpreting results.

CO-2: Synthesize and characterize inorganic complexes: Prepare coordination compounds such as [Ni(NH3)6]Cl2, K3[Fe(C2O4)3], and $[Mn(acac)_3]$. Evaluate their properties and confirm product formation using spot tests and qualitative analysis.

CO-3: Execute qualitative analysis of inorganic mixtures and toxicants: Identify cations and anions in complex mixtures using systematic qualitative analysis. Perform confirmatory tests for toxic ions (e.g., borate, copper, hypochlorite, nitrate, Sb/Bi, iodate, H2O2).

CO-4: Investigate ligand substitution and homogeneous catalysis reactions: Conduct ligand exchange reactions in Ni(II) complexes with bidentate ligands. Study catalytic degradation of organic dyes/pollutants using Fenton's reagent.

CO-5: Apply theoretical principles to practical inorganic chemistry experiments: Explore redox reactions, HSAB principle, and acid-base strength through experimental methods. Measure pH and determine dissociation constants (Ka, pKa) of weak and strong acids.

CO-6: Develop laboratory skills in safe handling, analysis, and reporting: Practice green chemistry protocols for synthesis and qualitative analysis. Record, interpret, and present experimental data with scientific accuracy and clarity.

CHMET-351A: Solid State Chemistry-I [Theory, 2 Credit paper, 30L]

Module-I	Crystalline solids and Crystal Structure	6 L
	Ionic Solids	9 L
Module-II	The Metallic Bond: Metals and Semiconductors	6 L
	Introduction to Nanomaterials	9 L

1. Crystalline solids and Crystal Structure [6 L]

Part-A: Crystalline and amorphous solids, unit cell and crystal lattice, types unit cell and Bravais lattices, number of atoms per unit cell three types of cubic and HCP unit cells, In brief symmetry elements of unit cell (center of symmetry, line of symmetry and plane of symmetry), planes in unit cells – Miller indices, d-Spacing Formulae, Crystal Densities and Unit Cell Contents, description of Close Packed Structures–Cubic and Hexagonal Close Packing Relationship between Cubic Close Packed and Face Centered Cubic, Hexagonal Unit Cell and Close Packing, Density of Close Packed Structures [Ref-3: pp- 1 to 22]

Part-B: X-ray Crystallography, **Generation of X-rays, Interaction of X-rays with matter, Crystals and diffraction of X-rays,** Brag law, Modern method of powder XRD, X-Ray diffractogram and its analysis, JCPDS data files and analysis of XRD using JCPDS data file. [Ref-3: 232 to 247 selective points only]

2. Ionic Solids [9 L]

Properties of ionic solids, packing arrangements of anions in an ionic solids, Voids in crystal structure-tetrahedral and octahedral, Ionic radius, Palings univalent and crystal radii, Conversion of univalent radii to crystal radii, problems based on conversion of radii, Radius ratio effect, Lattice energy, Born-Lande equation, Born Haber cycle and its applications, Schottky and Frenkel defect (Ref-4 and Ref-5)

3. The Metallic Bond: Metals and Semiconductors [6 L]

General Properties of Metals, The theories of bonding in metals, Conductors, insulators and semiconductors, Alloys, Superconductors [Ref-1: 121-140, Ref-2 and 3]

4. Introduction to Nanomaterials [9 L]

a) The Big World of Nanomaterials, History and Scope, Can Small Things Make a Big Difference?, Classification of Nanostructured Materials, Fascinating Nanostructures, Applications of Nanomaterials, Nature: The Best Nanotechnologist, Challenges and Future Prospects.

b) Unique Properties of Nanomaterials: Microstructure And Defects In Nanocrystalline Materials (Dislocations, Twins, Stacking Faults And Voids), Effect of Nano-Dimensions on Materials Behaviour (Elastic Properties, Melting Point, Diffusivity, Grain Growth Characteristics, Enhanced Solid Solubility) [Ref-4: Pp 29-43]

c) What is top to down and bottom-up approach in synthesis of nanomaterials? **Physical methods:** Physical vapor deposition and chemical vapor deposition (Thermally activated CVD only); **Chemical methods of Synthesis of nanomaterials:** Sol–gel process, Wet chemical synthesis, Self-assembly [Ref-4: pp 67-84]

Ref-1: Concise inorganic Chemistry, J. D. Lee, Blackwell publisher (1996)

Ref-2: Inorganic Chemistry Catherine Housecroft, Alan G. Sharpe, 3rd Ed, Pearson Education Limited

Ref-3: Solid State Chemistry and its Applications, Anthony R. West, Second Edition, Wiley.

Ref-4: Textbook of Nanoscience and Nanotechnology: B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday.

Course Outcomes (COs)

CO1 – Crystalline and Amorphous Solids: Students will be able to distinguish between crystalline and amorphous solids, describe unit cells, Bravais lattices, symmetry elements, Miller indices, and calculate crystal densities and unit cell contents.

CO2 – X-ray Crystallography and Structure Determination: Students will be able to explain the principles of X-ray generation, diffraction, Bragg's law, powder XRD techniques, and analyze X-ray diffractograms using JCPDS data files.

CO3 – Ionic Solids and Defects: Students will be able to analyze packing arrangements, voids, ionic radii, radius ratio effects, lattice energy calculations (Born-Landé equation), Born-Haber cycle applications, and identify point defects such as Schottky and Frenkel defects.

CO4 – Metallic Bonding and Electronic Properties: Students will be able to explain theories of metallic bonding, differentiate conductors, insulators, and semiconductors, and evaluate properties of alloys and superconductors.

CO5 – Nanomaterials: Properties and Applications: Students will be able to describe the history, scope, classification, and unique properties of nanomaterials, including the effect of nano-dimensions on mechanical, thermal, and diffusion behavior.

CO6 – Synthesis of Nanomaterials: Students will be able to compare top-down and bottom-up approaches, and explain physical (PVD, CVD) and chemical (sol–gel, wet chemical synthesis, self-assembly) methods for nanomaterial synthesis.

CHMET-352A: Agrochemicals I [Theory, 2 Credit paper, 30L]

Module-I	Plant Nutrients	5 L
	Fertilizers	5 L
	Manures	5 L
Module-II	Chemistry of Pesticides	15 L

Chapter 1. Plant Nutrients (05 L)

Need of plant nutrients, forms of nutrients updates, nutrient absorption by plants, Classification of essential nutrients, Primary nutrients (N, P, K), its role and deficiency symptoms in plants, Secondary nutrients, (Ca, Mg, S), its role and deficiency symptoms in plants, Micronutrients, General functions of micronutrients (Zn, Fe, Mn, Cu, B, Mo, Cl)

Chapter 2. Fertilizers (5 L)

Classification and types of fertilizers, Essential fertility requirements: Nitrogenous fertilizers: Ammonium nitrate, Urea, Calcium, Ammonium Nitrate, introduction, Raw materials and Mode of action of the fertilizers. Phosphate fertilizers: Normal Super Phosphate, Triple Super Phosphate, Ammonium Phosphate. Potassic fertilizers, Mixed fertilizers and positions of Fertilizer Industries in India

Chapter 3. Manures (5 L)

Humus and decomposition of organic matter in soils, Compost, composting of agriculture and city wastes, Manures, Role of Micro- organisms, in the process. Types and Chemical properties of Manures. Application of Organic Manures, Soil fertility and Vermi-culture and Vermicomposting

Chapter 4. Chemistry of Pesticides (15 L)

Introduction: History of pesticides, Innovation in pesticide chemistry, Development of Pesticides, Classification of Pesticides with respect to their Synthesis, Chemistry, Metabolites, Environmental fate. Insect attractants, Chemosterilants and Repellents. Organic Pesticides: Malathion, Monocrotophos, Dimethoate, Phosphamidon, Chloropyriphos, Quinolphos, Acephate, Ethephon, Temephos and Triazophos. Inorganic pesticides: Fungicides, Fumigants, Rodenticide, Herbicides

Course Outcomes (COs)

CO1 – Plant Nutrient Fundamentals: Students will be able to explain the need for plant nutrients, classify essential nutrients (primary, secondary, and micronutrients), and identify their roles and deficiency symptoms in plants.

CO2 – Fertilizer Chemistry and Applications: Students will be able to classify fertilizers, describe the chemistry and raw materials of nitrogenous, phosphate, and potassic fertilizers, and evaluate their mode of action and industrial significance in India.

CO3 – Organic Manures and Soil Fertility: Students will be able to analyze the decomposition of organic matter, composting processes, and the role of microorganisms in manure formation, while assessing the chemical properties and applications of organic manures, including vermiculture and vermicomposting.

CO4 – Chemistry of Pesticides: Students will be able to explain the history, development, and classification of pesticides, including their synthesis, chemistry, metabolites, and environmental fate.

CO5 – Organic and Inorganic Pesticides: Students will be able to describe the chemistry, properties, and applications of major organic pesticides (e.g., Malathion, Monocrotophos, Chloropyriphos) and inorganic pesticides (fungicides, fumigants, rodenticides, herbicides).

CO6 – Integrated Agrochemical Knowledge: Students will be able to integrate knowledge of plant nutrients, fertilizers, manures, and pesticides to evaluate their combined impact on soil fertility, crop productivity, and environmental sustainability.

