সকন ছিলাত, বস্তুৰন দুক

# P. D. E. A's Prof. Ramkrishna More Arts, Commerce and Science College Akurdi Pune-411044



Affiliated to



Savitribai Phule Pune University [SPPU]

# M. Sc-I Analytical Chemistry

(After three years B. Sc. in Chemistry)

Choice Based Credit System-2023 [CBCS-2023] Under Autonomy and NEP-2020

From Academic Year 2023-2024

# Syllabus First Year Post-Graduate (M. Sc.-I) Analytical Chemistry

# **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

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

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

- (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 – 2<sup>nd</sup> 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 or practical course will be of 2 credits = 50 marks
- b. Internal evaluation 30% weightage (15 marks)
- c. External evaluation 70% weightage (35 marks)
- d. Students should secure 40% marks in each type of evaluation for successful completion of a course (student should secure at least 6 marks in internal and 14 marks in external evaluation).

#### (v) Evaluation Pattern.

**a. Internal evaluation** - Two written test, each of 20 marks will be conducted i. e. two tests on two modules. 1<sup>st</sup> assignment after completing 6 weeks of teaching and 2<sup>nd</sup> on completion of 13<sup>th</sup> week of teaching. 5 marks out of 15 will be assigned from these written tests. Remaining 10 marks will be assigned from other types of evaluation such as seminars, orals, poster presentation, open book challenging tests, surprise test, objective test etc. Examination (Internal and external) will conducted so that CO, PO, PSO can be evaluated.

**b. External Evaluation** - External evaluation will be done at the end of each semester.

- i. For theory, 35 marks written examination will be conducted and time of examination will be 2-hours.
- ii. For practical, 35 marks practical examination will be conducted and time of examination will be 4-hours.
- iii. For project / field project, 35 marks evaluation will done on the basis of viva-voce and examination of thesis by the examiners.
- iv. For OJT 35 marks evaluation will be done on the basis of report of industrial mentor / supervisor / industry and viva-voce. However, student has to produce and submit OJT certificate from competent authority of industry.
- 7. Attendance: The student must have at least 70% attendance, to appear any type of examination.

#### 8. 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

	the following tabl	e
Semester GPA/ Program	% of Marks	Alpha-Sign / Letter
CGPA		Grade Result
Semester/Program		
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)

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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.

#### 9. 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.

#### **10. 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: 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.

# **11. Definitions:**

**i. One semester** = 15 weeks

**ii. 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 (Numerical problem solving sessions, revision on difficult topics, dialog on student's difficulties, and internal evaluation)
- **iii. 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.
- iv. Each theory course of any type (major, minor, VSC, VEC, OE/GE, VEC, SEC, CC, etc.) is of 2 credits.
- **v. Theory per semester:** Each theory course is of 2 credits. Thus, for each theory course contact hours = 24 teaching + 6 tutorials

# vi. Each practical course is of 2 credits = 60 hours per semester

- a. Minimum 12 laboratory sessions will be conducted in one semester.
- b. Each laboratory sessions will be of 4 hour.

# P. D. E. A's. Prof. Ramkrishna More College, Akurdi, Pune 411044 M. Sc-I Analytical Chemistry Course Framework under Autonomy as per NEP-2020

Sem	Major Courses	Major Elective Curses	Minor Curses	VSC	IKS	FP/OJT/CEP	GE/OE	SEC	AEC	VEC	CC	Total Credits
						PG Chem	istry					
I	CHMAT-511 CHMAT-512 CHMAT-513 CHMAT-514 CHMAT-515 CHMAP-516 CHMAP-517	CHMET-511-A CHMEP-512-A Or CHMET-511-B CHMEP-512-B	Research methodology (4 Credits course)	0	0	0		0	0	0	0	22
п	CHMAT-521 CHMAT-522 CHMAT-523 CHMAT-524 CHMAT-525 CHMAP-526 CHMAP-527	CHMET-521-A CHMEP-522-A Or CHMET-521-B CHMEP-522-B	0	0	0	On Job Training or Field Project (4 Credit)	0	0	0	0	0	22

Codes, Generic Name and Titles of the Paper								
Sem.	Code	Generic Name	Title of the Paper					
	Compulsory Papers							
	CHMAT-511	Chemistry theory paper-1	Thermodynamics and Chemical Kinetics					
	CHMAT-512	Chemistry theory paper-2	Molecular Symmetry and Group Theory:					
M. Sc-I			Applications in Chemistry					
Sem-I	CHMAT-513	Chemistry theory paper-3	Organic Stereochemistry and Aromaticity					
	CHMAT-514	Chemistry theory paper-4	Bioinorganic Chemistry					
	CHMAT-515	Chemistry theory paper-5	Rearrangement, Oxidation and Reduction					
			reactions					
	CHMAP-516	Chemistry practical paper-1	Practical Chemistry –I					
	CHMAP-517	Chemistry practical paper-2	Practical Chemistry –II					
		Elective Pa	pers					
	CHMET-511-	Elective Chemistry theory	Solid State Chemistry					
M. Sc-I	А	paper-3-A						
Sem-I	CHMET-512-	Elective Chemistry theory	Nuclear Chemistry					
	А	paper-3-B						
	CHMEP-511-B	Elective Chemistry practical	Chemistry Practical-III-A					
		paper-4-A (compulsory)	Inorganic Practical					
	CHMEP-512-B	Elective Chemistry practical	Chemistry Practical-III-A					
		paper-4-B	Biochemistry Practical					
	CHMAT-521	Chemistry theory paper-22	Quantum Chemistry and Bonding Theories					
M. Sc-I	CHMAT-522	Chemistry theory paper-23	Ligand Field Theory					
Sem-II	CHMAT-523	Chemistry theory paper-24	Theoretical basis of Molecular Spectroscopy					
	CHMAT-524	Chemistry theory paper-25	Advanced Organic Molecular Spectroscopic					
			Characterizations					
	CHMAT-525	Chemistry theory paper-26	Photochemistry and Pericyclic reactions					
	CHMAP-526	Chemistry practical paper-13	Practical Chemistry –XIII					
	CHMAP-527	Chemistry practical paper-14	Practical Chemistry –XIV					
		Elective pa	pers					
	CHMET-521-	Elective Chemistry theory	Chemistry of main group elements					
M. Sc-I	A	paper-5-A						
Sem-II	CHMET-521-B	Elective Chemistry theory	Electro Analytical Chemistry					
		paper-5-B						
	CHMEP-	Elective Chemistry practical	Chemistry Practical-IV-A					
	522-A	paper-6-A	Electrochemistry Practical					
	CHMEP-	Elective Chemistry practical	Chemistry Practical-IV-B					
	522-B	paper-6-B	Inorganic Practical on main group element					

# CHMAT-511, Chemistry Theory Paper-1 [2 Credits]

# **Title of the paper: Chemical Kinetics and Thermodynamics**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Fundamental Concepts of Kinetics	5 L
2	Kinetics of More Complex Systems	4 L
3	Techniques and Methods	4 L
4	Enzyme Catalysis	2 L
5	Thermodynamics	5 L
6	Change of State	4 L
7	Molecular Thermodynamics	6 L

#### **Module-1**

#### **Chapter-1: Fundamental Concepts of Kinetics**

Rates of Reactions, Dependence of Rates on Concentration, First-Order, Second-Order, Zero-Order, Nth-Order Reaction, Cautions on Treating Kinetic Data, Effect of Temperature, Some Common Reaction Mechanisms, Direct Combination, Chain Mechanisms, Substitution Reactions, Catalysis, Reference-1: 1-30

#### **Chapter-2: Kinetics of More Complex Systems**

Second-Order Reaction, First-Order in Two Components, Third-Order Reactions, Reversible Reactions, Effect of Temperature, Reference-1: 36-45; 58-64; 69-75

#### **Chapter-3: Techniques and Methods**

Calculating Rate Constants, The Method of Half-Lives, Initial Rates, The Logarithmic Method, Flow Techniques, Relaxation Techniques, Tracer Methods, Kinetic Isotope Effects, Reference-1: 79-89; 94 to 107

#### **Enzyme Catalysis**

Introduction, Enzyme Action, Kinetics of Reactions Catalysed by Enzymes, Michaelis-Menten Analysis, Lineweaver–Burk and Eadie Analyses. Reference-1: 205 -224

#### **Module-2**

#### 1. Thermodynamics

State function, path function, exact differential and inexact differential, internal energy and enthalpy, temperature dependent internal energy and enthalpy, reversible and irreversible adiabatic expansion. The entropy of irreversible changes, the Helmholtz and Gibbs function, Entropy and entropy change in an ideal gas with temperature and pressure, Clausius inequality, chemical potential, chemical potential of a substance in a mixture. Ref-2-3; Relevant pages

#### 2. Change of State

Partial molar quantities, methods for determination of molar quantities, ideal solutions, Raoult's and Henery's law, Thermodynamics of Gibbs function of mixing, colligative properties: Elevation in boiling point, depression in freezing point and osmosis. Ref-2-3: Relevant pages

#### 3. Molecular Thermodynamics

Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition function of diatomic molecule, obtaining energy, heat capacity, entropy and equilibrium constants from partition functions, Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics. Ref-2-3; Relevant pages

Reference-1: Principles of Chemical Kinetics, James E. House Second Edition, Elsevier Reference-2: Atkins Physical Chemistry by P. W. Atkin and De Paul, 11<sup>th</sup> Ed. Oxford Reference-3: Physical Chemistry by T. Engel and P. Reid

# [06 L]

#### [12 L + 3 T]

#### [05 L]

# [04 L]

# [12 L + 3 T][5 L]

# [4 L]

[2 L]

[4 L]

Course Outcomes: At the end of course student should able to -

CO-1: Define / recall the terms in thermodynamics and chemical kinetics included in syllabus.

- CO-2: Can evaluate various thermodynamic parameters, rate, order and molecularity of the chemical reactions from given experimental data.
- CO-3: Explain /discuss terms in thermodynamics and chemical kinetics included in syllabus.
- CO-4: Differentiates / compare/ relate among or between the terms such as enthalpy, internal energy, entropy; exact differential and inexact differential; Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics; Raoult's and Henery's law; molecularity and order; first, second and third order reactions; different methods of evaluating order of reactions; different mechanisms of reactions, etc.
- CO-5: Derive equations for enthalpy, Boltzmann distribution law, partition functions constant, Raoult's and Henery's law; half life of first, second and third order reactions. Graphical representation of the same.
- CO-6: Apply knowledge of thermodynamics and chemical kinetics to given reaction to predict order, molecularity and mechanism.

#### **Chemistry theory paper-2**[2-Credits] CHMAT-512 **Title of the Paper: Molecular Symmetry and its Applications**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Molecular Symmetry and Symmetry Groups	10 L
2	Symmetry Group	05 L
3	Representations of Matrix	08 L
4	Symmetry Adapted Linear Combinations (SALCs)	07 L
Module-I	[12]	L + 3 T]

#### Module-I

#### **Chapter-1: Molecular Symmetry and Symmetry Groups**

Symmetry elements and operations, Symmetry planes and reflections, the inversion centre, proper axes and proper rotations, improper axes and improper rotation, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations among symmetry elements and symmetry operations, classes of symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classification of molecular point groups.

