

HIGHLIGHTS OF REGULATIONS OF FYUGP**PROGRAMME DURATION**

- The Full-time, Regular UG programme for a regular student shall be for a period of four years with multiple entries and multiple exit options.

ELIGIBILITY

- The selection for admission will be primarily based on availability of seats in the Major subject and marks imposed by the institution. Merit point for selection will be based on marks obtained in Major subject at Class 12 (or equivalent level) or the aggregate marks of Class 12 (or equivalent level) if Marks of the Major subject is not available. Reservation norms of The Government of Jharkhand must be followed as and when amended in times.

ADMISSION PROCEDURE

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

ACADEMIC CALENDAR

- Each year the University shall draw out a calendar of academic and associated activities, which shall be strictly adhered to. The same is non-negotiable. Further, the Department will make all reasonable endeavors to deliver the programmes of study and other educational services as mentioned in its Information Brochure and website. However, circumstances may change prompting the Department to reserve the right to change the content and delivery of courses, discontinue or combine courses and introduce or withdraw areas of specialization.

PROGRAMME OVERVIEW/ SCHEME OF THE PROGRAMME

- Undergraduate degree programmes of either 3 or 4-year duration, with multiple entries and exit points and re-entry options within this period, with appropriate certifications such as:
 - a Certificate after completing 1 year (2 semesters) of study in the chosen fields of study,
 - a Diploma after 2 years (4 semesters) of study,
 - a Bachelor after a 3-year (6 semesters) programme of study,
 - a Bachelor (with Hons. / Research) after a 4-year (8 semesters) programme of study

VALIDITY OF REGISTRATION

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

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

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

PROMOTION AND SPAN PERIOD

- The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
- To get promotion from Semester-II to Semester-III a student will be required to pass in at least 75% of Courses in an academic year (a student has to pass in minimum 9 papers out of the total 12 papers. However, it will be necessary to procure pass marks in each of the paper before completion of the course.
- To get promotion from Semester-IV to Semester-V (taken together of Semester I, II, III & IV) a student has to pass in minimum 16 papers out of the total 22 papers.
- Eligibility to get entry in Semester VII is to secure a minimum of 7.5 CGPA up to semester VI along with other criteria imposed by the Institution.

PUBLICATION OF RESULT

- The result if the examination shall be notified by the Controller of Examinations of the University in different newspapers and also on University website.
- If a student is found indulged in any kind of malpractice during examination, the examination taken by the student will be cancelled. The candidate will be awarded zero marks in that paper. The candidate may re-appear in the subsequent semesters as per the available provisions.
- There shall be no Supplementary or Re-examination for any subject. Students who have failed in any subject in an even semester may appear in the subsequent even semester examination for clearing the backlog. Similarly, the students who have failed in any subject in an odd semester may appear in the subsequent odd semester examination for clearing the backlog.
- Regulation related with any concern not mentioned above shall be guided by the Regulations of the University for FYUGP.

COURSE STRUCTURE FOR FYUGP 'HONOURS/ RESEARCH'**Table 1: Credit Framework for Four Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 176]**

- There will be four disciplinary areas: A-Natural Science, B-Humanities, C-Social Science, and D-Commerce; each having basket of courses. A student will have to select a 'Major' from any of the four disciplinary areas (out of A, B, C & D). The selection for admission will be primarily based on availability of seats in Major and marks imposed by the institution.
- A student has to select three subjects for 'Introductory Regular Courses' from a pool of subjects associated with the Major offered by the institution. One of the three subjects will continue as 'Minor' from semester IV onwards, based on the academic interest and performance of the student.

Jharkhand, NEP, FYUGP 2022 onwards

Table 1: Credit Framework for Four Year Undergraduate Programme (FYUGP) under State Universities of Jharkhand [Total Credits = 176]

Common Courses (29)										Introductory Courses (15)		Minor* (32)		Research Courses (18)					Total Credit			
Semester																			176			
I	2	3	4	5	6	7	8	Major* (54) + Adv. Major (24)		Natural Sc./ Humanities/ Social Sc./ Commerce (18)		Vocational Studies (14)		Research Methodology Courses (6)		Research Proposal, Review of literature (4)		Research Internship/ Field Work (4)		Preparation of the Research Project Report (4)		
1	6			2	2				9	10	11	14	15	16	17	18	19	20	21	22		
II	6						2	2	3	3		6								22		
Exit Point: Undergraduate Certificate																						
III		3			3				3	3	4	6								22		
IV												6+6	6	4						22		
Exit Point: Undergraduate Diploma																						
V												6+6	6	4						22		
VI												6+6	6	4						22		
Exit Point: Bachelor's Degree																						
VII												6+6 (Adv. Topics)			6	4				22		
VIII												6+6 (Adv. Topics)		2			4	4		22		
Exit Point: Bachelor's Degree with Honors, Research																						

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**A student has to select three subjects for 'Introductory Regular Courses' from a pool of subjects associated with the Major offered by the institution. One of the three subjects will continue as 'Minor' from semester IV onwards, based on the academic interest and performance of the student.