CHMET-353A: Environmental Chemistry [Theory, 2 Credit paper, 30L]

Module-I	Concepts and Scope of Environmental Chemistry	5 L
	Hydrosphere and Water Pollution	10 L
Module-II	Analytical Techniques in water Analysis	5 L
	Water pollution and treatment methods	10 L

1: Concepts and Scope of Environmental Chemistry (05L)

Introduction, Environmental Pollution and Classification, Units of concentration, Segments of Environment, Biogeochemical cycles of C, N, P, S and O system

Reference: 1, 2, 3

2: Hydrosphere and Water Pollution (10L)

Water resources, Hydrological Cycle: stages of hydrological cycle and chemical composition of water bodies, Microbially mediated aquatic reactions, Classification of water pollutants

Organic and Inorganic pollutants, Sewage and Domestic waste, Sediments, Detergents, Pesticides, Eutrophication, Sampling and monitoring water quality parameters: pH, D.O. (Winkler Method), COD, TOC, Total hardness, free chlorine.

Reference: 1 Page no -47-62,

3. Analytical Techniques in water Analysis (8 L)

Water quality parameters and standards, domestic water quality parameters, surface water, sampling, preservation, Monitoring techniques and methodology (pH, conductance, DO, ammonia, nitrate and nitrite, Cl, F, CN, Sulfide, sulphate, phosphate, total hardness, boron, metals and metalloids- As, Cd, Cr, Cu, Fe, Pb, Mn, Hg (Exclude polarographic and AAS methods), COD, BOD, TOC, phenols, pesticides, surfactants, tannis and lignins, E. Coli, Case studies of water pollution.

Ref-1: 225-278

4. Water pollution and treatment methods (5 L)

Water pollutants, Eutrophication, Waste water treatment (domestic waste water, aerobic treatment, anaerobic treatment, upflow aerobic sludge bed, industrial waste water treatment, drinking water supplies, Trace elements in water, chemical speciation (Cu, Pb, Hg, As, Se, Cr) Ref-1: 167-225

References:

1. Environmental Chemistry – A. K. De, Third Edition (Wiley)
2. Environmental Chemistry – A. K. De, 5th Edition (New age international publishers)
3. Environmental Chemistry – A. K. Bhagi and C. R. Chatwal (Himalaya Publishing House)
4. Environmental Chemistry – H. Kaur 2nd Edition 2007, Pragati Prakashan, Meerut, India

Course Outcomes (COs)

CO1 – Fundamentals of Environmental Chemistry: Students will be able to explain the scope of environmental chemistry, classify types of pollution, and describe biogeochemical cycles of carbon, nitrogen, phosphorus, sulfur, and oxygen.

CO2 – Hydrosphere and Water Pollution: Students will be able to analyze the hydrological cycle, chemical composition of water bodies, and microbial aquatic reactions, while identifying and classifying organic and inorganic water pollutants.

CO3 – Water Quality Assessment: Students will be able to measure and interpret water quality parameters such as pH, dissolved oxygen (DO), chemical oxygen demand (COD), total organic carbon (TOC), hardness, and free chlorine using standard methods.

CO4 – Analytical Techniques in Water Analysis: Students will be able to apply appropriate sampling, preservation, and monitoring techniques to evaluate domestic and surface water quality, and assess pollutants including metals, pesticides, surfactants, and microbial contaminants.

CO5 – Water Pollution Case Studies: Students will be able to critically examine case studies of water pollution, interpret analytical data, and relate findings to environmental standards and regulatory frameworks.

CO6 – Wastewater Treatment and Pollution Control: Students will be able to evaluate water treatment methods (aerobic, anaerobic, sludge bed, industrial wastewater treatment, drinking water purification) and explain chemical speciation of trace elements (Cu, Pb, Hg, As, Se, Cr) in aquatic systems.

CHMEP-351B: Practical Organic and Medicinal Chemistry

[Practical, 2 Credits Paper, 60 L]

Total 12 Experiments to be performed

A) Interpretation of IR and NMR spectra (1 Experiments of each type)

1. Determination of functional group of organic compounds from given IR spectra.

2. Determination of structure of organic compound from given NMR spectra.

(Ethyl alcohol, Cis-2-butene, Trans-2-butene, Benzoic acid, Propanaldehyde, Ethyl methyl ether, 1 Butyne, Ethyl acetate, Propyl Cyanide, Salicylic Acid, Nitro phenols, Isopropyl benzene, Propanamine, Benzamide, n-Pentane, 2-chloro butane, Acetophenone)

B) Organic Estimations (Any Two)

1. Estimation of glucose.
2. Estimation of glycine.
3. Saponification value of oil.
4. Estimation of Alkali content in Antacid using HCl.

C) Organic Extractions (Any two)

1. Caffeine from tea leaves
2. Eugenol from cloves
3. Lycopene from tomato peels
4. Cinnamic acid from cinnamon
5. Trimyristin from nutmeg

D) Column chromatography (Any two)

1. Separation of mixture of aldehyde and carboxylic acid by column chromatography
2. Separation of mixture of O-nitrophenol and P-nitrophenol by column chromatography

E) Medicinal chemistry (Any Four)

1. Synthesis of dihydropyrimidinone from benzaldehyde and urea.
2. Synthesis of 7-Hydroxy-4-Methyl Coumarin from Resorcinol
3. Synthesis of Ethyl acetoacetate from ethyl acetate.
4. Synthesis of 2,6 di bromo 4-nitrophenol from 4-nitrophenol.
5. Bromination of Cinnamic acid using Sodium bromide and sodium bromate.
6. Synthesis of Benzilic acid from Benzil.
7. Synthesis of 2,4 Dimethyl 3,4-benzo[b] [1,4] diazepine from acetylacetone and O-phenylenediamine
8. Synthesis of 1, 1 bis-2 napthol from 2-napthol.
9. Ecofriendly nitration of phenol and its derivative using Calcium nitrate.
10. Synthesis of Diels -Alder adduct by using Anthracene.
11. Benzilic acid from benzoin (Benzilic acid rearrangement)
12. Benzopinacolone from Benzopinacol using iodine
13. Synthesis of Paracetamol from P- Amino Phenol
14. Synthesis of Aspirin
15. Synthesis of Benzimidazole from Ortho–Phenylene Diamine

Reference

1. Practical Organic Chemistry by - A. I. Vogel.
2. Practical Organic Chemistry by - O. P. Agarwal.
3. Aparna G.Sajina, Practical Manual Engineering Chemistry.

4. Fred.W.Billmayer, 1984, Text book of Polymer Science, 3rt Edition.

Course Outcomes:

CO1: The students will be able to Identify the broad regions of the infrared spectrum in which occur absorptions caused by N−H, C−H, and O−H, C≡C and C≡N, C=O, C=N, and C=C.

CO2: Understand use NMR spectra to determine the structures of compounds.

CO3: Achieve the practical skills required to different estimations.

CO4: Achieve the practical skills required to Saponification value of oil.

CO5: Describe the extraction separation process.

CO6: Realize the selection of appropriate mobile phase, column and detection. The students will be able to expertise the techniques of synthesis of medicinal molecules.

CHMEP-352B: Practical Organic and Agrochemistry

[Practical, 2 Credits Paper, 60 L]

Total 12 Experiments to be performed

A) Interpretation of IR and NMR spectra (1 Experiments of each type)

1. Determination of functional group of organic compounds from given IR spectra.
2. Determination of structure of organic compound from given NMR spectra.

(Ethyl alcohol, Cis-2-butene, Trans-2-butene, Benzoic acid, Propanaldehyde, Ethyl methyl ether, 1 Butyne, Ethyl acetate, Propyl Cyanide, Salicylic Acid, Nitro phenols, Isopropyl benzene, Propanamine, Benzamide, n-Pentane, 2-chloro butane, Acetophenone)

B) Organic Estimations (Any Two)

1. Estimation of glucose.
2. Estimation of glycine.
3. Saponification value of oil.
4. Estimation of Alkali content in Antacid using HCl.

C) Organic Extractions (Any two)

1. Caffeine from tea leaves
2. Eugenol from cloves
3. Lycopene from tomato peels
4. Cinnamic acid from cinnamon
5. Trimyristin from nutmeg

D) Column chromatography (Any two)

1. Separation of mixture of aldehyde and carboxylic acid by column chromatography
2. Separation of mixture of O-nitrophenol and P-nitrophenol by column chromatography

E) Agrochemicals (Any Four)

1. Synthesis diethyl thiocarbamate
2. Synthesis of Zn- diethyl thiocarbamate pesticide
3. Preparation of micronutrient supplement
4. Preparation and analysis of Bordeaux Mixture
5. Synthesis of acetanilide
6. Synthesis of 2-4-D
7. Synthesis of 4 nitroaniline.
8. Synthesis of 1,2,3,4, terhydrocarbazole
9. Synthesis of phenyl benzoate
10. Green Synthesis of Azomethine

Reference

1. Practical Organic Chemistry by - A. I. Vogel.

2. Practical Organic Chemistry by - O. P. Agarwal.

3. Aparna G.Sajina, Practical Manual Engineering Chemistry.

4. Fred.W.Billmayer, 1984, Text book of Polymer Science, 3rt Edition

Course Outcomes:

CO1: The students will be able to Identify the broad regions of the infrared spectrum in which occur absorptions caused by N−H, C−H, and O−H, C≡C and C≡N, C=O, C=N, and C=C.