#### **Chapter-2: Symmetry Group**

Defining properties of a group, group multiplication table, some examples of group, subgroups and classes.

#### **Module-2**

#### **Chapter-3: Representations of Matrix**

Matrix representation and matrix notation for geometric transformation, The Great Orthogonality theorem and its consequence, character tables (No mathematical part), wave function as basis for irreducible representations.

#### **Chapter-4:** Symmetry Adapted Linear Combinations (SALCs) (07L)

Projection operators and their use of construct SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D2h, D3h D4h, C4v, Td., Oh., normalization of SALC, transformation properties of atomic orbital, MO's for sigma bonding, ABn molecules, tetrahedral AB4 and Oh AB6 cases.

#### **References**:

- 1) Chemical Applications of Group Theory by F. A. Cotton;
- 2) Symmetry and spectroscopy of molecules by K. Veera Reddy;
- 3) Group Theory and its Chemical Application, P.K. Bhattarchrya

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# (10L)

# (05)

#### [12 L + 3 T](08 L)

Course Outcomes: At the end of course student should able to -

CO1: Define symmetry elements and symmetry operations, classes, properties of a group, group multiplication table, etc.

- CO2: Classify symmetry elements, point group, Group, sub-group and classes.
- CO3: Use wave function as basis for determination of irreducible representations and the Great Orthogonality theorem and its consequence.
- CO4: Solve problem based on point group, matrix representation and character table
- CO5: Construct character table of various point group

CO6: Justify which can take part in bonding on the basis of SALCs and point group of molecules

#### **Chemistry theory paper-3**[2-Credits] **CHMAT-513**

# **Organic Stereochemistry and Aromaticity**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Stereochemistry-I	15 L
2	Stereochemistry-II	05 L
3	Aromaticity	10 L
Module-I		[12 L + 3 T]

#### **Module-I**

#### **Chapter-1: Stereochemistry-I**

a) Sterochemical principles, Interconversions of projection and perspective formulae, enantiomeric relationship, distereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes, Topicity. Ref. 1 PP. 92 to 189

#### **Module-II**

#### **Chapter-2: Stereochemistry-II**

Conformational analysis of di, tri, tetra-substituted 5-6 membered rings and decalins. Ref. 1 PP. 160 to 189

#### **Chapter-3: Aromaticity**

Aromaticity: Benzenoid and non-benzenoid compounds, Huckel's rule, antiaromaticity, Application to carbocyclic and heterocyclic systems, annulenes, azulenes, current concepts of aromaticity. Ref. 1 PP 39 to 62

#### **References:**

- 1. Advanced Organic Chemistry, Jagdamba Singh and L. D. S. Yadav, Pragati Prakashan 20th edition (2014)
- 2. Stereochemistry of carbon compound-by E.L. Eliel
- Advanced Organic Chemistry (Part A) F. A. Carey and R. J. Sundberg 3.

# Course outcomes: Student will able to

**CO-1:** Learn Stereochemistry of organic compounds.

CO-2: Conversion of Fischer to Newmann, Newmann to Sawhorse and vice versa.

- **CO-3:** Assign absolute configuration to given organic molecules
- **CO-4:** Explain stereoselective and stereospecific reactions; acquire knowledge on topicity.
- **CO-5:** Understand some fundamental aspects of organic chemistry

**CO-6:** Discuss the concept aromaticity, and various types of aromatic compounds.

(10 L)

(15 L)

# [12 L + 3 T]

#### **Chemistry theory paper-4**[2-Credits] **CHMAT-514**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Overview of Bioinorganic Chemistry	06 L
2	Concepts of Inorganic Chemistry in	09 L
	Bioinorganic Chemistry	
3	Control and Utilization of Metal-Ion	07 L
	Concentration in Cells	
4	Biochemistry of following Elements	08 L
Module-I		[12 L + 3 T]

# **Title of the Pater: Bioinorganic Chemistry**

#### Module-I

#### **Chapter-1: Overview of Bioinorganic Chemistry**

#### (06 L)

What is bioinorganic chemistry, metal functions in metalloproteins: dioxygen transport, electron transfer, structural roles for metal ions, metalloenzyme functions: hydrolytic enzymes, two-electron redox enzymes, multielectron pair redox enzymes, and rearrangements, communication roles for metals in biology, interactions of metal ions and nucleic acids, metal-ion transport and storage, and metals in medicine.

Reference No.-1, page no. 1 to 16

#### **Chapter-2: Concepts of Inorganic Chemistry in Bioinorganic Chemistry** (09 L)

Thermodynamic aspects:- HSAB concept, chelate effect and Irving-William series, pKa values of coordinated ligands, Tuning of redox potential, Biopolymer effects. Kinetic aspects:- Ligand exchange rate, Substitution reactions, Electron transfer reaction, Electronic and Geometric Structures of Metal Ions in Biology, Reactions of coordinated ligands, and Concept of spontaneous self-assembly model compounds.

# Reference No.-1, page no. 21 to 37 Module-II:

# **Module-II**

# [12 L + 3 T]

#### **Chapter-3: Control and Utilization of Metal-Ion Concentration in Cells** (07L)

Beneficial and toxic effects of metal ions, beneficial metal under tight regulation: (Iron): solubilisation, uptake and transport, metalloregulation of uptake and storage, the enzymes involved in mercury detoxification, metalloregulation of the mercury detoxification genes, The generation and uses of metalion-concentration gradients: the generation of ionic gradients, ion transport by ion channels, the acetylcholine receptor, and the voltage-gated sodium channel.

# Reference No.-1, page no. 139 to 162

# **Chapter-4: Biochemistry of following Elements**

- (a) Metals at the centre of Photosynthesis: Magnesium and Manganese
- (b) Electron Carriers: iron-sulphur proteins, blue copper proteins, and cytochromes.
- (c) Calcium-Binding Proteins: calmodulin and Ca in Blood coagulation

# Reference No.-2, Page no. 51 to 74 and 290, 184 to 192

# Reference No.-1, page no. 231 to 243

# **References:**

- 1. Principle of Bioinorganic Chemistry by S.J. Lippard and J. M. Berg
- 2. Bioinorganic Chemistry: Inorganic Elements in Chemistry of Life by W.Kaim and B. Schwederski

(08L)

3. Biological Inorganic Chemistry, 2<sup>nd</sup> edition, Robert R. Crichton

#### **Course Outcomes:**

At the end of course student should able to –

- CO-1: Define metalloproteins, metallo-eznymes, photosynthesis, HSAB concept, nucleic acids, metalloregulation, Biopolymer effects and acetylcholine receptor.
- CO-2: Explain chelate effect and Irving-William series, pKa values of coordinated ligands, Tuning of redox potential, and Reactions of coordinated ligands.
- CO-3: Describe Fe-S clusters, model compounds and spontaneous self-assembly, metals in medicine, blue copper proteins, and cytochromes, and Na/K pumps.
- CO-4: Express nitrogen fixation, detoxification of mercury, structure of RNA, cis-platin, amino acids, siderophore, and calmoduline zinc finger proteins.
- CO-5: Distinguish between hemoglobin and myoglobin, transferrin and ferritin, photosystem-I and photosystem-II.
- CO-6: Decide role of metals in biological system, medicine, blood coagulation, oxygen storage and transport, photosynthesis and uptake and transport of iron.

#### CHMAT-515: Chemistry Theory Paper-5 [2 Credits]

# **Title of the Paper: Rearrangement, Oxidation and Reduction reactions**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Rearrangements	10 L
2	Oxidizing Agent –I	05 L
3	Oxidizing Agent –II	05 L
4	Reducing agents	10 L
Module-I		[12 L + 3 T]

#### **Module-I**

# **Chapter-1: Rearrangements:**

Beckmann, Hofmann, Curtius, Schmidt, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacolpinacolone, Benzil-benzilic acid, Fries, Tiffeneau Demjanov, Claisen, Cope Rearrangement. Reference No.-1, page no. – Relevant pages

(10 L)

[12 L + 3 T]

(5 L)

(10 L)

#### Chapter-2: Oxidizing Agent –I

(5 L) Oxidising agents: CrO<sub>3</sub>, PDC, PCC, KMnO<sub>4</sub>, MnO<sub>2</sub>; Ref. 2 PP 1063 to 1069

#### **Module-II**

#### **Chapter-2: Oxidizing Agent –II**

Oxidising agents: CrO<sub>3</sub>, PDC, PCC, KMnO<sub>4</sub>, MnO<sub>2</sub>, Swern, SeO<sub>2</sub>, Pb(OAc)<sub>4</sub>, Pd-C, RuO<sub>4</sub>, OsO<sub>4</sub>, m-CPBA, O<sub>3</sub>,NaIO<sub>4</sub>, HIO<sub>4</sub>, TEMPO, IBX, CAN, Dess-Martin, DDQ, Ag<sub>2</sub>O. Reference No.-2, page no. 1070 to 1162

#### **Chapter-3: Reducing agents**

Boranes and hydroboration reactions, MPV reduction and reduction with H<sub>2</sub>/Pd-C, Raney-Ni, NaBH<sub>3</sub>CN, Willkinsons catalyst, DIBAL and Wolff-Kishner reduction, Birch, Clemenson, Dissolving metal. Reference No.-2, page no. 289 to 365

#### **References:**

- 1. Name Reactions, Jie Jack Li, Third Expanded Edition, Springer
- 2. Advanced Organic Chemistry (Part B) C. A. Carey and R. J. Sundberg (Fifth edition) Springer
- 3. Organic Chemistry-by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
- 4. Advanced Organic Chemistry, Jerry March, JOHN WILEY AND SONS.INC. 4<sup>th</sup> Edition.

#### Course Outcome: Student will able to

- **CO-1:** Learn the role of various reaction intermediates like carbocation, carbanion, carbenes, radicals, and nitrenes in rearrangement reactions.
- **CO-2:** Explain the mechanism involved in rearrangement reactions.
- **CO-3:** Justify the product formation in rearrangement reactions.

#### 14

**CO-4:** Appreciates the various steps involved in the molecular rearrangements.

**CO-5:** Understand the mechanism involved in oxidation and reduction reactions.

**CO-6:** Apply synthetic reagent of oxidation and reduction for solving the problems.

# CHMAP-516, Chemistry practical paper-1, [2-Credits]

# **Practical Chemistry –XI (Physical Chemistry Practical)**

- **Experiment-1**. Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method) (compulsory)
- **Part-I: Chemical Kinetics:** (Any three)
- **Experiment-**2. Kinetic decomposition of diacetone alcohol by dilatometry.
- **Experiment-**3. Determination of an order of a reaction.
- **Experiment-**4. Brönsted primary salt effect.
- Experiment-5. Kinetics of oxidation of ethanol by K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>
- Part-II: Non-Instrumental: (Any Three)
- **Experiment-**6. Determination of surface excess of amyl alcohol or TX-100 surfactant by Capillary rise method.
- **Experiment-**7. Determination of molecular weight by steam distillation.
- Experiment-8. Glycerol radius by viscosity.
- **Experiment-**9. Partial Molar Volume (Polynometry) Determination of the densities of a series of solutions and to calculate the molar volumes of the components.