Jharkhand, NEP, FYUGP 2022 onwards

Table 2: Course structure for Undergraduate Certificate Programme [May Exit after Sem.-II]

Semester	Common Courses			Introductory Courses		Major	Total Credits
Sem.-I	LCS (MIL/TRL) (6 Credits)	Understanding India (2 Credits)	Health & Wellness, Yoga Education, Sports & Fitness (2 Credits)	IRC-1 (3 Credits)	IVS-1A (3 Credits)	MJ-1 (6 Credits)	(22)
Sem.-II	LCS (English) (6 Credits)	Global Citizenship Education (2 Credits)	Mathematical & Computational Thinking (2 Credits)	IRC-2 (3 Credits)	IVS-1B (3 Credits)	MJ-2 (6 Credits)	(22)

Total = 44 Credits

(LCS: Language and Communication Skills; MIL: Modern Indian Languages; TRL: Tribal Regional Languages;

IRC: Introductory Regular Courses; IVS: Introductory Vocational Studies, MJ: Major)

Table 3: Course structure for Undergraduate Diploma Programme [May Exit after Sem.-IV]

Semester	Common Courses			Introductory Courses	Major	Minor	Internship/ Project	Vocational	Total Credits
Sem.-III	Environmental Studies (3 Credits)	Community Engagement/ NCC/ NSS (3 Credits)	Digital Education (3 Credits)	IRC-3 (3 Credits)	MJ-3 (6 Credits)		Internship/ Project (4 Credits)		(22)
Sem.-IV					MJ-4, MJ-5 (6+6=12 Credits)	MN-1 (6 Credits)		VS-1 (4 Credits)	(22)

Total = 88 Credits

(MN: Minor; VS: Vocational Studies)

Table 4: Course structure for Bachelor's Degree Programme*[May Exit after Sem.-VI]*

Semester	Major Courses	Minor Courses	Vocational	Total Credits
Sem.-V	MJ-6, MJ-7 (6+6 = 12 Credits)	MN-2 (6 Credits)	VS-2 (4 Credits)	(22)
Sem.-VI	MJ-8, MJ-9 (6+6 = 12 Credits)	MN-3 (6 Credits)	VS-3 (4 Credits)	(22)

Total = 132 Credits**Table 5: Course structure for Bachelor's Degree with Hons./Research Programme**

Semester	Advance Courses	Research Courses	Vocational	Total Credit
Sem.-VII	AMJ-1, AMJ-2 (6+6=12 Credits)	Research Methodology (6 Credits)	Research Proposal (4 Credits)	(22)
Sem.-VIII	AMJ-3, AMJ-4 (6+6=12 Credits)	Research Int./Field Work (4 Credits)	Research Report (4 Credits)	VSR (2 Credits)

Total = 176 Credits

(AMJ: Advance Major; VSR: Vocational Studies associated with Research)