CO2: Understand use NMR spectra to determine the structures of compounds.

CO3: Achieve the practical skills required to different estimations.

CO4: Achieve the practical skills required to Saponification value of oil.

CO5: Describe the extraction separation process.

CO6: Realize the selection of appropriate mobile phase, column and detection. The students will be able to expertise the techniques of synthesis of medicinal molecules.

CHVST-351: Pharmaceutical Analysis-III

Module-I	Non-Aqueous Titrations	4 L
	Iodimetric and Iodometric Titrations	3 L
	Karl Fischer Method for Determination of Water	2 L
	Gravimetry	6 L
Module-II	Refractometry	3 L
	Polarimetry	3 L
	UV-Visible Spectroscopy	9 L

1. Non-Aqueous Titrations [4L]

Introduction; Theory; Solvents; Methodology; Preparation of 0.1 N Perchloric Acid; Standardization of 0.1 N Perchloric Acid; Choice of Indicators; Effect of Temperature on Assays; Assay by Non-Aqueous

Titrations; Acidimetry in Non-Aqueous Titrations; Alkalimetry in Non-Aqueous Titrations. ***(Ref-1: 106-117)***

2. Iodimetric and Iodometric Titrations [3L]

Introduction, Theory, Assay Methods, Iodimetric Assays, Iodometric Assays. ***(Ref-1: 137-144)***

3. Karl Fischer Method for Determination of Water [2L]

Introduction; Theory; Instrumentation; Automated Electrochemical Karl Fischer Analysis; Applications of Karl Fischer Method for Determination of Water in Pharmaceutical Analysis; Examples ***(Ref-1: 223-226)***

4. Gravimetry [6L]

What is gravimetry, Steps in gravimetric methods of analysis, **Theory:** Law of Mass Action and Reversible Reactions, principle of Solubility Product, Common ion Effect; Assay Methods: Substances Assayed Gravimetrically (NaCl and Alum), Substances Assayed After Conversion (Phenobarbitone Sodium, Papaverine Hydrochloride Tablets, Amodiaquine Hydrochloride, Mephobarbital Tablets, Benzylpenicillin, Thiamine Hydrochloride). Problems ***(Ref-1: 173-181), Ref-2*** Relevant pages

5. Refractometry [3L]

Introduction, Theory, Instrumentation, Determination of Refractive Index of Pharmaceutical Substances, Applications of Refractivity. ***(Ref-1: 265-271)***

6. Polarimetry [3L]

Introduction, Theory, Instrumentation, Determination of Optical Activity of Pharmaceutical Substances, Determination of Optical Rotation of Pharmaceutical Substances, Determination of Specific Optical Rotation of Pharmaceutical Substances. ***(Ref-1: 274-279)***

7. UV-Visible Spectroscopy [9L]

Interaction of UV-Visible Light with substance, basic definitions (radiant power, transmittance, percent transmittance, absorbance), Beers Law (qualitative explanation), Mathematical statement and graphical representation, deviation from beers law, simultaneous analysis, specific absorbance, Instrumentation-single beam and double beam equipment: Applications – **Identification of substances** (Identification of paracetamol by UV spectrophotometry, Identification of Diazepam in Diazepam Tablets, Identification of Miconazole in Miconazole Nitrate Cream; **Quantitative Analysis**: Assay of Paracetamol in Paracetamol Tablets, Assayof Doxapramin Doxapram Hydrochloride Injection, Numerical ***(Ref-3 (Chapter-7, 18, 19 relevant points only) and 2-relevent pages).***

Reference-1: Pharmaceutical Drug Analysis, Ashutosh Kar, New Age International (P) Limited.
Reference-2: Vogel's Textbook of Quantitative Chemical Analysis 5th Ed.
Reference-3: Introduction to Pharmaceutical Analytical Chemistry, Pedersen-Bjergaard Stig, Gammelgaard Bente, Halvorsen, Trine G. Wiley, 2nd Ed.

Course Outcomes

CO-1: Define terms related to: errors, non-aqueous solution, viscosity, Accuracy; Precision, Refractive Index, Iodimetric Assays, volumetric analysis.

CO-2: Explain the terms and facts related to: Determinate (Systematic) Errors; Indeterminate (Random) Errors, Minimising Systematic Errors, Viscosity the property of liquids,

CO-3: Describe the Refractive Index determination of Pharmaceutical Substances, Iodometric Assays,

Automated Electrochemical Karl Fischer Analysis.

CO-4: Determine Refractive Index of Pharmaceutical Substance, Water in Pharmaceutical Analysis, viscosity of organic liquids.

CO-5: Illustrate Electrochemical Karl Fischer Analysis, Assay Methods, Iodimetric Assays, Effect of temperature on Assays.

CO-6: Calculate mean, median, Standard deviation, refractive index, viscosity of liquids.

Semester-VI Course Wise Syllabus

CHMAT-361: Physical Chemistry-III [Theory, 2 Credit paper, 30L]

Module-I	Applied Electrochemistry-Batteries	10 L
	Applied Electrochemistry-Electroplating	5 L
Module-II	Nuclear Chemistry	15 L

1: Applied Electrochemistry-Batteries [10 L]

a) Basics of batteries: Galvanic Cells, Types of Batteries, Energy Conversion in Batteries, Battery Components, Principle of Operation, Electrode Selection, Calculating Battery Cell Voltage, Battery Cell Voltage and Nernst Equation, Electrolyte for Batteries, Gibbs-Free Energy and Battery Voltage, Theoretical Battery Capacity, Practical Energy of a Battery, Specific Energy and Power, Battery Testing. (Ref-1; Supplementary ref-3).

b) Lead–Acid Batteries: Principle of Operation, Types of Lead–Acid Batteries, Cell Components and Fabrication, Failure Modes, Charge Process, Discharge Process, Electrolyte, State of Charge, Capacity, Cycle Life, Self-Discharge. (Ref-1; Supplementary ref-3).

c) Nickel–Cadmium Batteries: Overview and Characteristics, Principle of Operation, Reactions During Overcharge, Voltage During Charge and Discharge, Charge, Discharge, Effect of Temperature on Discharge, Polarity Reversal, Cycle Life, Self-Discharge, Memory Effect, Cell Components and Failure Modes. (Ref-1; Supplementary ref-3).

d) Lithium Batteries: Introduction, Early Lithium Batteries: Li Metal, Current Lithium Batteries (Li–Ion), Future Lithium System (Li–Air and Li–S), Cell Components and Fabrication, Charging, Discharge, Cycle Life, Self-Discharge. (Ref-1; Supplementary ref-3)

e) Zinc Primary Batteries: Zn-Carbon Cells, Alkaline Manganese Cells (Ref-2; Supplementary ref-3)

f) Fuel Cells: Construction and Working : (Ref-https://www.electrochem.org/dl/interface/spr/spr06/spr06_p41-44.pdf)

g) Advances in Battery materials

2: Applied Electrochemistry-Electroplating [5 L]

Introduction and principles of electroplating, the electrical supply, the electroplating tank, cleaning of substrate, the electrolyte, electroforming and electroplating on non-conductors, electrodeless electroplating, an example and consideration of electroplating,

3: Nuclear Chemistry

Part-A: Isotopes, Isobars and Isotones: Basics: *Structure of atom, atomic particles electron, proton and neutrons, atomic number and atomic mass number*; Isotopes, Representation of Isotopes, Identification of Isotopes, Aston's Mass Spectrograph, Dempster's Mass Spectrograph, Separation of Isotopes, Gaseous Diffusion, Thermal Diffusion, Distillation, Ultra centrifuge, Electro-magnetic Separation, Fractional Electrolysis, Laser Separation, Isotopes of Hydrogen Isotopes of Neon, Isotopes of Oxygen, Isotopes of Chlorine, Isotopes of Uranium, Isotopes of Carbon, Isotopic Effects, Isobars, Isotones. (Ref-4 and 5)
Part-B: Radioactivity: Radioactivity, Types of Radiations, Properties of Radiations, Detection and Measurement of Radioactivity, Types of Radioactive Decay, The Group Displacement Law, Radioactive Disintegration Series, Rate of Radioactive Decay, Half-life, Radioactive Dating, Nuclear Reactions, Nuclear Fission, Reactions, Nuclear Fusion Reactions, Nuclear Equations, Artificial Radioactivity, Nuclear

Isomerism, Mass Defect, Nuclear Binding Energy, Nuclear Fission Process, Nuclear Chain Reaction, Nuclear Energy, Nuclear Reactor, Nuclear Fusion Process, Solar Energy, Fusion as a Source of Energy in 21st Century. (**Ref-4:** 85-150, **Ref-5**).