#### **Part-III: Colorimetry and spectrophotometry (Any four experiments)**

- Experiment-10. Simultaneous determination of Ni(II) and Co(II) by spectrophotometry (Ref-1)
- Experiment-11. Simulations determination of KMnO4 and K2Cr2O7 by spectrophotometry.(Ref-7)
- **Experiment-**12. To study the adsorption of certain dyes such as methyl violet, picric acid or malachite green on charcoal. (Ref-2)
- **Experiment-**13. To determine the indicator constant of bromocresolpuple by half height method (Ref-8)
- Experiment-14. Estimation of Cu(II) by titration with Na2 EDTA by colorimetry
- **Experiment-**15. a. Determination of energy of n to  $\Pi^*$  transition in acetone and study of effect of solvent on energy of this transition by recording absorbance spectra in n-hexane and water. b. To study the effect of the extended conjugation on the  $\lambda$ max of p-nitro phenol by recording spectrum in acidic and alkaline medium (Ref-8).
- Part -IV: Radioactivity: (Any one)
- Experiment-16. Estimation of Mn in tea leaves by NAA.
- **Experiment-**17. Half-life of a radioactive nuclide and counting errors.

# **Experiment-**18. Determination of E-max of $\beta$ radiation and absorption coefficients in Al.

# **References:**

- 1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)
- 2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. Richett( Pergamon Press)
- 3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).
- 4. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
- 5. Physical chemistry by Wien (2001)
- 6. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut),
- 7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
- 8. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

# Course Outcome: Student will able to

**CO-1:** Prepare solution of required conc. And handle laboratory equipment property.

**CO-2**: Perform experiment accurately and able to perform calculation.

- **CO-3:** Explain experiment and principal of experiment in detail. **CO-4**: Write / discuss results and conclusions of the experiment.
- **CO-5:** Apply knowledge to a) design experiment for given aim or modify experiment to enhance results. b) to find out lacuna in experimental procedure.
- **CO-6**: Solve problem/ numerical depending on given data / information.

# CHMAP-517, Chemistry practical paper-2, [2-Credits]

# **Practical Chemistry –XII (Organic Chemistry Practical)**

**Experiment-1: Introduction to Laboratory Safety:** Meaning of safety signs on container of chemicals, safety handling of chemicals, MSDS sheets: Detailed explanation at least for 4 different types of substances (e.g. nitric acid, benzene, potassium dichromate, bromine, etc.), Handling of glassware's and care to be taken, handling of organic flammable as well as toxic solvents in laboratory, use of safety goggles, shoes and gloves, fire extinguisher and its use, action to be taken in accidental cases e.g. cleaning of acid spill over, use eye wash station and bath station in emergency, etc. (compulsory)

Experiment-2: Introduction to Green Chemistry (Compulsory; Ref-3 and 4)

Concept of green chemistry, twelve principals of green chemistry, applications of green chemistry for sustainable development, Atom economy, monitoring of reaction using TLC.

#### Any 8 experiments from 1 to 21 from following experiments

**Note:** Wherever necessary, 1) purification solids must be performed by crystallization or sublimation 2) TLC of products must be recorded 3) Wherever possible search frr green chemistry procedures for practical 1 to 16 and practice green chemistry methods for regular practicals.

# Part-I: classical organic synthesis (oxidation, reduction, nitration, N and O-acylation, condensation, etc).

Experiment-1: Alkene oxidation: preparation of adipic acid from cyclohexene Ref-1; pp-240

**Experiment-2:** Synthesis of an ether: preparation of  $\beta$ -naphthyl methyl ether Ref-1; pp-250

Experiment-3: Auto-oxidation-reduction of aromatic aldehydes: cannizzaro reaction Ref-1; pp-259

Experiment-4: Synthesis of  $\alpha$ ,  $\beta$ -unsaturated ketones: Claisen-Schmidt reaction Ref-1; pp-262

Experiment-5: Multistep synthesis of a drug: paracetamol Ref-1; pp-280

- Experiment-6: Hofmann rearrangement: synthesis of 2-aminobenzoic acid (anthranilic acid) Ref-1; pp-323
- Experiment-7: N-Heterocycle synthesis: producing benzo-triazol Ref-1; pp-336

Experiment-8: Synthesis of macrocycles: preparation of calix[4]pyrrole Ref-1; pp-338

- **Experiment-9:** Methylketone reactivity: acetophenone oxidation with sodium hypochlorite Ref-1; pp-380
- **Experiment-10:** Electrophilic aromatic substitution (SEAr): preparation of 4-methyl-3-nitroacetanilide from 4-methylaniline. Ref-1; Pp-382
- Experiment-11: Sandmeyer reaction: 2-iodobenzoic acid synthesis Ref-1; pp-385
- Experiment-12: Free-radical halogenation: 9-bromoanthracene preparation Ref-1; pp-389
- **Experiment-13:** Alkylbenzene oxidation: reactivity of alkyl groups in aromatic compounds with KMnO<sub>4</sub> Ref-1; pp-391

- **Experiment-14:** Reduction of a ketone alkaline solution: cyclohexanone reaction with NaBH<sub>4</sub> Ref-1; pp-439
- Experiment-15: Acylation of aromatic amines: obtention of acetanilide with acetic acid and Zn Ref-1; pp-425

Experiment-16: Thiamine-catalysed benzoin condensation (Ref-2; 657)

- **Experimen-**17: Preparation of triphenyl pyridine (ref-5, pp-366)
- **Experiment-**18: Reduction of vanilline using NaBH<sub>4</sub> (internet source PDF)
- **Experiment** 19: Reduction of Nitro compounds under mild condition. (Ref: Chemical papes, 66, 8, 772-778, 2012)
- Experiment 20: Reduction of Nitro compounds under mild condition using Zn-Hydrazine. (Ref: Indian journal of chemistry, Vol42-B, 2003, 180-183)

Experiment-21: Benzoin reduction by NaBH<sub>4</sub> (internet source PDF).

#### Part-II: Green Chemistry Experiments (any two) (Ref-3 and 4)

Experiment-17: Preparation of Schiff's bases in aqueous medium.

Experiment-18: Preparation of dihydropyrimidinone under solvent free conditions

**Experiment-19:** Preparation of acetanilide from aniline and acetic acid using Zn dust

#### **References:**

- Reference-1: Experimental Organic Chemistry, Laboratory Manual; Joaquín Isac-García, José A. Dobado, Francisco G. Calvo-Flores, Henar Martínez-García, Academic Press is an imprint of Elsevier.
- Reference-2: Macroscale and Microscale Organic Experiments, Kenneth L. Williamson, Katherine M. Masters, Cengage Learning.
- Reference-3: Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
- Reference-4: Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST.
- Reference-5: A Microscale Approach to Organic Laboratory Techniques, SIXTH EDITION, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Randall G. Engel, Cengage Learning

#### **Course Outcome: Student will able to**

- CO-1: Learn safety techniques and handling of chemicals.
- CO-2: Purify organic compounds by techniques like recrystallization and sublimation
- CO-3: Ccarrying out different types of reactions and their workup methods.
- CO-4: Understand the green chemistry and role of green chemistry in pollution reduction.
- CO-5: Avoid solvents and do solvent free reaction.

CO-6: Also the work-up procedure in many experiments is made more eco-friendly to environment.

#### CHMAET-511-A, Elective Chemistry theory paper-6-A [2 Credits]

# **Title of the Paper: Solid State Chemistry**

Chapter No. Name of the Chapter		Lectures Assigned	
1	Bonding in Solids and Electronic	05 L	
	Properties		
2	Defects and Non-Stoichiometry	07 L	
3	Superconductivity	04 L	
4	Synthesis of Solids	08 L	
1. Bonding in Solids and Electronic Properties (Ref-1, 4) (05 L)			

1. Bonding in Solids and Electronic Properties (Ref-1, 4)

Recollect the concepts: Crystalline solids, unit cell, and types of unit cells

Introduction, Bonding in Solids-Free Electron Theory, Electronic Conductivity, Bonding In Solids-Molecular Orbital Theory, Simple Metals, Semiconductors-Si And Ge, Photoconductivity, The P-N Junction—Field-Effect Transistors, Bands In Compounds—Gallium Arsenide, Bands In D-Block Compounds—Transition Metal Monoxides.

#### 2. Defects and Non-Stoichiometry (Ref-1, 4)

Introduction, point defects—an introduction, defects and their concentration, intrinsic defects, extrinsic defects the concentration of defects, ionic conductivity in solids, solid electrolytes, fast-ion conductors: oxygen ion conductors, fast-ion conductors: sodium ion conductors, Applications: 1) fuel cells, 2) sensors, 3) electrochromic devices, non-stoichiometric compounds, introduction, non-stoichiometry in wustite, the titanium monoxide structure.

#### 3. Superconductivity (Ref-1, 4)

Introduction, Discovery, The Magnetic Properties Of Superconductors, Josephson Effects, The Bcs Theory Of Superconductivity, High Temperature Superconductors, Theory Of High Tc Superconductors, Uses Of High Temperature Superconductors

#### 4. Synthesis of Solids (Ref-2 and 3)

Introduction, Common Reactions Employed in Synthesis, Soft-Chemistry Routes, Ceramic Methods, Decomposition of Precursor Compounds, Combustion Synthesis, Mechano-chemical and Sono-chemical methods, Soft Chemistry Routes(Ion Exchange Reactions, Use of Fluxes, Sol–Gel Synthesis, Electrochemical Methods, Hydrothermal, Solvothermal and Ionothermal Synthesis), Chemical Vapour Deposition and Atomic Layer Deposition, Procedures of synthesis of some nano-materials- Gold and Silver nanoparticles, CdS nanoparticles, ZnO, TiO<sub>2</sub> and Fe<sub>2</sub>O<sub>3</sub> nanoparticles and Porous Silica

#### References

Ref.-1: Elaine A. Moore, Lesley E. Smart - Solid State Chemistry - an Introduction. Third Ed. / Fourth Ed. CRC Press (2012)

Ref-2: C. N. R. Rao, Kanishka Biswas, Essentials of inorganic materials synthesis, Wiley, 2015

Ref-3: Nanotechnology: Principles and Practices, S. K. Kulkarni, Third Ed. Springer

Ref-4: Anthony R. West, Solid State Chemistry and its Applications Second Edition (Student Edition), Wiley.