SEMESTER WISE COURSES OF STUDY FOR FOUR YEAR UNDERGRADUATE PROGRAMME

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Credits
	Code	Paper	
I	CC-1	Language and Communication Skills (Modern Indian language including TRL)	6
	CC-2	Understanding India	2
	CC-3	Health & Wellness, Yoga Education, Sports & Fitness	2
	IRC-1	Introductory Regular Course-1	3
	IVS-1A	Introductory Vocational Studies-1	3
	MJ-1	Major paper 1 (Disciplinary / Interdisciplinary Major)	6
II	CC-4	Language and Communication Skills (English)	6
	CC-5	Mathematical & Computation Thinking Analysis	2
	CC-6	Global Citizenship Education & Education for Sustainable Development	2
	IRC-2	Introductory Regular Course-2	3
	IVS-2B	Introductory Vocational Studies-2	3
	MJ-2	Major paper 2 (Disciplinary / Interdisciplinary Major)	6
III	CC-7	Environmental Studies	3
	CC-8	Digital Education (Elementary Computer Applications)	3
	CC-9	Community Engagement & Service (NSS / NCC / Adult Education)	3
	IRC-3	Introductory Regular Course-3	3
	IAP	Internship /Apprenticeship / Project	4
	MJ-3	Major paper 3 (Disciplinary / Interdisciplinary Major)	6
IV	MJ-4	Major paper 4 (Disciplinary / Interdisciplinary Major)	6
	MJ-5	Major paper 5 (Disciplinary / Interdisciplinary Major)	6
	MN-1	Minor Paper 1 (Disciplinary / Interdisciplinary Minor)	6
	VS-1	Vocational Studies - 1 (Minor)	4
V	MJ-6	Major paper 6 (Disciplinary / Interdisciplinary Major)	6
	MJ-7	Major paper 7 (Disciplinary / Interdisciplinary Major)	6
	MN-2	Minor Paper 2 (Disciplinary/Interdisciplinary Minor)	6
	VS-2	Vocational Studies - 2 (Minor)	4
VI	MJ-8	Major paper 8 (Disciplinary / Interdisciplinary Major)	6
	MJ-9	Major paper 9 (Disciplinary / Interdisciplinary Major)	6
	MN-3	Minor Paper 3 (Disciplinary / Interdisciplinary Minor)	6
	VS-3	Vocational Studies - 3 (Minor)	4
VII	AMJ-1	Advance Major paper 1 (Disciplinary / Interdisciplinary Major)	6
	AMJ-2	Advance Major paper 2 (Disciplinary / Interdisciplinary Major)	6
	RC-1	Research Methodology	6
	RC-2	Research Proposal	4

VIII	AMJ-3	Advance Major paper 3 (Disciplinary / Interdisciplinary Major)	6
	AMJ-4	Advance Major paper 4 (Disciplinary / Interdisciplinary Major)	6
	RC-3	Research Internship / Field Work	4
	RC-4	Research Report	4
	VSR	Vocational Studies (Associated with Research)	2
		Total Credit	176

Abbreviations:

CC Common Courses

IRC Introductory Regular Courses

IVS Introductory Vocational Studies

IAP Internship/Apprenticeship/ Project

VS Vocational Studies

MJ Major Disciplinary/Interdisciplinary Courses

MN Minor Disciplinary/Interdisciplinary Courses

AMJ Advance Major Disciplinary/Interdisciplinary Courses

RC Research Courses

VSR Vocational Studies associated with Research

SEMESTER WISE COURSES IN CHEMISTRY FOR FYUGP**Semester wise Examination Structure in Discipline Courses:**

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I	MJ-1	Inorganic Chemistry – I (Theory + Lab)	6			
II	MJ-2	Organic Chemistry – I (Theory + Lab)	6			
III	MJ-3	Physical Chemistry –I (Theory + Lab)	6			
IV	MJ-4	Inorganic Chemistry – II (Theory + Lab)	6			
	MJ-5	Organic Chemistry – II (Theory + Lab)	6			
V	MJ-6	Physical Chemistry –II (Theory + Lab)	6			
	MJ-7	Analytical & Instrumental Chemistry (Theory + Lab)	6			
VI	MJ-8	Quantum Chemistry, Spectroscopy & Photochemistry (Theory + Lab)	6			
	MJ-9	Biomolecules & Organic Spectroscopy (Theory and Lab)	6			
VII	AMJ-1	Electrochemistry (Theory + Lab)	6			
	AMJ-2	Environmental & Industrial Chemistry (Theory + Lab)	6			
	RC-1	Research Methodology	6			
	RC-2	Research Proposal	4			
VIII	AMJ-3	Biochemistry (Theory + Lab)	6			
	AMJ-4	Green Chemistry (Theory + Lab)	6			
	RC-3	Research Internship/Field Work	4			
	RC-4	Research Report	4			
	VSR	Vocational Studies (Associated with Research)	2			
	Total Credit		98			

Semester wise Course Code and Credit Points:**Introductory and Minor Courses:**

Semester	Common, Introductory, Major, Minor, Vocational & Internship Courses		Examination Structure			
	Code	Papers	Credits	Mid Semester Theory (F.M.)	End Semester Theory (F.M.)	End Semester Practical/ Viva (F.M.)
I/II/III	IRC	Introductory Chemistry	3			
IV	MN-1	Physical & Organic Chemistry - I	6			
V	MN-2	Physical & Inorganic Chemistry - II	6			
VI	MN-3	Physical & Organic Chemistry- III	6			
	Total Credits		21			