Part-C: Few Chemical Applications of Radioactivity: Chemical investigation – Esterification, Friedel - Craft reaction, Structural determination – Phosphorus pentachloride, Age determination – use of tritium and C^{14} dating, Problems, **Ref-5).**

Ref-1: Battery Technology Crash Course- A Concise Introduction, -Springer

Ref-2: Syllabus Understanding Batteries by R M Dell, D A J Rand, Paul Connor, Robert (Bob) D Bailey, RSC publication

Ref-3: Battery Reference Book, T R Crompton, Newnes, Third Edition

Ref-4: Essentials of Nuclear Chemistry, H, J, Arnikar, New Age Publication

Ref-5: Essentials of physical Chemistry by Bahl, Bahl and Tuli, S. Chand Publication

Course Outcomes (COs)

CO1: Explain the fundamental principles of batteries, including galvanic cells, energy conversion, electrode selection, electrolyte role, and the application of thermodynamic concepts such as Gibbs free energy and the Nernst equation in determining battery performance.

CO2: Analyze the construction, operation, and performance characteristics of different battery systems (Lead–Acid, Nickel–Cadmium, Lithium-based, Zinc primary batteries, and Fuel Cells), including charge/discharge processes, cycle life, self-discharge, and failure modes.

CO3: Evaluate the practical energy, specific energy, and power of batteries through testing methods, and compare theoretical versus practical battery capacities for real-world applications.

CO4: Apply the principles of electroplating to understand substrate preparation, electrolyte composition, electroforming, electroplating on non-conductors, and advanced techniques such as electroless plating, with emphasis on industrial applications.

CO5: Demonstrate knowledge of nuclear chemistry concepts including isotopes, isobars, isotones, methods of isotope separation, radioactivity, radioactive decay laws, nuclear reactions (fission and fusion), and their applications in energy production.

CO6: Assess the chemical applications of radioactivity in structural determination, reaction mechanisms, and age determination techniques (e.g., tritium and C-14 dating), while critically evaluating the role of nuclear energy and fusion as sustainable energy sources.

CHMAT-362: Inorganic Chemistry III [Theory, 2 Credit paper, 30L]

Chapter No	Name of the Chapter	Lectures Assigned
Module-I	Inorganic Materials in Heterogeneous Catalysis	10
	Structure, Bonding, Preparation, Properties and Uses of some p-block elements	05
Module-II	Biological Inorganic Chemistry	15

1. Inorganic Materials in Heterogeneous Catalysis [8 L]

Part-A: Basics of Heterogeneous catalysis: definition and importance, Mechanisms of contact catalysis. Steps 1 and 5: diffusion of reactants and products, Step 2: chemisorption of the reacdng substances, Step 3: transformation of the adsorbed species, Step 4: de-sorption of products (Ref-4 PP 1-14); Adsorption (what is physical and chemical adsorption both must be explained) and adsorption isotherm, The influence of temperature on adsorption, effect of temperature on adsorption, Adsorption as the limiting step (**Ref-1**: pp-17-21), Properties and characteristics of industrial catalysts (**Ref-1**: pp-67-74).

Part-B: Examples: **Example-1:** Hydrogenation of benzene to cyclohexane- Industrial importance of the conversion, Thermodynamics of benzene hydrogenation, Selecting the active species (**Ref-1**: PP-291 to 295) Required qualities for the catalyst, Stability, Rany Nickel-Preparation of reny Ni, Propertie of Rany Ni (**Ref-1: pp-**298 to 302) , **Example-2**: Direct oxidation of methanol to formaldehyde- Industrial importance of the transformation, Analysis of the chemical conversion, Selecting the active species, Developing The Catalyst- The kinetics and mechanism of the reaction, Composition of the catalyst, Preparing the catalyst (**Ref-1**: pp-311-322).

2. Structure, Bonding, Preparation, Properties and uses of some Inorganic Compounds [5 L]

Boric acid and borates, boron nitrides, borohydrides (diborane), carboranes and graphitic compounds, silanes, Oxoacids of - Nitrogen, Sulphur, Phosphorus and Chlorine. Per-oxo acids of Sulphur inter-halogen compounds, polyhalide ions, pseudo-halogens, properties of halogens. [Ref-4]

3. Biological Inorganic Chemistry [15 L]

Part-A: The organization of cells, he physical structure of cells, The inorganic composition of living organisms, Compartmentalization, Biological metal-coordination sites, Special ligands, The structures of metal-coordination sites, Role of Na, K, Ca and Mg in biological systems, Transport, transfer, and transcription, Sodium and potassium transport, Calcium-signalling proteins, Zinc in transcription, Selective transport and storage of iron, Oxygen transport and storage, Electron transfer (**Ref-4**: pp 763-788)

Part-B: Inorganic medicinal Chemistry: The chemistry of elements in medicine, Inorganic complexes in cancer treatment, Anti-arthritis drugs, Bismuth in the treatment of gastric ulcers, Lithium in the treatment of bipolar disorders, Chelation therapy. (Ref-5, Ref-8)

Part-C: Toxicity of Metals: Toxic chemicals in the environment, Impact of toxic chemistry on enzymes. Biochemical effect of Arsenic, Cadmium, Lead and Mercury. Biological methylation.

References:

Ref-1. Applied Heterogeneous catalysis: L. F. Le Page, Edition Technip

Ref-2. Heterogeneous catalysis in industrial practice, Chaerls N. Shatterfield, second edition, Krieger Publishing Company, Florida USA

Ref-3. Principles and practices of heterogeneous catalysis, Tomas and Tomas, Wiley-VCH publication

Ref-4: Concise Inorganic Chemistry, J. D. Lee, Blackwel 5th Ed.

Ref-5: Inorganic Chemistry Duward Shriver, Mark Weller, Tina Overton, Jonathan Rourke, Fraser Armstrong and P.W. Atkins, 6th Edn, W. H. Freeman and Company, 2014.

Ref-6: Environmental chemistry by A. K. De, Wiley Eastern Limited New Age International Limited Page No. 75-100.

Ref-8: Biological Inorganic Chemistry - Structure and Reactivity, Bertini, Ivano; Gray, Harry B.; Stiefel, Edward Stiefel, Joan Selverstone Valentine, UNIVERSITY SCIENCE BOOKS Sausalito, California

Course Outcomes (COs)

CO1. **Explain the fundamental principles of heterogeneous catalysis:** Define and describe mechanisms of contact catalysis, adsorption processes, and adsorption isotherms. Distinguish between physical and chemical adsorption and analyze the influence of temperature on adsorption.

CO **2. Analyze industrial catalytic processes using inorganic materials:** Evaluate case studies such as hydrogenation of benzene and oxidation of methanol. Assess catalyst properties, preparation methods, and stability requirements in industrial applications.

CO **3. Demonstrate knowledge of structure, bonding, preparation, and properties of inorganic compounds:** Discuss borates, boron nitrides, borohydrides, carboranes, silanes, oxoacids, inter-halogen compounds, polyhalide ions, and pseudo-halogens. Relate their chemical behavior to practical uses in industry and research.

CO **4. Interpret the role of inorganic elements in biological systems:** Explain the functions of Na, K, Ca, Mg, Zn, and Fe in transport, signaling, transcription, and electron transfer. Illustrate the structural and functional aspects of biological metal-coordination sites.

CO**5. Evaluate the applications of inorganic chemistry in medicine:** Discuss the use of inorganic complexes in cancer treatment, anti-arthritis drugs, lithium therapy, bismuth compounds, and chelation therapy. Assess the chemical basis of therapeutic effectiveness and limitations.

CO6. Assess the toxicity and biochemical effects of heavy metals: Identify toxic metals such as arsenic, cadmium, lead, and mercury. Analyze their impact on enzymes, biological methylation, and overall biochemical processes in living organisms.

CHMAT-363: Organic Chemistry -IV, [Theory, 2 Credits Paper, 30 L]

Module	Chapter No.	Title of Topic/Chapter	No. of lecture
I	1	Rearrangement Reactions	04
	2	Active Methylene Compounds	05
	3	Elimination reactions	
II	4	Polynuclear and Heteronuclear Aromatic Compounds	05
	5	Retrosynthetic Analysis and Applications	05
	6	Stereochemistry of Disubstituted Cyclohexane and Decalin	05

1. Rearrangement Reactions [04 L]

Introduction, Types of rearrangement, Types of reactive intermediate involved in different rearrangements, Rearrangement – Beckmann, Baeyer-Villiger, Favorskii, Curtius, Lossen, Schmidt and Pinacol-Pinacolone with mechanism. Electrocyclic Rearrangements- Claisen, Cope and Mc-Lafferty rearrangements with mechanism. Ref.1: Pages 618-656. Ref.2: Pages 89-94, 105-107, 112-114, 122-125, 158-161. Ref.3: Pages 130-132. **[15 L]**

2. Active Methylene Compounds [5 L]

Definition, Preparation of Ethylacetoacetate and Synthetic uses of ethylacetoacetate Preparation of Diethyl malonate and Synthetic uses of diethyl malonate, (preparation of non-heteromolecules having upto 6 carbon). Ref.2: Pages 864 – 875. Ref.3: Pages 859 – 874. Ref.6: Pp 206 – 213.

3. Electrophilic aromatic substitution reactions:

Introduction to Aromaticity, General Mechanism of Electrophilic Aromatic Substitution, Theory of orientation and reactivity in Electrophilic Aromatic Substitution reaction. Nitration, Halogenation, sulphonation, halogention, FC alkyation, FC acylation. Synthetic applications

4. Polynuclear and Heteronuclear Aromatic Compounds [05 L]

Introduction, Classification of aromatic compounds, Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. (Ref.2: Pages 759 – 779, Ref 3: Pages 952 – 962.)