#### **Course outcomes:**

At the end of course student will learn

**CO-1**. Bonding in solids – band theory

CO-2. Electronic conductivity

CO-3. Semiconductors, photoconductivity

CO-4. Non-stoichiometry, defects and types of defects in solids

**CO-5**. Ionic conductivity and their applications

CO-6. Superconductivity and theory of superconductivity

# CHMAET-512-A, Elective Chemistry theory paper-6-A,

# **Title of the Paper: Nuclear Chemistry**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Radioactivity	04 L
2	Elements of Radiation	06 L
3	Determination of Radioactivity	04 L
4	Nuclear Fission:	06 L
5	Applications of Radioactivity	09 L

#### **Department of Chemistry**

#### (07 L)

(04 L)

(08L)

#### CBCS Syllabus Under NEP-2020 M. Sc. –I (Analytical Chemistry)

# Module-1

#### **Chapter-1: Radioactivity**

Types of radioactive decay, general characteristics of radioactive decay, decay kinetics, general expression for the activity of a daughter nuclide, Geiger- Nuttalis law, α-decay: A problem in classical physics, Internal conversion and the Auger effect. Referenc-1: Relevant pages

#### **Chapter-2: Elements of Radiation**

Chemistry: Interaction of radiation with matter, interaction of y radiation with matter, units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radicals in water radiolysis, Radiolysis of some aqueous solutions. Referenc-1: Relevant pages

#### **Chapter-3: Determination of Radioactivity**

Ionization Counters: Introduction, Ionization Counter, General Design of an Ionization Chamber, Current-Voltage Characteristics of the Ionization Chamber, Nature of Gas to be used in Ionization Chamber, Regions Suitable for Counting Purposes, and Pulses Due to α- and β-Particles, Relationship between Energy of Radiation and Pulse Height, Ionization Counters; Geiger-Müller Counter: Design of the End-Window G.M. Counter, Principle of a G.M. Counter, Liquid Geiger-Müller Counter Liquid Geiger-Müller Counter, The Assembly of the Liquid G.M. Counter, Thickness of the Window and Density Correction, Necessary Precautions While Using Liquid G.M. Counter, Current-Voltage Characteristics of the G.M. Counter, Dead Time of Geiger-Müller Counter, Chemically Quenched G.M. Counter, Organic Gas Quenched G.M. Counter, Limitations of Ionization Counters. Refence-2: 53 to 93 (relent part only)

#### **Module-2**

#### **Chapter-4: Nuclear Fission**:

The discovery of nuclear fission, the process of nuclear fission, fission fragments and their mass distribution, charge distribution, Ionic charge of fission fragments, fission energy, fission cross-section and threshold, fission neutrons, theory of nuclear fission, Neutron evaporation and spallation. Referenc-1: Relevant pages

#### **Chapter-5: Applications of Radioactivity**

Typical reaction involved in the preparation of radioisotopes, The Szillard- Chalmers reaction, Radiochemical principles in the use of tracers, Isotopes in elucidating reaction mechanism and structure determination, physic-chemical research - The solubility of a sparingly soluble substances, surface area of a powder or precipitate rates of diffusion, Analytical applications- Isotope dilution analysis, Neutron activation analysis, Radiometric titrations, Medical applications-Thyroiditis, Assessing the volume of blood in a patient, Industrial applications thickness measurements and control, friction and wear out, gamma radiography. *Referenc-1:* Relevant pages

#### **References:**

Referenc-1: Elements of Nuclear Chemistry by H.J.Arnikar, CBS Publisher

Referenc-2: Nuclear Chemistry, Second Edition, Maheshwar Sharon, Madhuri Sharon, Springer

#### Course Outcomes: At the end of course student should able to -

- **CO-1**: Define and discuss the various terms in nuclear chemistry as in syllabus.
- **CO-2**: Can evaluate / demonstrate decay kinetics of a particular nuclear reaction, age of particular sample from data, use of radioactivity in different fields of chemistry, etc.
- **CO-3**: Explain different types of nuclear reactions and their mechanism.
- **CO-4**: Differentiates / compare/ relate among or between various terms in nuclear chemistry as in syllabus, such as different types of decay, methods of measurement of radioactivity, types of nuclides, types of nuclear reactions, ion pair behavior in electrical field, Nuclear fission and fusion, application of particular isotope in tracer application, etc.

[06 L]

[04 L]

**Department of Chemistry** 

# 19

# [09 L]

[12 L + 3 T]

[06 L]

# [04 L]

#### CBCS Syllabus Under NEP-2020 M. Sc. –I (Analytical Chemistry)

- **CO-5**: Apply knowledge of radioactivity in different fields of chemistry such as structure of molecule, mechanism of reaction, determination of age of sample such as rock, wood/fossil, water, and in medicine.
- CO-6: Solve problem/ numerical depending on given experimental data.

# CHMAEP-512B-Elective Chemistry practical paper-7-B [2 Credits]

# **Chemistry Practical-III-A (Inorganic Chemistry Practical)**

Part-I: Analysis (at least two of the following) (Ref. -1)

Experiment-1. Determination of Silica and Manganese from pyrolusite ore.

- **Experiment-**2. Determination of Aluminum and Silica from Bauxite ore.
- **Experiment-**3. Determination of silica and iron from hematite ore.
- **Experiment-**4. Determination of copper and iron from Chalcopyrite ore.

# Part-II: Alloy Analysis (at least two of the following) (Ref. -1)

- **Experiment-5**. Determination of tin and lead from solder alloy.
- **Experiment-**6. Determination of iron and chromium from stainless steel alloy.
- **Experiment-**7. Determination of copper and nickel from cupranickel alloy.
- Part-III: Synthesis of solid state materials / nano-materials (any three) (Ref- 2 and 3)
- **Experiment-**8. Synthesis of ZnO from zinc oxalate precursor method and determine band gap by absorption spectroscopy
- **Experiment-**9. Synthesis of TiO<sub>2</sub> TiCl<sub>4</sub> or Ti-Isopropoxide by Sol-gel method and determine band gap by absorption spectroscopy
- **Experiment-**10. Synthesis of Colloidal silver nanoparticles and determine band gap by absorption spectroscopy
- **Experiment-**11. Synthesis of Fe<sub>2</sub>O<sub>3</sub> nanoparticles sol-gel/coprecipitation/hydrothermal (any one method)
- **Experiment-**12. ZnO, TiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub> nanoparticles powder XRD, SEM, TEM (at least one spectral analysis should be done)
- **Part-IV: Applications of Solid State Materials**
- Experiment-13. Removal and kinetics of photocatalytic dyes, degradation (methylene blue) by ZnO TiO<sub>2</sub> photocatalysis (Ref-2)

Experiment-14. Study of adsorption of phosphate ion on alfa-Fe2O3 (Ref-2)

# **References:**

- 1. Text book of Quantitative Analysis by A.I. Vogel 3ededn (1963).
- 2. Experimental Inorganic Chemistry by Mounir A. Malati, Horwood
- 3. Nanotechnology by S. K. Kulkarni

# Course Outcome: Student will able to

- **CO-1:** Prepare solution of required conc. And handle laboratory equipment property.
- **CO-2**: Perform experiment accurately and able to perform calculation.
- **CO-3:** Explain experiment and principal of experiment in detail.
- CO-4: Write / discuss results and conclusions of the experiment.
- **CO-5:** Apply knowledge to a) design experiment for given aim or modify experiment to enhance results. b) to find out lacuna in experimental procedure.
- CO-6: Solve problem/ numerical depending on given data / information.

# M. Sc-I, Semester-II

M. Sc. –I (Analytical Chemistry)

# CHMAT-521, Chemistry Theory Paper-1 [2-Credits]

# **Title of the Paper: Quantum Chemistry and Bonding Theories**

Chapter No.	Name of the Chapter	Lectures Assigned
1	The origins of quantum mechanics	03 L
2	The particle in a box [transitional	03 L
	motion	
3	Operators	05 L
4	The harmonic Oscillator [Vibrational	04 L
	Motion]	
5	The Hydrogen Atom	04 L
6	Electronic Structure of Diatomic	03 L
	Molecule	
7	Molecular Orbital Theory: The	02 L
	hydrogen Molecule ion	
8	Molecular Orbital Theory:	02 L
	Homonuclear Diatomic Molecules	
9	Molecular Orbital Theory: Hetero-	02 L
	nuclear Diatomic Molecules	
10	Molecular Orbital Theory: Polyatomic	02 L
	molecules	
Module-1		[12 L + 3 T]

#### **Chapter-1: The origins of quantum mechanics**

CBCS Syllabus Under NEP-2020

Quantum chemistry, historical background of quantum mechanics, Heisenberg's uncertainty Principle, Energy Quantization, (Black-body radiation, Heat capacity, Atomic and molecular spectra) Waveparticle duality (The particle character of electromagnetic radiation, The wave character of particles), Wavefunctions: The time dependent Schrödinger equation, The time independent Schrödinger equation, Probability, Complex Numbers, units. *Reference-1: pp-1 to 18*.

# **Chapter-2: The particle in a box [transitional motion]**

Differential equations, Particle in a one-dimensional box, The free particle in a one dimension, Particle in a rectangular well, Tunnelling, Reference-1: pp-21 to 32

# **Chapter-3: Operators**

Operators, Eigenfunctions and Eigenvalues, Operators and quantum mechanics, The three-dimensional many particle Schrödinger equation, The particle in a three-dimensional box, Degeneracy, Average values, Requirement for an acceptable wave function. Reference-1: pp-35 to 58

#### **Chapter-4: The harmonic Oscillator [Vibrational Motion]** [4 L]

The one-dimensional Harmonic oscillator (classical mechanical treatment, quantum mechanical treatment, Even and Odd functions, the harmonic Oscillator wave functions,), Vibration of molecules, Reference-1: pp-62 to 77

# **Module-2**

# **Chapter-5: The Hydrogen Atom**

The hydrogen atom, solution of the radial equation, Degeneracy, The bound state hydrogen atom wave functions (radial factor, Ground state wave function and energy, wave function for n=2, the radial distribution function, the radial hydrogen like functions, hydrogen like orbitals, the Zeeman effect, Reference-1: pp-134 to 156; The Pauli Exclusion principle, Hund's Rule: Reference-2: relevant pages

# [12 L + 3 T]

[4 L]

[3 L]

[3 L]

[5 L]

# CBCS Syllabus Under NEP-2020M. Sc. –I (Analytical Chemistry)DepaChapter-6: Electronic Structure of Diatomic Molecule[3 L]

The Born-Oppenheimer Approximation, Valence bond Theory (diatomic molecules, polyatomic molecules, promotion, hybridization, *Referenc-2: pp- 343 to 350*.

# Chapter-7: Molecular Orbital Theory: The hydrogen Molecule ion [2 L]

Introduction, Linear combination of atomic orbitals (the construction of linear combinations, bonding orbitals, Antibonding orbitals, Orbital Notations. *Referenc-2*: pp-351 to 356

# Chapter-8: Molecular Orbital Theory: Homonuclear Diatomic Molecules [2 L]

Introduction, Electronic configuration, sigma and pi orbitals, the bond overlap integral, period-2 diatomic molecules, MO energy level diagram, [MO energy level diagram electronic configuration bond orders and magnetic properties homo-diatomic molecules of H to F elements i.e. second period elements for Students self-study], Photoelectron spectroscopy. **Referenc-2**: pp-357 to 363.

# Chapter-9: Molecular Orbital Theory: Hetero-nuclear Diatomic Molecules [2 L]

Introduction, Polar bond and electronegativity, the variation principle, the procedure, the features of the solution, [MO energy level diagram electronic configuration bond orders and magnetic properties homo-diatomic molecules of HF, CO and NO for Students self-study] **Referenc-2**: pp-359-370.

Chapter-10: Molecular Orbital Theory: Polyatomic molecules[2 L]Introduction, The Huckel approximation (an introduction to method, the matrix formulation of the<br/>method, finding molecular orbitals by matrix diagonalization, Applications: pi-electron binding energy,<br/>aromatic stability. *Referenc-2: pp-371 to 377.* 

**Referenc-1:** Quantum Chemistry, Ira Levine, 5<sup>th</sup> Ed. Prentice Hall.

Referenc-2: Atkins Physical Chemistry, Peter Atkins, Julio de Paula James Keeler, 11th Ed. Oxford.