AIM OF BACHELOR'S DEGREE PROGRAMME IN CHEMISTRY

The FYUGP educational program in Chemistry aims -

- To develop students friendly learning environment in educational institutions to enhance the knowledge acquired at +2 level. Motivate students to develop career-oriented knowledge in chemistry by applying basic concepts, principles and theories of Chemistry.
- To provide opportunities to learn, develop and perform experiments in lab and acquire a deeper understanding of concepts, principles and theories learned in the classroom through laboratory demonstration and computational simulation of experimental data.
- To develop the ability in students to apply the practical knowledge and skills they have acquired to get to the solutions of specific theoretical and applied problems in Chemistry.
- To prepare students for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas, as Chemistry is among the most important branches of science necessary for interdisciplinary and multidisciplinary research.
- To prepare students for developing new technologies and theoretical methods for applications in diverse branches for sustainable economic life of the country, as Chemistry is one of the branches of science which makes a more thoughtful use of our resources favouring more efficient transformations and providing more sustainable solutions in applications ranging from new material and more efficient product that contribute directly to technological development;

In light of all of the above to provide students with the knowledge and skill base that would enable them to undertake further studies in Chemistry and related areas, or in Interdisciplinary / multidisciplinary areas, or join and be successful in diverse professional streams including entrepreneurship.

PROGRAMME LEARNING OUTCOMES

Students graduating with the B.Sc. (Honours) / Research Chemistry degree should be able to -

- Acquire
 - 1) a fundamental / systematic and coherent understanding of the academic field of Chemistry in areas like Quantum Chemistry, Spectroscopy, Analytical and Instrumental methods, Biomolecules, Environment, green Chemistry and their applications to other core subjects in Chemistry;
 - 2) a wide ranging and comprehensive experience in Chemistry laboratory methods in experiments related to Spectroscopy, Analytical and Instrumental methods, Biomolecules, Environmental Chemistry, Green Chemistry and their applications to other core subjects in Chemistry,, solid state Chemistry and modern Chemistry, Students should acquire the ability for systematic observations, use of scientific research instruments, analysis of observational data, making suitable error estimates and scientific report writing;
 - 3) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Chemistry, including professionals engaged in research and development, teaching and government / public service / private sector;
 - 4) knowledge and skills in areas related to their specialization area corresponding to elective subjects within the disciplinary/subject area of Chemistry and current and emerging developments in the field of Chemistry.
- Demonstrate the ability to use skills in Chemistry and its related areas of technology for formulating and tackling problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Chemistry.
- To reshape our world into one that is safer and promises more efficient tests to promote the fundamental role of chemistry to protect society and our planet.
- Plan and execute Chemistry-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Chemistry.
- Demonstrate relevant generic skills and global competencies such as
 - 1) problem-solving skills that are required to solve different types of problems with well-defined solutions,
 - 2) tackle investigative skills, including skills of independent investigation of related problems;
 - 3) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;
 - 4) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Chemistry and ability to translate them with popular language when needed;
 - 5) Information and Communication Technology skills;
 - 6) personal skills such as the ability to work both independently and in a group.

- Demonstrate professional behavior such as
 - 1) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;
 - 2) the ability to identify the potential ethical issues in work-related situations;
 - 3) be committed to the free development of scientific knowledge and appreciate its universal appeal for the entire humanity;
 - 4) appreciation of intellectual property, environmental and sustainability issues;
 - 5) promoting safe learning and working environment.

SEMESTER I**Major Course MJ 1****INORGANIC CHEMISTRY-I**

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

Periodicity of Elements: *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* & *p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffe's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Chemical Bonding: (i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) *Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2 , O_2 , C_2 , B_2 , F_2 , CO , NO , and their ions; HCl , BeF_2 , CO_2 , (idea of *s*-*p* mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and σ bond and π approach (its electrons and bond multiple bonding (lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. (iii) *Weak Chemical Forces*: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process. Principles involved in volumetric analysis to be carried out in class.

Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

MJ 1 LAB

(A) Titrimetric Analysis

- (i) Calibration and use of apparatus
- (ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

- (i) Estimation of Fe(II) and oxalic acid using standardized KMnO_4 solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference Books:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
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SEMESTER II**Major Course MJ 2****ORGANIC CHEMISTRY- I****Basics of Organic Chemistry**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules,

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment, Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Stereochemistry:

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

Chemistry of Aliphatic and Aromatic Hydrocarbons**A. Carbon-Carbon sigma bonds**

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

B. Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration, oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction;

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Aromatic Hydrocarbons:

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

Chemistry of Halogenated Hydrocarbons:

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN₁, SN₂ and SN_i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SN_{Ar}, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and arylhalides towards nucleophilic substitution reactions.