5. Retrosynthetic Analysis and Applications [05 L]

Introduction, Different terms used – Disconnection, Synthons, Synthetic equivalence, FGI, TM. One group disconnection, Retrosynthesis and Synthesis of target molecules: Acetophenone, Crotonaldehyde, Cyclohexene, Benzylbenzoate, and Benzyl diethyl malonate.

Ref 1: Page Nos. 1-34 Ref. 2: Page Nos. 694-722

6. Stereochemistry of Disubstituted Cyclohexane and Decalin [05 L]

Recapitulation, Geometrical and optical isomerism of 1,3- dimethyl and 1,4-dimethyl cyclohexane with their stability and energy calculations. Conformations of decalin and their stability. (Ref.2: Pages 94, 213 - 216, 250. Ref.3: Pages 243 – 250, 289-292.)

References:

1) R.T. Morrison & R.N. Boyd: Organic Chemistry, 7th edition, Prentice Hall.

2) Organic Chemistry: Clayden, Greeves, Wothers, Warren, Oxford Press.

3) Organic Chemistry: Graham Solomans

4) E. S. Gould: Mechanism and Structure in Organic Chemistry4. R.T. Morrison & R.N. Boyd: Organic Chemistry, 7th edition, Prentice Hall.

5) Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman

6) I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.

7) S. N. Sanyal: Reactions, Rearrangements and Reagents

8) Eliel: Stereochemistry of Organic Compounds, Tata Mc Graw Hill, 1989

9) D. Nasipuri: Stereochemistry of Organic Compounds- Principles and Applications, New Age International Publishers, 3rd edition.

10) Jagdamba Singh, Jaya Singh: Photochemistry and Pericyclic reactions.3rd edition

Course Outcomes:

CO1: Student should understand use of reagents in given organic reaction.

CO2: Student should identify the reactive position in the molecule.

CO3: Student should remember different paths of elimination reaction.

CO4: Student should classify the organic compounds.

CO5: Student understand should apply the correct disconnection approach, reagents and reactions.

CO6: Student should visualise and compare three-dimensional structure of the molecule.

CHMAT-364: Analytical Chemistry, [Theory, 2-Credit, 30L]

	Title of Topic/Chapter	No. of lecture
Module-I	Solvent extraction	07
	Instrumental Methods of Chromatographic Analysis	03
	Gas Chromatography	05
Module-II	High Performance Liquid Chromatography	06
	Atomic Absorption Spectroscopy	06
	Flame Emission Spectroscopy	03

1. Solvent extraction (7 L)

Introduction to solvent extraction, organic phase, Partition the theory of extraction (distribution coefficient, Distribution ratio, solute remaining unextracted, Separation coefficient), Factors favoring solvent extraction, Quantitative treatment to solvent extraction equilibrium, Ion association complexes, synergic extraction, some extraction reagent specifically used for inorganic ions (Acetylacetone, 8-Hydroxyquinoline, Diphenylthiocarbazone, Sodium diethyldithiocarbamate, Ammonium pyrrolidine dithiocarbamate), some practical aspects, Applications: determination of copper as the diethyldithiocarbamate complex, Determination of Fe(III) with 8-hydroxyquinoline, determination of nickel by synergistic extraction. Solid phase extraction (Ref-3) Numericals; Key Reference-2: 242- 253, [Supplementary Ref-3: 579-593] 2.

2. Instrumental Methods of Chromatographic Analysis (3 L)

Principles of Chromatographic Separations, classification, Theory of Column Efficiency in Chromatography, (theoretical plate, rate theory of chromatography - the Van Deemter equation, efficiency and particle size in HPLC, retention factor efficiency and resolution, Key Reference -4: 603-617, Supplementary reference-3: 547-556.

3. Gas Chromatography (5 L)

Introduction, Apparatus: A supply of carrier gas from a high-pressure cylinder, Sample injection system and derivatization, the column (Packed columns, Open tubular columns), the detector (properties, hot wire detector or TCD, FID, ECD), Quantitative analysis by GC (Area normalization method and internal standard addition method), Elemental analysis, Applications: Assay of drugs (Assay of Cetostearyl Alcohol), Determination of Water in a Drug, Determination of chloroform in colchicine by head-space gas chromatography, numerical Key Reference-2: 317- 337, [Supplementary reference - 7: 1-209 (relevant part)]

4. High Performance Liquid Chromatography (6 L)

Introduction, Types of liquid chromatography (liquid-solid, liquid-liquid, bonded phases), Choice of mode of separation, Equipment for HPLC: mobile phase, sample injection and column design (mobile

phase, optimization of mobile phase, gradient elution, solvent delivery and sample injection, sample injection system, the column (effect of column length and column diameter), Choosing the Detector, Ultraviolet detector, Luminescence detector, RI detector, electrochemical detector, Column efficiency, HPLC chromatogram and its characteristics (retention time, peak height, peak area), method of quantitative analysis by HPLC, Example: determination of aspirin, phenacetin and caffeine in a mixture, Applications: Assay of dichlorphenamide, Assay of human insulin, Assay of theophylline numerical, Key Reference -2: 289-315, [Supplementary reference - Ref-3: 649 – 724, Ref-6: 1-325 -relevant part

5. Atomic Absorption Spectroscopy (6 L)

Introduction, Elementary theory, Instrumentation, flames, the nebulizer-burner system, nonflame techniques, (graphite furnace, cold vapour technique), resonance line sources, monochromator, detectors, interferences, chemical interferences, background correction methods, Atomic absorption spectrophotometers, Experimental preliminaries (calibration curve methods, standard addition method) Preparation of sample (wet ashing, fusion, Dry ashing, microwave dissolution, concentration procedures), Detection limits, Estimation of Ca and Mg in water. Applications: Assay of total zinc in insulin zinc suspension, assay of palladium in carbenicillin sodium Key Ref-2: 612 – 643 6.

6. Flame Emission Spectroscopy (3 L)

Introduction, emission spectra, flame emission spectroscopy, flame photometers. Evaluation methods, calibration curve procedure, the standard addition technique, Applications: determination of alkali metals by flame photometry, determination of trace elements in contaminated soil by AAS. Applications: assay of sodium, potassium and calcium in blood serum and water, assay of barium, potassium and sodium in calcium acetate Numerical, Key Reference-2: 645-649, 655-656

References:

Ref-1: Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney, 5th Ed, Longman Scientific Technical, USA (copublished with John Wiley Sons).

Ref-2: Vogel's textbook of Inorganic Quantitative Analysis, Mendham, Deney Barnes, 6th Ed, Pearson Education.

Ref-3: Analytical Chemistry by G. D. Christian, et al, Wiley, 6th Ed.

Ref-4: Principles of Instrumental Analysis: Holler, Skoog, Crouch 6th Ed. Thomson Publication

Ref-5: Modern Analytical Chemistry, David Harvey, Mc-Graw Hill Higher Education.

Ref-6: High performance Liquid Chromatography, (Analytical Chemistry through open learning series) Second Ed, Sandie Lindsay, Wiley.

Ref-7: Gas Chromatography, (Analytical Chemistry through open learning series) 2nd Ed, Ian A. Fowlis,

Course Outcomes (COs)

CO-1: Understand and explain the fundamental principles of solvent extraction, chromatographic separations, and spectroscopic techniques, including their theoretical basis and practical applications. *(Knowledge & Comprehension)*

CO-2: Apply quantitative methods to evaluate extraction equilibria, chromatographic efficiency (Van Deemter equation, plate theory), and spectroscopic calibration techniques for accurate chemical analysis. *(Application)*

CO-3: Analyze instrumental setups such as GC, HPLC, AAS, and flame photometry, identifying critical components (detectors, columns, nebulizers, burners) and their role in analytical performance. *(Analysis)*

CO-4 : Perform numerical problem-solving related to distribution ratios, chromatographic resolution, retention factors, and quantitative analysis methods in GC, HPLC, and spectroscopy. *(Application & Analysis)*

CO-5: Evaluate and interpret experimental data obtained from solvent extraction, chromatographic separations, and spectroscopic assays to determine concentrations of inorganic and organic analytes. *(Evaluation)*

CO-6: Demonstrate practical competence in applying solvent extraction reagents, chromatographic techniques, and spectroscopic methods for real-world applications such as drug assays, trace element determination, and environmental analysis. *(Synthesis & Practical Skills)*

CHMAP-365: Practical Physical and Analytical Chemistry-II [Practical, 2 Credit, 60L]

Part-I. Electrochemistry

A. Potentiometry (any Three)

1) To determine the pKa value of given monobasic weak acid by potentiometric titration.

2) To determine the formal redox potential of Fe^{2+}/ Fe^{3+} system potentiometrically.

3) To determine the amount of NaCl in the given solution by potentiometric titration against silver nitrate.

4) To determine the solubility product and solubility of AgCl potentiometrically using chemical cell.

B. Electrochemical Cells (any one)

5. Construction and working of galvanic cell, cell emf and free energy, effect of conc. of Zn^{2+}/Cu^{2+} on cell emf, and related calculations.

6. Construction and working of Lead acid battery, care and maintenance of lead-acid battery.

C. Electrolysis (Compulsory)

7. Electroplating – Cu or Cr or Ni plating on iron – different ways.

D. pH metry (any three)

8) To determine the degree of hydrolysis of aniline hydrochloride.