#### Course Outcome: Student will able to

CO-1: Define and discuss the various terms in quantum chemistry as in syllabus.

- CO-2: Derive equation in quantum chemistry such energy particle 1D box, 3D box, LCAO for diatomic molecule, orbital function, etc.
- CO-3: Explain application of LCAO method in deriving different molecular orbitals and formation of simple molecules. Explain different types of operators and their use in quantum chemistry calculations.
- CO-4: Differentiates / compare/ relate among or between various terms in quantum chemistry as in syllabus.
- CO-5: Apply knowledge of quantum chemistry to the formation of simple homo and hetero diatomic molecules. Construction of the MO energy level diagram.
- CO-6: Solve problem/ numerical depending on given data / information.

# CHMAT-522, Chemistry Theory Paper-2 [2-Credits]

# **Title of the Paper: Ligand Field Theory of coordination Compounds**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Concept and Scope of Ligand Fields	05 L
2	Ligand Field Theory of Coordination	10 L
	Complexes	
3	Electronic spectra of Transition Metal	10 L
	Complexes	
4	Magnetic Properties of Coordination	05 L
	Complexes	

#### Module-I:

#### [12 L + 3T]

#### **Chapter-1: Concept and Scope of Ligand Fields:**

Quantum numbers, Free ion Configuration, Terms and States, Energy levels of transition metal ions, free ion terms, microstates, term wave functions, spin-orbits coupling.

(05 L)

# Chapter-2: Ligand Field Theory of Coordination Complexes (10L)

Effect of ligand field on energy levels of transition metal ions, weak cubic ligand field effect on Russell-Saunders terms, Orgel diagrams, strong field effect, correlation diagrams, Tanabe-Sugano Diagrams, Spin-Pairing energies.

# Module-II

#### [12L + 3T]

#### Chapter-3: Electronic spectra of Transition Metal Complexes

Introduction, band intensities, band energies, band width and shapes, transition metal spectra of 1st, 2ndand 3 rd row ions and complexes, electronic spectra of Lanthanide and Actinide, spectro-chemical and nephelauxetic series, charge transfer and luminescence spectra, calculations of Dq, B,  $\beta$  parameters, percentage of covalent character for metal complexes.

#### Chapter-4: Magnetic Properties of Coordination Complexes (05 L)

Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of complexes-Para magnetism, 1stand 2<sup>nd</sup> Ordered Zeeman effect ,quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E and T ground terms in complexes, spin free and spin paired equilibria, temperature dependence of magnetism.

# **References:**

- 1. Ligand field theory and its applications by B.N. Figgis and M.A. Hitachman
- 2. Symmetry and spectroscopy of molecules by K. Veera Reddy
- 3. Elements of Magneto-Chemistry by R. L. Datta and A. Syamal

Course Outcomes: At the end of course student should able to -

- **CO-1:** Define R. S. term, configuration, microstate, paramagnetic, diamagnetic ferromagnetic, antiferromagnetic, Curie and Neel temperature.
- **CO-2**: Identify complex ions showing same R.S. terms, degeneracy of ground state terms of metal ions, and spin multiplicities of different configurations.
- **CO-3**: Interpret electronic spectra for spin allowed Oh and Td complexes using Orgel diagram, Magnetic properties of A, E and T ground terms in complexes and selection rules.
- **CO-4**: Calculate frequencies of absorption spectrum, 10Dq, Racah and nepholauxetic parameter for a complex, and magnetic moments of complexes
- **CO-5**: Construct microstate table for various configuration and prepare correlations diagram and Tanabe-Sugano diagram for various configurations in Td an Oh ligand field.

**CO-6**: Assess appropriate full spectroscopic terms for various configuration/ion/term.

# CHMAT-523, Chemistry Theory Paper-3, [2-Credits]

# **Title of the Paper: Theoretical Basis of Molecular Spectroscopy**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Introduction	02 L
2	Microwave Spectroscopy	04 L
3	Infra-red Spectroscopy	06 L
4	Raman Spectroscopy	05 L
5	Electronic Spectroscopy of molecules	08 L
6	Spin Resonance Spectroscopy	07 L

#### Module-1

# [12 L + 3 T]

#### **Chapter-1: Introduction**

Characterization of Electromagnetic Radiation, The Quantization of Energy, Regions of the Spectrum, Representation of Spectra *Reference-1*; pp 1-13

[2 L]

(10 L)

# **Chapter-2: Microwave Spectroscopy**

**Chapter-3: Infra-red Spectroscopy** 

The Rotation of Molecules, Rotational Spectra, Diatomic Molecules, Polyatomic Molecules, Techniques and Instrumentation, Chemical Analysis by Microwave Spectroscopy. *Reference-1; pp 31-52* 

The Vibrating Diatomic Molecule, The Diatomic Vibrating Rotator, The Vibration-Rotation Spectrum of Carbon Monoxide, Breakdown of the Born-Oppenheimer Approximation: The Interaction of Rotations and Vibrations, The Vibrations of Polyatomic Molecules, The Influence of Rotation on the Spectra of Polyatomic Molecules, Analysis by Infra-red Techniques, Techniques and Instrumentation. *Reference-1*; pp 55-98

#### **Chapter-4: Raman Spectroscopy**

Introduction, Pure Rotational Raman Spectra, Vibrational Raman Spectra, Polarization of Light and the Raman Effect, Structure Determination from Raman and Infra-red spectroscopy, Techniques and Instrumentation, Near Infra-red FT-Raman Spectroscopy; *Reference-1*; pp 100-125

#### Module-2

# **Chapter-5: Electronic Spectroscopy of molecules**

Electronic Spectra of Diatomic Molecules, Electronic Structure of Diatomic Molecules, Electronic Spectra of Polyatomic Molecules, Instrumentation, Molecular Photoelectron Spectroscopy. *Reference-1*; pp 162-197

# **Chapter-6: Spin Resonance Spectroscopy**

Spin and an Applied Field, Nuclear Magnetic Resonance Spectroscopy: Hydrogen Nuclei, Nuclear Magnetic Resonance Spectroscopy: Nuclei Other Than Hydrogen, Techniques and Instrumentation; *Reference-1*; pp 199-142.

- Reference-1: Fundamentals of Molecular Spectroscopy, Fourth Edition, Colin N. Banwell, Elaine M. McCash, The McGraw-Hill Companies
- Reference-2: Fundamentals of Molecular Spectroscopy, Walter S. Struve, Wiley A Wiley-Interscience Publication John Wiley & Sons

Course Outcomes: At the end of course student should able to –

- CO-1: Define and discuss the terms in molecular spectroscopy-IR spectroscopy, microwaves spectroscopy, Raman spectroscopy, ESR spectroscopy.
- CO-2: Can evaluate molecular characteristics of simple molecule from IR, microwave, electron and Raman spectra.
- CO-3: Explain /discuss spectroscopic parameters of molecules in , IR, microwave, Raman, electron and ESR spectroscopy.
- CO-4: Differentiates / compare/ relate among or between types of spectroscopy and their applications, mechanism of molecular excitation in different types of spectroscopy, selection rules, types of electromagnetic radiations and their interaction with matter.
- CO-5: Investigate characteristics of known molecules from different types of spectroscopic techniques.
- **CO-6:** Apply molecular spectroscopy knowledge to identify molecule.

#### Department of Chemistry (04 L)

# (06 L)

# (05 L)

[12 L + 3 T]

# (07 L)

(08 L)

#### CBCS Syllabus Under NEP-2020 M. Sc. –I (Analytical Chemistry) CHMAT-524, Chemistry Theory Paper-4,

# **Title of the Paper: Advanced Organic Molecular Spectroscopic Characterizations**

Chapter No.	Name of the Chapter	Lectures Assigned
1	UV Spectroscopy	03 L
2	IR Spectroscopy	03 L
3	<sup>1</sup> H-NMR Spectroscopy-I	09 L
4	<sup>1</sup> H-NMR Spectroscopy-II	03 L
5	<sup>13</sup> C-NMR Spectroscopy	05 L
6	Mass spectrometry (MS)	05L
7	Combined problems:	02 L

#### **Module-1**

#### **Chapter-1: UV Spectroscopy**

UV: Recapitulation of UV spectroscopy, Calculations of  $\lambda$  Max of diene, enone and Aromatic compounds, Applications of UV Spectroscopy. Ref. 1 PP 353

#### **Chapter-2: IR Spectroscopy**

Principle, IR spectra of important functional groups, Factor affecting on IR stretching frequencies. Ref. 1 PP 13

#### Chapter-3: <sup>1</sup>H-NMR Spectroscopy-I

Understanding of basic principle, chemical and magnetic non-equivalence, Homotopism, Enantiotopism, diastereotopism, chemical shifts and factors influencing chemical shift: electronegativity, NMR solvent polarity, temperature, anisotropic effect, chemical shifts of acidic protons, D<sub>2</sub>O exchange,

# Module-2

# Chapter-4: <sup>1</sup>H-NMR Spectroscopy-II

Multiplicity patterns and Coupling Constants: Pascal's triangle, understanding of tree diagram, complex splitting patterns in aromatic, vinylic, saturated monocyclic compounds, bicyclic compounds (fused and bridged rings), Integration: NMR of racemic mixture, relationship between integration and ee % in diasterotomers. Ref. 1 PP 102

### Chapter-5: <sup>13</sup>C-NMR Spectroscopy

Basic of <sup>13</sup>C-NMR: Chemical shift and factors affecting chemical shifts in 13C NMR, off resoanance and proton decoupled spectra. Simple problems on <sup>13</sup>C-NMR. Ref. 1 PP 167

# **Chapter-6: Mass spectrometry (MS)**

Basic principle of MS, significance of M+(m/z) in determination of molecular formula, Rule of 13. Genesis of m/z fragments: alkanes (cyclic and acyclic), alcohols, amines. Ref. 1 PP 390

# **Chapter-7: Combined problems:**

Problems based on UV, IR, MS, <sup>1</sup>H-NMR, <sup>13</sup>C-NMR. Ref. 1 PP 466

# **References:**

- 1. Introduction to Spectroscopy, Donald L. Pavia and Gary M. Lampman.
- 2. Elementary Organic Spectroscopy, Y. R. Sharma, S. Chand & Company PVT. LTD.

# [12 L + 3 T]

# (3L)

# (05 L)

# (05 L)

**Department of Chemistry** 

# [2-Credits]

# (02 L)

# [12 L + 3 T]

(03 L)

(03 L)

(9 L)

- 3. Organic Structures from Spectra, L. D. Field, S. Sternhell, J. R. Kalman, Fourth edition, JOHN WILEY AND SONS. LTD.
- 4. Guide to Spectroscopic Identification of Organic Compounds, Karen Feinstein.
- 5. Applications of NMR Spectroscopy, Atta-ur-Rahman, M. Iqbal Choudhar.