9) To determine the dissociation constant of oxalic acid by pH-metric titration with strong base.

10) Determination of Pka of given weak acid by pH metry titration with strong base

11) To determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of an acid.

II. Colligative properties (any one)

16. To determine the molecular weight of solute by depression in freezing point method (acetic acid water system)

17. To study the association of Benzoic acid in benzene by Beckmann Method

18. Determine the molecular weight of given electrolyte and non-electrolyte by Landsberger's method and to study the abnormal molecular weight of electrolyte

III. Turbidometry: (any one)

19. Determination of SO_4^{2-} and Cl^- by turbidimetric method (turbidimetric titration or calibration curve method)

20. To determine the molecular weight of a given polymer by turbidometry

IV. Table work (compulsory)

21. Analysis of crystal structure from X-ray diffraction spectra of any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks.

22. Use of AI in Chemoinformatic

23. Drawing and optimization of structure of some molecules and visualization of HOMO and LUMO and energy gap between them, comparing theoretical energy gap with practically observed energy gap, locating frontier orbitals of some molecules and their uses.

References:

1. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut),

2. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House

3. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

4. Advanced Physical Chemistry Practical Guide, Charu Arora and Sumantra Bhattacharya, Bentham Science Publishers (2022).

Course Outcomes

CO-1: Apply electrochemical principles: Students will be able to perform potentiometric titrations to determine dissociation constants, solubility products, and redox potentials, thereby applying theoretical electrochemistry concepts to practical problem-solving.

CO-2: Analyze and construct electrochemical cells: Students will gain hands-on experience in designing galvanic and lead-acid cells, measuring cell emf, and interpreting the effect of ion concentration on free energy, linking experimental data with thermodynamic calculations.

CO-3: Demonstrate electrolysis techniques: Students will acquire practical skills in electroplating (Cu, Cr, Ni) on iron substrates, understanding industrial applications, electrode processes, and the influence of experimental conditions on plating quality.

CO-4: Utilize pH-metric methods for equilibrium studies: Students will be able to determine dissociation constants, hydrolysis degrees, and isoelectric points of acids, bases, and amino acids using pH metry, strengthening their grasp of acid-base equilibria.

CO-5: Investigate colligative properties and molecular interactions: Students will determine molecular weights of solutes and study association/abnormal behavior of electrolytes using freezing point depression, Beckmann, and Landsberger methods, connecting macroscopic measurements with molecular-level phenomena.

CO-6: Interpret structural and computational chemistry data: Students will analyze crystal structures using X-ray diffraction, apply chemoinformatics tools, and visualize molecular orbitals (HOMO, LUMO), thereby integrating experimental and computational approaches in modern chemistry.

CHMAT-366: Practical Inorganic and Analytical Chemistry [Practical, 2 Credit, 60L]

Total 12 Experiments to be performed.

Part-A. Volumetric Estimations (Any 2)

1. Analysis of Phosphate (PO_4^{3-}) from Fertilizer. (Ref-1)
2. Analysis of Cu from Cu-Fungicide. (Ref-1)
3. Analysis of Calcium from milk powder. (Ref-1)

Part-B. Flame Photometry (Ref-1)

1. Estimation of Na from water by flame photometry by calibration curve method. Regression analysis of curve should be performed.
3. Estimation of K from soil by flame photometry by calibration curve method. Regression analysis of curve should be performed.

Part-C. Column Chromatography (Ref-1)

1. Purification of water using cation/anion exchange resin and analysis by qualitative analysis /Conductometer.

Part-D. Materials synthesis (Any 2) (Ref-3, 4)

1. Synthesis of Silver nanoparticles by wet Chemical Method and determination of band gap by UV-Visible spectroscopy.
2. **Heterogeneous catalysis**: Synthesis of MnO_2 wet chemical method (reaction between $KMnO_4$ and $MnSO_4$). Study of decompaction of H_2O_2 on MnO_2 as heterogeneous catalyst.
3. Synthesis of CuO by grinding method and study of its stability in water, dil. HCl (0.1 M) dilute ammonia (0,1 M), dilute EDTA (0.025M) and glycine (0.025 M). Predicting observation by writing reaction in each.
4. Synthesis of Fe_2O_3 by precursor method (from FeC_2O_4 as a precursor).
5. Synthesis of ZnO by Sol-Gel / combustion method. Determination of band gap of ZnO.

Part-E (Any -1)

1. Determination of solubility product of $Ca(OH)_2$ and effect of common ion (NaOH) on solubility of $Ca(OH)_2$.
2. Verification of periodic trends using solubility of alkaline earth metal hydroxides $Ca(OH)_2$, $Mg(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$. (Ref-1)

Part-F. (any-2)

1. Determination of the Metal to ligand ratio in $K_3[Fe(C_2O_4)_3]$ (M : L) in complexes. (Ref-5)
2. Green Chemistry: Grinding synthesis of SALEN ligand and its Complex with Cu(II)/Ni(II)/Co(II).
3. Green Chemistry: Solvent free microwave assisted one pot synthesis of pthalocynin copper (II) complex.

Part-G. (Any one)

2. Homogeneous catalysis - Fenton reaction: Degradation of organic dye using Fenton reagent i.e. H_2O_2 –Fe(III) catalyst. (Ref-6).

2. Heterogeneous catalysis: Photocatalytic Degradation of dyes using nano-ZnO photocatalyst.

References:

1: Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney, 5th Ed, Longman Scientific Technical, USA (copublished with John Wiley Sons)

2: General Chemistry Experiment – Anil J Elias (University press).

3: Nanotechnology: Principles and Practices by Dr.Sulbha Kulkarni. Third Edition,Springer

4: A laboratory course in nanoscience and nanotechnology, Dr. Gerrad Eddy Jai Poinem, CRC press.

5: Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horword Publishing, Chichester) 1999

6: Environmental Chemistry Microscale Laboratory Experiments, Jorge G.Ibanez Margarita Hemandez-Esparza Carmen Doria-Serrano Arturo Fregoso-Infante, Springer

Course Outcomes (COs)

CO-1: Perform volumetric estimations with accuracy and precision: Quantitatively determine phosphate, copper, and calcium content in fertilizers, fungicides, and food samples. Apply titrimetric methods to real-world materials and interpret results scientifically.

CO-2: Apply flame photometry for quantitative analysis of alkali metals: Estimate sodium and potassium concentrations in water and soil using calibration curve methods. Perform regression analysis to validate calibration curves and ensure reliability of measurements.

CO-3: Demonstrate purification techniques using column chromatography: Purify water samples with cation/anion exchange resins. Analyze purified samples using qualitative tests or conductometric methods.

CO-4: Synthesize and characterize inorganic and nanomaterials: Prepare materials such as Ag nanoparticles, MnO2, CuO, Fe2O3, and ZnO using green and wet chemical methods. Study their stability, catalytic activity, and band gap properties using UV-Visible spectroscopy.

CO-5: Investigate solubility and periodic trends experimentally: Determine solubility product of Ca(OH)2 and study the effect of common ions. Verify periodic trends in alkaline earth metal hydroxides through solubility measurements.

CO-6: Explore coordination chemistry and catalysis through experiments: Determine metal-to-ligand ratios in complexes and synthesize ligands/complexes using green chemistry approaches. Study homogeneous (Fenton reaction) and heterogeneous (photocatalytic degradation using ZnO) catalytic processes for pollutant removal.

CHMAT-361A: Dyes and Drugs; [Theory, 2 Credits Paper, 30 L]

Module	Chapter No.	Title of Topic/Chapter	No. of lecture
I	1	Introduction to Dyes	5
	2	Natural Dyes	4
	3	Synthetic Dyes	6
II	4	Introduction to Drugs	6
	5	Antipyretics and Analgesics	5
	6	Anaesthetics and Antiseptics	4

1. Introduction to Dyes 05 L

Definition of dyes, Difference between dyes and pigments, Chromophore and auxochrome concept, Color and constitution theory: Witt's theory, Quinonoid theory, Modern MO theory, Classification of Dyes- Based on source (Natural and Synthetic), - Based on chemical constitution (Azo, Nitro, Triphenylmethane, Anthraquinone, Phthalein dyes), - Based on method of application (Direct, Acid, Basic, Vat, Reactive, Disperse, Mordant dyes). Properties of Dyes- Fastness properties (light, wash, perspiration)- Factors affecting dyeing- Environmental impact of dyes

2. Introduction to Natural Dyes 04 L

Historical background and sources, Classification of Natural Dyes- Indigoid dyes- Anthraquinone dyes - Flavonoid dyes- Carotenoid dyes, Important Natural Dyes (Structure, Source & Application)- Indigo - Alizarin- Turmeric (Curcumin)- Henna- Saffron2.4 Mordants (Definition, types and role in dye fixation)2.5 Advantages and Limitations of Natural Dyes

3. Synthetic Dyes 6L

Introduction and historical development, Classification Based on Chemical Constitution
- Azo dyes (monoazo, diazo)- Triphenylmethane dyes- Anthraquinone dyes- Phthalocyanine dyes 3.3 Preparation (General Methods)- Diazotization and coupling reactions - Synthesis of Methyl orange, Congo red, Malachite green, Crystal violet Reactive Dyes and Vat Dyes (Mechanism of dye-fiber bonding)3.5 Environmental Aspects (Effluent treatment, Biodegradation, Green chemistry approach)

4. Introduction to Drugs 06 L

Definition of drug- Difference between drug and medicine- Pharmacokinetics and Pharmacodynamics- Therapeutic index- Receptors and drug–receptor interaction1. Classification of Drugs- Based on therapeutic action- Based on chemical structure- Based on mechanism of action1.3 Drug Action and Metabolism- Absorption, Distribution, Metabolism and Excretion (ADME)- Factors affecting drug action- Side effects and drug toxicity1.4 Important Terms- Agonist and Antagonist- Prodrugs- Drug resistance- Overdose and antidotes

5. Antipyretics and Analgesics 05 L

Introduction to fever and pain mechanism, Antipyretic Drugs, - Paracetamol (structure, synthesis and uses)- Aspirin (structure, synthesis and uses), Analgesic Drugs- Morphine (narcotic analgesic), - Ibuprofen (non-narcotic analgesic), Side Effects and Limitation, - Gastric irritation, - Addiction potential- Liver toxicity

6. Anaesthetics and Antiseptics 04L

Anaesthetics, - General anaesthetics: Nitrous oxide, Chloroform, - Local anaesthetics: Lidocaine, Benzocaine, - Mechanism of action and side effects, Antiseptics and Disinfectants, - Definition and difference, - Examples: Dettol (Chloroxylenol), Iodine, Hydrogen peroxide, - Uses, concentration effects and toxicity.

References:

1. **Gurudeep R. Chatwal**, *Synthetic Organic Chemistry*, Himalaya Publishing House.
2. **Dr. Padma S. Vankar**, *Chemistry of Natural Dyes* / Relevant Publications on Dye Chemistry.
3. **Wilson and Gisvold**, *Textbook of Organic Medicinal and Pharmaceutical Chemistry*.
4. **Ashutosh Kar**, *Medicinal Chemistry*, New Age International Publishers.

Course Outcomes:

After successful completion of this course, students will be able to:

CO1: Explain the basic concepts, classification and theories related to dyes and drugs.

CO2: Describe the structure, preparation, properties and applications of natural and synthetic dyes.

CO3: Understand drug classification, drug–receptor interaction and pharmacological principles including ADME.

CO4: Illustrate the synthesis, mechanism of action and therapeutic uses of important drugs such as antipyretics, analgesics, anaesthetics and antiseptics.

CO5: Analyze dye–fiber bonding mechanisms and drug metabolism pathways.

CO6: Evaluate environmental impact of dyes and safety, toxicity and responsible use of drugs.

CHMET-362A: Polymer Chemistry [Theory, 2 Credit paper, 30L]

Chapter No	Name of the Chapter	Lectures Assigned
Module-I	Introduction and history of polymeric materials	05 L
	Polymerization Chemistry	10 L
Module-II	Molecular weight of Polymers	05 L
	Important Polymers	10 L

1) Introduction and history of polymeric materials: **[05 L]**

Brief history, Basic terms- monomer, polymer, polymerisation, degree of polymerisation, functionality. Different schemes of classification of polymers, polymer nomenclature, molecular forces and chemical bonding in polymers, glass transition temperature of polymer.

Ref. 1: Pages 1-20, 150; Ref. 2: Pages 1-16; Ref. 5, 7 & 8 Relevant Pages

2) Polymerization Chemistry **[10 L]**

Classification of polymerization processes, mechanism of- step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations. Polymerization techniques- bulk, solution, suspension, emulsion and interfacial condensation. Ref. 1: Pages 20-58, 71-79 ; Ref. 2: Pages 25-32, 49-56, 82-86, 88-94, 126-132 ; Ref. 3 & 4 Relevant Pages

3. Molecular weight of Polymers **[5 L]**

Average molecular weight of polymer, Number average molecular weight (*Mn*), Weight average molecular weight (*Mw*), Number average molecular weight by end group analysis, Viscosity average molecular weight by viscometric method, kl Molecular weight distribution and its significance, polydispersity index. Ref. 1: Pages 86-98, 402-409.

4. Important Polymers: [12 L]

Brief introduction to preparation, structure, properties and application of the following polymers: polyethylene, polystyrene, polyvinyl chloride, polyvinyl alcohol, polymethyl methacrylate, polytetrafluoroethylene, polyamides, polyesters, phenol formaldehyde resins (Bakelite, Novolac), silicone polymers, polyisoprene, conducting Polymers. Ref. 1: Pages 215-255; Ref. 3, 4 & 6 Relevant Pages

5. Characterization of Polymers

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

Reference Books:

1. Polymer Science by V.R. Gowarikar, N.V.Vishvanathan, JaydevShreedhar New Age International Ltd. Publisher 1996. (Reprint 2012)
2. Textbook of Polymer Science by Fred Billmeyer, 3rd Edn. A Wiely-Interscience Publication John Wiley& Sons New York 1984. (Reprint 2008)
3. Introductory Polymer Chemistry by G.S.Misra New Age International (P) Ltd. Publisher 1996.
4. Polymer Chemistry by Charles E. Carraher (Jr.), 6th Edn, (First Indian Print 2005), New York- Basel.
5. Principle of Polymer Science by P. Bahadur, N.V. Sastry, 2nd Edn, Narosa Publishing House.
6. Polymer Chemistry by Ayodhya Singh, 2008, Published by Campus Book International, New Delhi.
7. Organic Polymer Chemistry by Jagdamba Singh, R.C. Dubey, 4th Edn, 2012.
8. Principles of Polymerisation by George Odian3rd Edn. John Wiley & Sons New York.

Course Outcomes (COs)

CO1 – Fundamentals of Polymeric Materials: Students will be able to explain the historical development, basic terminology, classification schemes, and nomenclature of polymers, along with understanding molecular forces, bonding, and glass transition temperature.

CO2 – Polymerization Mechanisms and Techniques: Students will be able to differentiate between step-growth, radical chain-growth, ionic (cationic and anionic), and coordination polymerization mechanisms, and evaluate various polymerization techniques such as bulk, solution, suspension, emulsion, and interfacial condensation.

CO3 – Molecular Weight Analysis: Students will be able to calculate and interpret different types of polymer molecular weights (Mn, Mw, viscosity average), analyze molecular weight distribution, and assess the significance of polydispersity index in polymer characterization.

CO4 – Knowledge of Important Polymers: Students will be able to describe the preparation, structure, properties, and applications of major commercial and specialty polymers such as polyethylene,

PVC, PMMA, PTFE, polyamides, polyesters, phenol-formaldehyde resins, silicones, and conducting polymers.

CO5 – Polymer Characterization Techniques: Students will be able to apply methods such as light scattering, osmometry, viscometry, gel permeation chromatography, and spectroscopic techniques (FTIR, UV-Vis, NMR, Mass) for polymer identification and characterization.

CO6 – Application-Oriented Understanding: Students will be able to integrate knowledge of polymer chemistry, molecular weight determination, and characterization techniques to evaluate polymer properties and select suitable materials for industrial and research applications.

CHMEP-361B: Practical Organic, Dyes and Drug Chemistry

[Theory, 2 Credits Paper, 30 L]

Total 12 Experiments to be performed

A) Separation of Binary Mixtures and Qualitative Analysis (Any four)

a) Solid-Solid (2 Mixtures) b) Solid-Liquid (1 Mixtures) c) Liquid-Liquid (1 Mixture)

Any four mixture of the following should be given-Acid-Base, Acid- Phenol, Acid-Neutral, Phenol-Base, Phenol-Neutral, Base-Neutral and Neutral- Neutral. (Solid-solid mixtures must be insoluble in water)

B) Preparations

a) Green Chemistry Preparations (Any Two)

1. Preparation of dibenzalpropanone from benzaldehyde and acetone using $LiOH.H_2O$/NaOH
2. Nitration of phenol or substituted phenols using $CaNO_3$.
3. Bromination of acetamide using ferric ammonium nitrate and KBr in aqueous medium.

b) Organic Preparations (Any Two)

1. Preparation of 1, 4- dihydropyrimidinone from ethyl acetoacetate, benzaldehyde and urea using oxalic acid as catalyst.
2. Preparation p-Iodonitrobenzene from p-Nitroaniline by Sandmeyer Reaction
3. Preparation P-chloro benzoic acid and p-chloro benzyl alcohol from p-chloro benzaldehyde.

C) Dyes chemistry practical (Any two)

1. Synthesis of Azo dyes -1: Aniline and 1-Naphthol/2-Naphthol
2. Synthesis of Azo dyes -2: Nitro aniline and 1-Naphthol/2-Naphthol
3. Synthesis of Azo dyes -3: O-toludine / p- toludine and 1-Naphthol/2-Naphthol
4. Synthesis of Azo dyes -4: P-aminophenol / O-phenylenediamine and 1-Naphthol/2-Naphthol
5. Synthesis fluorescein
6. Synthesis of methyl orange

D) Dyes chemistry practical (Any two)

1. Synthesis of Benzotriazole.
2. Synthesis of 2,3-Diphenylquinoxaline.

3. Synthesis of Benzil from Benzoin

4. Synthesis of Paracetamol from P- Amino Phenol

5. Synthesis of Aspirin

6. Synthesis of Benzimidazole from Ortho–Phenylene Diamine

Course Outcomes:

CO-1: The students will be able to perform the qualitative chemical analysis of binary mixture, explain principles behind it.