#### **Course Outcome:**

### Student will able to

- **CO-1:** Calculate  $\lambda$  max of organic compounds containing more than one and less than four conjugated systems and aromatic compounds.
- **CO-2:** Correlate IR bands with functional groups using numerical data as well as spectral data.
- **CO-3:** Solve <sup>1</sup>H-NMR problems.
- **CO-4:** Draw the <sup>1</sup>H-NMR spectrum for simple organic compounds mentioning multiplicity pattern and coupling constant with the help of "Tree Diagram" and able to predict and analyze the multiplicity patterns with more than one coupling constants.
- **CO-5:** Use <sup>13</sup>C-NMR data to interpret the structure.
- CO-6: Understand the basic principle of spectroscopic methods and their applications in structure elucidation of organic compounds using given spectroscopic data or spectra.

# CHMAT-525; Chemistry theory paper-5

# **Title of the Paper: Photochemistry and Pericyclic Reactions**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Photochemistry	15 L
2	Pericyclic Reactions	15 L
Module-1		[12 L + 3 T]
Photochemistry		(15 L)

#### Photochemistry

Principles of Photochemistry, photochemistry of carbonyl compounds, alkenes, dienes, and aromatic compounds, photo rearrangements, Barton reaction. Ref. 1; relevant pages

# **Module-2**

#### **Pericyclic Reactions**

Electrocyclic reactions, Cycloaddition reactions, Analysis by correlation diagrams, FMO approach, sigmatropic and ene reactions, 1,3-dipolar additions. Ref. 2 PP 663 to 740

# **References:**

- 1. Introduction To Organic Photochemistry, J. D. Coyle -Wiley (1991)
- 2. Advanced Organic Chemistry, Jagdamba Singh, L. D. S. Yadav, Pragati Prakashan, 20<sup>th</sup> edition (2014)
- 3. Excited states in Organic Chemistry by J.A. Barltrop and J.D.Coyle
- 4. Organic photochemistry: A visual approach by Jan Kopecky
- 5. Pericyclic Reactions, Ian Fleming
- 6. Pericyclic Reactions by A Mechanistic and Problem-Solving Approach, Sunil Kumar Vinod Kumar S.P. Singh
- 7. The Conservation of Orbital symmetry, R. B. Woodward and Roald Hoffmann, Angew. Chem. Internat. Edit. 1 Vol. 8 (1969) 1 No. 11, 781-932.
- 8. Pericyclic Reactions, S. Shankar Raman (Text Book)

### **Course Outcome:**

Student will able to

- **CO-1:** Understand Photochemical excitations in molecule
- **CO-2:** Explain different photochemical reactions
- **CO-3:** Discuss stability and reactivity, the stereochemistry as well as to understand the preferred reaction pathways.

# [12 L + 3 T]

# (15 L)

[2-Credits]

- **CO-4:** Predict the probable reaction mechanisms.
- CO-5: Write MO diagram for various olefinic compounds and able to predict the products
- **CO-6:** Extend the knowledge of pericyclic reactions in predicting reaction mechanism and stereochemistry of pericyclic reactions

# CHMAP-526, Chemistry practical paper-1, [2-Credits]

# **Practical Chemistry –XI (Inorganic Chemistry Practical)**

#### Part-I: Synthesis of coordination complexes (any three) (Ref. 2)

- Experiment-1. Synthesis and Purity of [Mn(acac)<sub>3</sub>]
- Experiment-2. Synthesis and Purity Chloropentaamminecobalt(III) chloride.
- Experiment-3. Synthesis and Purity Nitro pentaamminecobalt(III) chloride.
- Experiment-4. Synthesis and Purity Bis[TrisCu(I)thiourea]

#### Part-II: Inorganic Conductometry (any two)

- Experiment-4. Structural determination of metal complexes by conductometric measurement. (Ref-3)
- **Experiment-5**. To study complex formation between Fe(III) with sulfosalicylic acid by conductometry (Ref-3).
- **Experiment-**6. To verify the Debye Huckel theory of ionic conductance for strong electrolytes KCl, BaCl<sub>2</sub>, K<sub>2</sub>SO<sub>4</sub> and [K<sub>3</sub>Fe(CN)<sub>6</sub>] (Ref-3)
- Experiment-7. Determination of Pb(II) in solution with Na<sub>2</sub>SO<sub>4</sub> solution and determination of solubility product of PbSO<sub>4</sub> (Ref-4)

#### Part-III: Inorganic characterization techniques (any two of the following)

- **Experiment-8**. Determination of equilibrium constant of M L systems Fe(III)–Sulphosalicylic acid or Fe(III)– $\beta$ –resorcilic acid by Job's continuous variation method. (Ref.-3, 5)
- **Experiment-9**. Solution state preparation of [Ni(en)<sub>3</sub>]S<sub>2</sub>O<sub>3</sub>, [Ni(H<sub>2</sub>O)<sub>6</sub>]Cl<sub>2</sub>, [Ni(NH<sub>3</sub>)<sub>6</sub>]Cl<sub>2</sub>. Record absorption spectra in solution of all three complexes and calculate 10 Dq. Arrange three ligands according to their increasing strength depending on your observations. (Ref. -5)
- **Experiment-**10. Determination of magnetic susceptibility ( $\chi g$  and  $\chi m$ ) of mercury tetracyanato cobalt or Fe(acac)<sub>3</sub> or Ferrous ammonium sulfate by Faraday or Gouy method. (Ref. -3, 5)

# Part-IV: Inorganic Kinetics Experiment (any two)

- Experiment-11. Synthesis and photochemistry of K<sub>3</sub>[Fe(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>].3H<sub>2</sub>O. (Ref-4)
- **Experiment-12**. Kinetics of substitution reaction of  $[Fe(Phen)_3]^{2+}$  (Ref-3)
- **Experiment-**13. Kinetics of formation of Cr(III)-EDTA complex (Ref-3)

#### **Part-V: Ion – Exchange Chromatography (Ref. -1 and 3)**

**Experiment-**14. Separation of mixture of Zn(II) and Mg(II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn(II) and Mg(II)

#### Part-VI: Solvent Extraction and colorimetric (any one experiment) (Ref. -1 and 3)

Experiment-15. Determination of Cu(II) by solvent extraction as Dithiocarbamate complex (Ref-1)

Experiment-16. Determination of iron by solvent extraction techniques in a mixture of Fe(III) +Al(III)

or Fe(III) + Ni(III) using 8-hydroxyl-quinoline reagent. (Ref. -1)

# **References:**

- 1. Vogel's Textbook of Inorganic quantitative analysis
- 2. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.
- 3. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
- 4. General Chemistry Experiments, Anil. J Elias, University Press (2002)
- 5. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

# Course Outcome: Student will able to

**CO-1**: Define coordination complex, cell constant, resistance, specific conductance, equilibrium constant, absorbance, beers law, solubility product, chromatography, etc.

- **CO-2**: Discuss photochemistry of potassium trioxalatoferrate complex, kinetics of formation of Cr(III)-EDTA, Determination of Cu(II) and Fen(II) by solvent extraction technique.
- **CO-3**: Outline the flow-chart for synthesis of [Mn(acac)3], Chloropentaamminecobalt(III) chloride, Nitro pentaamminecobalt(III) chloride, Bis[TrisCu(I)thiourea complexes.
- **CO-4**: Estimate purity of the [Mn(acac)3], Chloropentaamminecobalt(III) chloride, Nitro pentaamminecobalt(III) chloride, Bis[TrisCu(I)thiourea complexes.
- **CO-5**: Determine equilibrium constant of M L systems Fe(III)–Sulphosalicylic acid, magnetic susceptibility ( $\chi g$  and  $\chi m$ ) of mercury tetracyanato cobalt or Fe(acac) and magnetic susceptibility ( $\chi g$  and  $\chi m$ ) of mercury tetracyanato cobalt or Fe(acac).
- **CO-6**: Calculate the quantity from observation of the experiments and Interpret the result obtained respective experiments.

# CHMAP-527, Chemistry practical paper-2, [2-Credits]

# Practical Chemistry –XII (Organic Chemistry Practical)

# Perform any 12 experiments

Experiment-1. Base catalyzed aldol condensation using LiOH.H<sub>2</sub>O as a Catalyst.

Experiment-2. Bromination of trans-stilbene using sodium bromide and sodium bromate

Experiment-3. [4+2] cycloaddition reaction in aqueous medium at room temperature

Experiment-4. Benzil Benzilic acid rearrangement under solvent free condition

**Experiment-5**. Clay catalyzed solid state synthesis of 7-hydroxy-4-methylcoumarin

**Experiment-**6. Ecofriendly nitration of phenols and its derivatives using Calcium nitrate

Experiment-7. Bromination of acetanilide using ceric ammonium nitrate in aqueous medium

**Experiment-**8. Green approach for preparation of benzopinacolone from bezopinacol using iodine catalyst,

**Experiment-**9. Preparation of 1, 1-bis-2-naphthol under grinding at room temperature.

**Experiment-**10. Solvent free aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone **Experiment-**11. Preparation of azalactone from hippuric acid

**Experiment-**12. Preparation of thioamide from benzaldehyde in water.

**Note:** Students should perform a) Relevant chemical analysis. b) Column chromatography. c) Elemental analysis. d) Spectroscopic interpretation. e) How to draw schemes and mechanism using Chem-Draw / ISIS Draw etc.

# **References:**

- 1. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
- 2. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry TaskForce Committee, DST

# Course Outcome: Student will able to

- **CO-1**: The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future.
- **CO-2:** Making derivatives of organic compounds will help them in industry or while doing research in medicinal chemistry for Drug development.
- **CO-3**: Ccarrying out different types of reactions and their workup methods.
- **CO-4**: Understand the green chemistry and role of green chemistry in pollution reduction.
- CO-5: Avoid solvents and do solvent free reaction.
- CO-6: Also the work-up procedure in many experiments is made more eco-friendly to environment.

# CHMAET-521-A: Elective Chemistry theory paper-6-A [2 Credits]

# **Title of the Paper: Chemistry of Main Group Elements**

Chapter No.	Name of the Chapter	Lectures Assigned

# **Module-1**

# **Chapter-1: Hydrogen and its compounds:**

Classification of Hydrides: Molecular hydrides, saline hydrides, metallic hydrides and electron deficient, electron precise and electron rich hydrides. *Reference-1*, page no. 283 to 290 (02 L)

# **Chapter-2. Alkali and Alkaline Earth Metals**

Solutions in liquid ammonia, application of crown ether in extraction of alkali and alkaline earth metal. Reference-1, page no. 305 to 307

# **Chapter-3. Boron Group**

Simple hydrides of boron, Boron trihalides, Boron-oxygen compounds, Compounds of boron with nitrogen, Metal borides, Higher boranes and borohydrides, Metallaboranes and carborane, Reference-1, page no. 330 to 343

# **Chapter-4.** Carbon Group

Allotropes of carbon: Diamond, Graphite, Graphene, fullerenes and carbon nanotube, Carbides, Extended silicon oxygen compounds, Organo-silicon compounds. *Reference-1*, page no. 354 to 358, 368 to 371

#### **Module-2**

### **Chapter- 5. Nitrogen Group**

Nitrogen activation, nitrides and azides, phosphides, Oxidation states of nitrogen and their interconversion, Halides, Oxohalides, Oxides and oxoanions and oxyacid of nitrogen, Condensed phosphates and Phosphazenes. *Reference-1*, page no. 381 to 383, 385 to 395 (04 L)

# **Chapter-6. Oxygen Group**

Metal sulfides, selenides, tellurides, and polonides, Oxides, Oxoacids of sulphur, Polyanions of sulfur, Polycations of sulfur, selenium, and tellurium, Sulfur-nitrogen compounds. Reference-1, page no. 409 to 417

# **Chapter-7. Halogen Group:**

Pseudohalogens, Special properties of fluorine compounds, Structural features, The interhalogens, Halogen oxides, Oxoacids and oxoanions. Reference-1, page no. 427 to 434

# Chapter-8. Noble gases:

Occurrence, Synthesis and structure of xenon fluorides, Reactions of xenon fluorides, and Xenonoxygen compounds. Reference-1, page no. 441 to 445

Note: Student should learn the name of element, symbol, atomic number and electronic configuration present in respective group.