CO-2: The students will be able to do and understand stoichiometric calculations and relate them to green process metrics.

CO-3: The students will be able to learn the basic principles of green and sustainable chemistry.

CO-4: The students will be able to understand the techniques involving drying and recrystallization by various method.

CO-5: The students will be able to understand principle of Thin Layer Chromatographic techniques.

CO-6: The students will be able to expertise the various techniques of preparation and analysis of organic substances. The students will be able to expertise the techniques of synthesis of polymer.

Reference

1. Practical Organic Chemistry by - A. I. Vogel.

2. Practical Organic Chemistry by - O. P. Agarwal.

3. Aparna G.Sajina, Practical Manual Engineering Chemistry.

4. Fred. W. Billmayer, 1984, Text book of Polymer Science, 3rt Edition.

CHMEP-362B: Practical Organic and Polymer Chemistry

[Theory, 2 Credits Paper, 30 L]

Total 12 Experiments to be performed

A) Separation of Binary Mixtures and Qualitative Analysis (Any four)

a) Solid-Solid (2 Mixtures) b) Solid-Liquid (1 Mixtures) c) Liquid-Liquid (1 Mixture)

Any four mixture of the following should be given-Acid-Base, Acid- Phenol, Acid-Neutral, Phenol-Base, Phenol-Neutral, Base-Neutral and Neutral- Neutral. (Solid-solid mixtures must be insoluble in water)

B) Preparations

a) Green Chemistry Preparations (Any Two)

1. Preparation of dibenzalpropanone from benzaldehyde and acetone using $LiOH.H_2O$/NaOH

2. Nitration of phenol or substituted phenols using $CaNO_3$.

3. Bromination of acetamide using ferric ammonium nitrate and KBr in aqueous medium.

b) Organic Preparations (Any Two)

1. Preparation of 1, 4- dihydropyrimidinone from ethyl acetoacetate, benzaldehyde and urea using oxalic acid as catalyst.
2. Preparation p-Iodonitrobenzene from p-Nitroaniline by Sandmeyer Reaction
3. Preparation P-chloro benzoic acid and p-chloro benzyl alcohol from p-chloro benzaldehyde.

C) Polymer chemistry practical (Any four)

1. Preparation of epoxy resin.
2. Synthesis of polyesters.
3. Preparation of sodium carboxy methyl cellulose.
4. Estimation of Amount of HCHO from phenol formaldehyde resin.
5. Preparation of urea-formaldehyde resin.
6. Preparation of phenol formaldehyde resin.
7. Determination of molecular weight of polymer by viscometry.
8. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated to students)

Reference

1. Practical Organic Chemistry by - A. I. Vogel.
2. Practical Organic Chemistry by - O. P. Agarwal.
3. Aparna G.Sajina, Practical Manual Engineering Chemistry.
4. Fred. W. Billmayer, 1984, Text book of Polymer Science, 3rt Edition.

Course Outcomes:

CO-1: The students will be able to perform the qualitative chemical analysis of binary mixture, explain principles behind it.

CO-2: The students will be able to do and understand stoichiometric calculations and relate them to green process metrics.

CO-3: The students will be able to learn the basic principles of green and sustainable chemistry.

CO-4: The students will be able to understand the techniques involving drying and recrystallization by various method.

CO-5: The students will be able to understand principle of Thin Layer Chromatographic techniques.

CO-6: The students will be able to expertise the various techniques of preparation and analysis of organic substances. The students will be able to expertise the techniques of synthesis of polymer.

CHVSP-351: Practical Pharmaceutical Analysis -II

[Practical, 2-Credits, 60 L]

Experiment 1 to 3: Compulsory- practical's: Total analysis of aspirin as per Indian Pharmacopeia (all type of analyses given monograph of Aspirin)**.** (Ref-2; 127-128)

4 to 6. Analysis of magnesium hydroxide as per Indian Pharmacopeia. (Ref-2; pp 714)

Experiment-4. **Magnesium hydroxide -** Tests: Identification; Appearance of solution; heavy metals, iron and chloride

Experiment-5. **Magnesium hydroxide -** Tests: Sulphate; calcium; soluble substances; substances insoluble in acetic acid;

Experiment-6. **Magnesium hydroxide -** Loss on drying and assay

Alternative practical to analysis of magnesium hydroxide

4 to 6. Analysis of calcium phosphate as per Indian Pharmacopeia. (Ref-2; pp 227-228)

Experiment-4. **Calcium Phosphate:** Tests: Identification, acid insoluble substances, Heavy metals, Barium.

Experiment-5. **Calcium Phosphate:** Tests: Carbonate, chloride, nitrate and Monocalcium and tricalcium phosphates, Reducing substances

Experiment-6. **Calcium Phosphate:** Loss on ignition and assay (calibration of acid solution must be performed)

Experiment-7. **Compulsory:** Identification test for Paracetamol tablet and tablet dissolution test on Paracetamol according to Indian Pharmacopeia (Ref-3: 902-903).

Experiment-8. Identification test for Paracetamol table (according to IP); Average wt. of 20 tablets and UV-absorbance based assay of plane Paracetamol table using specific absorbance (British Pharmacopeia). (Ref-4: 419-421).

Experiment-9. **Compulsory:** Non-aqueous titration: Interpretation of IR spectra of caffeine and assay of caffeine by **non-aqueous titration** method according to IP (Ref-2 pp 215) [standardize perchloric acid with potassium hydrogen phthalate].

Experiment-10. Interpretation of IR spectra of and assay of nicotine amide by **non-aqueous titration** method according to IP (Ref-2 pp 824) [standardize perchloric acid with potassium hydrogen phthalate].

Experiment-11. Identification test for dextrose i.e. glucose (anhydrous or monohydrate); determination of a) specific optical rotation and b) water by Karl Fischer Method. (Ref-1 93, 138 and 2; 397-398)

Experiment-12. Determination of NaCl and dextrose content in DNS saline solution: **a)** Cl by potentiometric titration and **b)** Dextrose by polarimetry (Ref-3: pp-1084).

Experiment-13. Determination of refractive index of four liquids as per IP. Calculation of Rs and Rm

Experiment-14: Viscosity of ethyl cellulose by Oswald viscometer (use viscometer which comply specification of IP) and its molecular weight.

Experiment-15. Identification and Assay of nicotinamide from tablets or capsules (VU-spectroscopy) (Ref-2: 824 – 825).

Experiment-16. Optical rotation and assay of ascorbic acid from tablet or from vit-C pure material by iodimetric titration (vit-C) (ref-2: 124-126).

Experiment-17. Tablet friability and disintegration test; capsule disintegration test (Ref-1)

Experiment-18. Related substances in paracetamol or in paracetamol tablet by thin layer chromatography (prefer to use readymade silica coated plate with silica gel GF254) (Ref-3: 900-901).

Experiment-19. **Compulsory: Table Work:** a) Theoretical discussion on theory of identification of organic compound by IR spectroscopy and interpretation of IR spectra of at least three pharmaceutical compounds (Ref-4: 396 to 401; Ref-1: 107-112). b) Calibration UV-Visible spectrophotometer as per IP (Ref-1).

References:

Ref-1. Indian pharmacopeia Vol-1, 2007

Ref-2. Indian pharmacopeia Vol-2, 2007

Ref-3. Indian pharmacopeia Vol-3, 2007

Ref-4. Introduction to Pharmaceutical Analytical Chemistry, Stig Pedersen-Bjergaard, Bente Gammelgaard, Trine Grønhaug Halvorsen, Second Edition, Wiley (2012).

Ref-5. Pharmaceutical Drug Analysis-New Age International Pvt Ltd Publishers (2005).

Course Outcome - At the end of course students should able to-

CO-1: Apply the procedures of Indian Pharmacopoeia and British Pharmacopoeia for identification, purity testing, and assay of pharmaceutical substances such as Aspirin, Magnesium hydroxide, Calcium phosphate, Paracetamol, Caffeine, Nicotinamide, Dextrose, and Ascorbic acid.

CO-2: Perform qualitative and limit tests for pharmaceutical substances including tests for heavy metals, chloride, sulphate, iron, calcium, carbonate, nitrate, and related substances using pharmacopoeial methods.

CO-3: Conduct quantitative estimations using classical and instrumental analytical techniques such as non-aqueous titration, potentiometric titration, iodimetric titration, Karl Fischer method, polarimetry, UV-Visible spectroscopy, and thin layer chromatography.

CO-4: Standardize analytical reagents (e.g., perchloric acid) and perform assay calculations including loss on drying, loss on ignition, refractive index, viscosity, molecular weight determination, and specific optical rotation as per pharmacopoeial standards.

CO-5: Operate and calibrate pharmaceutical analytical instruments such as UV-Visible spectrophotometer, IR spectrophotometer, Oswald viscometer, polarimeter, potentiometric titration apparatus, and dissolution and disintegration test apparatus.

CO-6: Interpret IR spectra of pharmaceutical compounds and evaluate quality control parameters of solid dosage forms including tablet friability, disintegration, dissolution, average weight, and related substances analysis.