# **References:**

- 1) Inorganic Chemistry by Shriver and Atkins
  - 2) Concise Inorganic Chemistry by J. D. Lee
  - 3) Inorganic chemistry by Principle of Structures and Reactivity by Huheey, Keiter, Medhi
- 4) Inorganic Chemistry by Catherine Housecraft

# Course Outcomes: At the end of course student should able to -

- **CO-1:** Define electron deficient, electron precise and electron rich species, Pseudohalogens, Oxoacids and Oxidation state.
- CO-2: Describe special properties of fluorine, Nitrogen activation, Oxo acids of nitrogen, sulphur and phosphorous, synthesis and structure of xenon fluorides.

# [12 L + 3 T]

# (05L)

(05L)

(03 L)

# [12 L + 3 T](05L)

#### (03 L)

# (03 L)

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#### CBCS Syllabus Under NEP-2020 M. Sc. –I (Analytical Chemistry) **Department of Chemistry** Hydrogen and its compounds 03 L 1 2 Alkali and Alkaline Earth Metals 02 L 3 Boron Group 05 L 4 Carbon Group 05 L 5 Nitrogen Group 05 L Oxygen Group 04 L 6 7 Halogen Group 03 L 8 Noble gases 03 L

- CO-3: Explain term metal sulfides, selenides, tellurides, polonide, inter-halogens, Halogen oxides, Graphene, fullerenes and carbon nanotube.
- CO-4: Determine Oxidation states of nitrogen and their interconversion and application of crown ether in extraction of alkali and alkaline earth metal.
- **CO-5**: Differentiate between diamond and graphite, Pseudohalogens and interhalogens.

**CO-6**: Classify the hydrides, borides and oxyacids and draw their structure.

# CHMAEP-522-A Elective Chemistry practical paper-6-A [2 Credits]

# **Title of the Paper: Electro Analytical Chemistry**

Chapter No.	Name of the Chapter	Lectures Assigned
1	Coulometry	06 L
2	Polarography (linear scan	09 L
	polarography)	
3	Voltammetry Methods of Analysis.	15 L

#### **Module-1**

#### [12 L + 3 T]

[6 L]

#### **1.** Coulometry

Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, constant current electrolysis, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, potentiation coulometry-Instrumentation and applications, coulometric titrations apparatus and applications, problems.(Ref.-1:696-712, Ref-2: relevant pages) [9 L]

# **Chapter-2: Polarography (linear scan polarography)**

Polarographic principles, Instrumentation (different types of microelectrode such as dropping mercury electrode, the static drop mercury electrode, rotating disc and ring disc electrode, cell for polarography, reference and counter electrode and circuit diagram), polarogram and polarographic currents, charging or capacitive current, role of supporting electrolyte, factors affecting on polarographic wave, Ilkovic Equation, advantages and disadvantages of DME, polarographic maxima and maxima suppresors, interference due to dissolved oxygen, Applications (qualitative analysis, quantitative analysis by calibration curve and standard addition methods), specific examples of analysis - analysis of Cu, Cd, Zn, Pb, etc. from tap water and alloys., problems.(Ref-1: 716-723, Ref-2, Supplementary Ref. 3 and 4)

# **Module-2**

# [12 L + 3 T][15 L]

#### 3. Voltammetry Methods of Analysis.

a) Hydrodynamic Voltametry: Hydrodynamic voltametry and applications of hydrodynamic voltametry (volatameric detectors in chromatography and flow injection analysis, Voltametric oxygen sensors, amperometric titration. (Ref-1: 723-735)

b) Cyclic Voltametry: Principle of cyclic Voltammetry, cyclic voltamogram of K<sub>3</sub>[Fe(CN)<sub>6</sub>] and parathion (Fundamental studies), determination of analytes using CV, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes(Ref1:735-742 Ref-2: Relevant pages, Supplementary Ref.-5: 27-68)

c) Pulse Polarography: different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, and Stripping method. Voltammetry with ultramicroelectrode, Applications of these techniques Cu and Zn from tap water by differential pulse polarography and by square wave polarography, Vitamin-C by differential pulse polarography, Determination of Pb in tap water by stripping method. (Ref-1: 742-753 2, Supplementary Ref. 3 and 4)

References 1. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.

Referenc-2. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed.

Reference-3. Introduction to Instrumental Analysis by R. D. Braun, Pharmamed Press.

- Reference-4. Analytical Chemistry, A Modern Approach to Analytical Science, Ed. by R. Kellner, J. M. Mermet, O. Otto, M. Valcarcel, H. M. Widmer, Second Ed. Wiley –VCH CBCS: 2019 Pattern
- Reference-5. Cyclic Voltammetery, Simultaneous Analysis and Reaction Mechanism, David K Gosser, VCH, 1994.
- CO-1. Define various terms in electrochemistry included in syllabus.
- CO-2. Explain / discuss instrumentation in electrochemistry. Differentiate among the various methods of electrochemistry
- CO-3. Describe basic principles of electrochemistry and applications of electrochemistry in industry and in analytical laboratory.
- CO-4. Apply / select particular method of analysis for sample to be analysed.
- CO-5. Solve numerical problems on electrochemistry.

CO-6. Interpret polarogram, cyclic voltammogram, pulse polarogram, thermogram, differential thermogram and DSC thermogram.

# CHMAET-521-B: Elective Chemistry theory paper-7-B [2 Credits]

# **Title of the Paper: Chemistry Practical-IV-A**

- **Part-I: Conductometry:** (Any three)
- **Experiment-**1. Hydrolysis of NH<sub>4</sub>Cl or CH<sub>3</sub>COONa or aniline hydrochloride.
- **Experiment-**2. Determination of  $\lambda 0$  or  $\lambda \alpha$  and dissociation constant of acetic acid.
- **Experiment-**3. Hydrolysis of ethyl acetate by NaOH.
- **Experiment-**4. Determination of  $\Delta G$ ,  $\Delta H$ , and  $\Delta S$  of silver benzoate by conductometry.
- **Experiment-5**. Determination of critical micellar concentration (CMC) and  $\Delta G$  of micellization of

 $so dium \ Lauryl \ Sulphate \ / \ Detergent$ 

# Part-II: Polarography (any one)

- **Experiment-**6. Determination of half wave potential E 1/2 and unknown concentration of Cu or Pb or Zn ion.
- Experiment-7. Amperometric titration of Pb(NO<sub>3</sub>)<sub>2</sub> with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>.
- Part-III: Potentiomerty: (Any three)
- **Experiment-**8. Stability Constant of a complex ion.
- **Experiment-**9. Solubility of a sparingly soluble salt.
- **Experiment-**10. To determine the ionic product of H<sub>2</sub>O
- **Experiment-**11. Estimation of halide in mixture.

# Part-IV: pH metry (any two)

- **Experiment-**12. Determination of the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid.
- Experiment-13. Determination of dissociation constants of tribasic acid (phospheric acid)
- **Experiment-**14. Construct pH curve for titration of strong base strong acid, strong base weak acid and predict the best indicator in these titrations (methyl orange, methyl orange, brocresol green, phenolphthalein, etc.)

# Part-V: Table Work (any two)

- **Experiment-**15. Analysis of powder XRD of SrTiO<sub>3</sub> and Ag metal or any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data)
- Experiment-16. Cyclic voltamogram of K<sub>3</sub>Fe(CN)<sub>6</sub> in KCl/H<sub>2</sub>O / Ferrocene in TEAP//MeCN

# **Experiment-**17. Detailed interpretation of Raman spectra of diatomic molecules **References:**

- 1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)
- 2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. Richett( Pergamon Press)

3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).

- 4. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
- 5. Physical chemistry by Wien (2001)
- 6. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut)

# Course Outcome: Student will able to

- **CO-1:** Prepare solution of required conc. and handle laboratory equipment property.
- **CO-2**: Perform experiment accurately and able to perform calculation.
- CO-3: Explain experiment and principal of experiment in detail.
- **CO-4**: Write / discuss results and conclusions of the experiment.
- **CO-5:** Apply knowledge to a) design experiment for given aim or modify experiment to enhance results. b) to find out lacuna in experimental procedure.
- **CO-6**: Solve problem/ numerical depending on given data / information.

# CHMAET-522-B: Elective Chemistry practical paper-7-B [2 Credits]

# **Title of Paper: Inorganic Practical on Main Group Elements**

- 1. Synthesis of graphine oxide by modified Hummers method (Ref-1)
- 2. Synthesis of silica nanoparticles from sodium silicate under alkaline conditions (Ref-2, 3)
- 3. Synthesis of cadmium sulfide thin films (Ref-4, 5, 6, 7)
- Synthesis of carbon nitride or graphitic carbon nitride and its band gap / photocatalytic application. (ref- 8, 9, 10, 11)
- 5. Laboratory Preparation of Borazine (Ref: 12)
- Synthesis and analysis of K<sub>3</sub>[Al(C<sub>2</sub>O<sub>4</sub>)<sub>3</sub>]3H<sub>2</sub>O or Synthesis of [Al(acac)<sub>3</sub>] and study of its IR spectra.
- 7. Adsorption of methylene blue on nanosilica (ref-13)
- 8. Synthesis of Alumina and adsorption (Ref: 14-17)
- 9. Determination of point of zero charge (PZC) of oxide powder (alumina or silica).

# P-block Analytical Chemistry (any four experiments) (Ref-18, 19)

- 10. Estimation of Ca and Mg in dolomite ore
- 11. Estimation of Ca from soil or milk powder as Ca-oxalate.
- 12. Estimation of Al and Silica in bauxite ore
- 13. Analysis of Solder Alloy for Sn and Pb content
- 14. Estimation of KI/KIO3 content in iodized salt.
- 15. Estimation of Phosphate from soil or fertilizer.
- 16. Estimation of organic nitrogen by Kjedahl's method.
- 17. Estimation of K potash fertilizer by gravimetric method.
- 18. NaOCl content of commecial NaOCl solution.

# Any three experiments (Ref-18, 19)

- 19. Solubility product of  $Ca(OH)_2$  or  $Mg(OH)_2$  and effect of  $OH^-$  conc. on solubility product.
- 20. Study on basicity of boric acid.
- 21. Determination of Pka of Orthophosphoric Acid
- 22. Water of crystallization of  $MgSO_47H_2O$

23. Kinetics of oxidation of iodide (I) with Fe(III)

ati, Horwood

3. Nanotechnology by S. K. Kulkarni

#### Course Outcome: Student will able to

**CO-1:** Prepare solution of required conc. And handle laboratory equipment property.

- **CO-2**: Perform experiment accurately and able to perform calculation.
- CO-3: Explain experiment and principal of experiment in detail.
- CO-4: Write / discuss results and conclusions of the experiment.
- **CO-5:** Apply knowledge to a) design experiment for given aim or modify experiment to enhance results. b) to find out lacuna in experimental procedure.
- **CO-6**: Solve problem/ numerical depending on given data / information.

#### References

- 1. Ref: Synthesis of Graphene Oxide using Modified Hummers Method: Solvent Influence, https://doi.org/10.1016/j.proeng.2017.04.118
- Zulfiqar, U., Subhani, T. & Wilayat Husain, S. Synthesis of silica nanoparticles from sodium silicate under alkaline conditions. *J Sol-Gel Sci Technol* 77, 753–758 (2016). https://doi.org/10.1007/s10971-015-3950-7
- 3. Evaluation of scale-up strategies for the batch synthesis of dense and hollow mesoporous silica microspheres; https://doi.org/10.1016/j.cej.2017.11.026
- 4. A facile route for synthesis of cadmium sulfide thin films; doi:10.1016/j.tsf.2018.08.034
- 5. CdS Thin Film Photo-Electrochemical Electrodes: Combined Electrochemical and Chemical Bath Depositions By Sahar Mustafa Asad Khudruj.
- 6. Photoelectrochemical investigations of cadmium sulphide (CdS) thin film electrodes prepared by spray pyrolysis; https://doi.org/10.1016/j.jallcom.2011.02.061
- 7. Novel-approach for fabrication of CdS thin films for photoelectrochemical solar cell application. *J Mater Sci: Mater Electron* 25, 5606–5617 (2014). <u>https://doi.org/10.1007/s10854-014-2350-z</u>
- 8. Simple pyrolysis of urea into graphitic carbon nitride with recyclable adsorption and photocatalytic activity; DOI <u>https://doi.org/10.1039/C1JM12620B</u>
- 9. Facile Large-Scale Synthesis of Urea-Derived Porous Graphitic Carbon Nitride with Extraordinary Visible-Light Spectrum Photodegradation; <u>https://doi.org/10.1021/acs.iecr.6b00041</u>
- 10. Molecular Mechanism for the Self-Supported Synthesis of Graphitic Carbon Nitride from Urea Pyrolysis; <u>https://doi.org/10.1021/acs.jpclett.0c03559</u>
- Melamine-derived graphitic carbon nitride as a new effective metal-free catalyst for Knoevenagel condensation of benzaldehyde with ethylcyanoacetate; DOI: https://doi.org/10.1039/C8CY00253C
- 12. Convenient Procedures for the Laboratory Preparation of Borazine; https://doi.org/10.1021/ic00108a039
- 13. Adsorption of methylene blue on silica nanoparticles: Modelling analysis of the adsorption mechanism via a double layer model; https://doi.org/10.1016/j.molliq.2020.114348
- 14. Synthesis of mesoporous silica nanoparticles derived from rice husk and surface-controlled amine functionalization for efficient adsorption of methylene blue from aqueous solution; https://doi.org/10.1016/j.crgsc.2021.100116
- 15. Synthesis of alumina nanoparticles by sol-gel method and their applications in the removal of copper ions (Cu<sup>2+</sup>) from the solution; **10.1088/1757-899X/701/1/012034**
- **16. Synthesis and structural characterization of alumina nanoparticles;** <u>https://doi.org/10.1080/01411594.2020.1765245</u>
- 17. Low-Cost Synthesis of Alumina Nanoparticles and Their Usage for Bisphenol-A Removal from Aqueous Solutions, <u>https://doi.org/10.3390/pr9101709</u>
- 18. Vogel's textbook of inorganic quantitative analysis.
- 19. Experimental inorganic / Physical Chemistry; Mounir A. Malati, Harwood Series in Chemical sciences.

# Course RM: Research Methodology 4 Credit (60 L)

Course/ Paper Title	Research Methodology
Course Code	
Semester	П
No. of Credits	4

#### Module-1:

#### **Chapter-1: Introduction to Research methodology:**

Objective of research, motivation in research, types of research, Fundamental research, applied research, experimental research, and interdisciplinary research.

#### **Chapter-2: Scope of Research and Ethics:**

Steps in scientific research: scientific methods of research, criteria of good research, and characteristics of a good research, Research problem: Identification, Selection, developing research title, Criteria for prioritizing topics for research, Prioritizing Topics for Research, Formulation of research objectives.

Types and importance of research ethics, Institutional ethics committee, Plagiarism, Patenting and intellectual property rights. Publication ethics: definition, introduction, and importance.

#### Chapter-3: Literature Survey and Search technique:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, and Formula Index. Literature Search technique: SCOPUS, Google Scholar, PUBMED, Web of Science, science direct, Indian Citation Index, Research Gate, and scifinder, Scirus, ChemIndustry, Wiki- Databases, ChemSpider.

#### Module-2:

#### Chapter-4: Overview of the journal article:

Selection of journals, Data bases and research metrics Databases: i) indexing databases ii) Citation databases: Web of Science, Scopus, UGC-Care List etc.

Research Metrics: a) Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score b) Metrics: h-index, g index, i10 index.

#### Chapter-5: Presentation of Scientific findings, Scientific Report Writing: (09 L)

Publication Process: Types of technical documents- Full length research paper, Short/Brief communications, Letters to editor, Book chapter, Review, Conference report, Patents, dissertation. Components of a research publication: Title/Topic statement, Abstract/key words, Aims and objectives, Hypothesis building, Rationale of the paper, Work plan, Materials and methodology, Results and discussion, Key issues, and arguments, Acknowledgement, Conflict of

interest statement, bibliography, Technical Resumes & Cover Letters. Softwares in Chemistry Data plotting Structure Drawing, Grammar Checkers and Sentence Correction Tools.

# Module-3:

#### **Chapter-6: Data Analysis and interpretation:**

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

#### **Module-4:**

#### (15 L)

# (**06 L**)

34

#### (**02L**) earch, ap

(05 L)

(08L)

#### Chapter-7: Presentation and Communication skills: (05 L) Tables, Figures and Pictures using Excel, PowerPoint slide preparation, Preparation of Posters, Electronic submission of manuscripts, oral and poster, Communication skills.

### Chapter-8: Chemical Safety and Ethical Handling of Chemicals:

#### (10 L)

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Handling of various chemicals, solvents & glassware. Fires and fighting with fires. Hazardous substances, Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards classification, and handling Safety Data Sheet. Chemical entries, MSDS, CAS numbers, dead stocks maintenance. Disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals.

# **References:**

- 1) Best and Kahn, Research Methodology, PHI Limited.
- 2) Kothari, C. K., Research Methodology-Methods and Techniques, 2nd Ed., New Age International, New Delhi.
- 3) Kumar, R., Research Methodology A Step-By-Step Guide for Beginners, Pearson Education, Delhi (2006).
- 4) Fundamentals of modern statistical methods by Rand R.wilcox.
- 5) Power Analysis for Experimental research A Practical Guide for the Biological, Medical and social Sciences by R. Barker Bausell, Yi-Fang Li Cambridge University Press.
- 6) Design of Experience: Statistical Principles of Research Design and Analysis, by Robert O. Kuehl Brooks/cole.
- 7) Panneerselvam R., Research Methodology, Prentice Hall Of India, New Delhi,2004
- 8) Montgomery, D. C., Design & Analysis of Experiments, 5th Ed., Wiley India (2007).

# **Course Outcomes (CO):**

- CO-1: Define term research, ethics, plagiarisms, safety, MSDS sheet, errors, precision, linear regression, CAS number, manuscript, search engine, citation, reviews, indices, etc.
- CO-2: Describe Correlation and regression, analysis of residuals, linearizing transformations, exponential function, Handling of various chemicals, solvents & glassware, Chemical Abstract.
- CO-3: Explain Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Handling of various chemicals, solvents & glassware.
- CO-4: Discuss disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, Work plan, materials and methodology, results and discussion, Data bases and research metrics databases
- CO-5: Interpret Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit.
- CO-6: Performs statically analysis of experimental results, Analyze impact Factor of journal as per Journal Citation Report.
  - M. Sc. Field Work / On Job training (OJT)

Department	of	Ch	emistry
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C	BCS Syllabus Under NEP-2020	M. Sc. –I (Analytical Chemistry)	Depa
	Course/ Paper Title	Field Work / On Job training (OJT)	
	Course Code	CHOJT-521	
	Semester	Π	

4 (60 L)

- ✓ The students, as a part of their course, will be given opportunities to enroll for Field Project(s) or on job training.
- ✓ The student must undergo field work project which related to chemistry.
- ✓ The students must undergo industrial on job training/internship in the 2<sup>nd</sup> semester in any of the reputed industry, Government-sponsored Research & Development Organization, and reputed academic institution/foreign universities.

# Program: MSc [Chemistry], 2023-24

No. of Credits

# **Program Outcomes**

- PO-1: **Disciplinary knowledge and skill:** A graduate student is expected to be capable of demonstrating comprehensive knowledge and understanding both theoretical and practical fundamental concepts in all disciplines of Chemistry. Further, the student will be capable of applying modern technologies, handling advanced instruments and Chemistry related soft-wares for chemical analysis, characterization of materials and in separation technology.
- PO-2: **Skilled communicator:** The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.
- PO-3: **Critical thinker and problem solver:** The course curriculum also includes components that can be helpful to graduate students to develop critical thinking and to design, carry out, record and analyze the results of chemical reactions. Students will be able to think and apply evidence based comparative chemistry approach to explain chemical synthesis and analysis.
- PO-4: Sense of inquiry: It is expected that the course curriculum will develop an inquisitive characteristics among the students through appropriate questions, planning and reporting experimental investigation.
- PO-5: **Team player:** The course curriculum has been designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.
- PO-6: **Skilled project manager:** The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.

- PO-7: **Digitally literate:** The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, use of chemical simulation software and related computational work.
- PO-8: **Ethical awareness:** A graduate student requires understanding and developing ethical awareness or reasoning which is adequately provided through the course curriculum. Students CO-2: To know how to handle the technical devices for presenting research works. can also create an awareness of the impact of chemistry on the environment, society, and also make development outside the scientific community.
- PO-9: **Environmental Awareness:** As an inhabitant of this green planet a Chemistry graduate student should have many social responsibilities. The course curriculum is designed to teach a Chemistry graduate student to follow the green routes for the synthesis of chemical compounds and also find out new greener routes for sustainable development. The course also helps them to understand the causes of environmental pollution and thereby applying environmental friendly policies instead of environmentally hazard ones in every aspect.
- PO-10: Analytical skill development and job opportunity: The course curriculum is designed in such a way that Chemistry graduate students can handle many Chemistry based software, modern instruments and advanced technologies to synthesize, characterize and analyze the chemical compounds very skillfully. Such a wonderful practice in the graduate level will bring a good opportunity to the students for getting job in industries besides academic and administrative works. Programme.