Alcohols and Phenols:

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

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

Carbonyl Compounds:

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

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

Reference Books:

- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
 - Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
 - McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
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MJ 2 LAB

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
 - i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β -naphthol, vanillin, salicylic acid) by any one method:
 - a. Using conventional method.
 - b. Using green approach
 - ii. Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β -naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.
 - iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
 - iv. Bromination of any one of the following:
 - a. Acetanilide by conventional methods
 - b. Acetanilide using green approach (Bromate-bromide method)
 - v. Nitration of any one of the following:
 - a. Acetanilide/nitrobenzene by conventional method
 - b. Salicylic acid by green approach (using ceric ammonium nitrate).
 - vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

- vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
 - viii. Hydrolysis of amides and esters.
 - ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
 - x. *S*-Benzyliothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
 - xi. Aldol condensation using either conventional or green method.
 - xii. Benzil-Benzilic acid rearrangement.
- The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books

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

SEMESTER III**Major Course MJ 3****PHYSICAL CHEMISTRY-I****Gaseous state:**

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

Liquid state: Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature.

Ionic equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and triprotic acids (exact treatment). Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

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

Introduction to thermodynamics:

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

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

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

Reference Books:

- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University Press (2014).
 - Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
 - Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
 - Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
 - Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed. Pearson (2013).
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MJ 3 LAB

1. Surface tension measurements.

- a. Determine the surface tension by (i) drop number (ii) drop weight method.
- b. Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald's viscometer.

- a. Determination of viscosity of aqueous solutions of
(i) polymer (ii) ethanol and (iii) sugar at room temperature.
- b. Study the variation of viscosity of sucrose solution with the concentration of solute.

3. Thermochemistry (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

(f) Determination of enthalpy of hydration of copper sulphate.

(g) Study of the solubility Δ of benzoic acid in water and determination of H . Any other experiment carried out in the class.

Any other experiment carried out in the class.

Reference Books:

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

SEMESTER IV**Major Course MJ 4****INORGANIC CHEMISTRY-II****Oxidation-Reduction and general Principles of Metallurgy**

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

Acids and Bases

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

Chemistry of *s* and *p* Block Elements:

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

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Transition Elements:

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

Coordination Chemistry:

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of $10 Dq$ (Δ_o), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of $10 Dq$ (Δ_o , Δ_t). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory. IUPAC nomenclature of coordination compounds, isomerism in coordination compounds.

Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect.

Lanthanoids and Actinoids:

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Noble Gases:

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

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

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann. 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010.
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

MJ 4 LAB**(A) Iodo / Iodimetric Titrations**

- (i) Estimation of Cu(II) and $\text{K}_2\text{Cr}_2\text{O}_7$ using sodium thiosulphate solution (Iodimetrically).
- (iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

- (i) Cuprous Chloride, Cu_2Cl_2
- (ii) Preparation of Manganese(III) phosphate, $\text{MnPO}_4 \cdot \text{H}_2\text{O}$
- (iii) Preparation of Aluminium potassium sulphate $\text{KAl(SO}_4)_2 \cdot 12\text{H}_2\text{O}$ (Potash alum) or Chrome alum.

Gravimetric Analysis:

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN

Inorganic Preparations:

- i. Tetraamminecopper (II) sulphate, $[\text{Cu(NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- ii. *Cis* and *trans* $\text{K} [\text{Cr (C}_2\text{O}_4)_2 \cdot (\text{H}_2\text{O})_2]$ Potassium dioxalatodiaquachromate (III)
- iii. Tetraamminecarbonatocobalt (III) ion
- iv. Potassium tris(oxalate)ferrate(III)

Chromatography of metal ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

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

Reference Book:

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

Major Course MJ 5

ORGANIC CHEMISTRY-II

Nitrogen Containing Functional Groups

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

Polynuclear Hydrocarbons

Reactions of naphthalene anthracene and phenanthrene, Structure, Preparation and structure elucidation and important derivatives of naphthalene, anthracene and phenanthrene

Heterocyclic Compounds

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

Condensed five-membered Heterocycles:

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

Alkaloids

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Terpenoids

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

Reference Books:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.

- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Pragati Parakashann (2010).

MJ 5 LAB

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books

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

SEMESTER V**Major Course MJ -6****PHYSICAL CHEMISTRY-II****Phase Equilibria:**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions*: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Chemical Kinetics

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

Catalysis:

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

Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms. Nature of adsorbed state.

Solutions and Colligative Properties: Dilute solutions; (i) Lowering of vapour pressure, Raoult's and Henry's Laws and their applications. (ii) Elevation of boiling point, (iii) Depression of freezing point, (iv) Osmotic pressure applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books:

- Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.:New Delhi (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.
- *Commonly Asked Questions in Thermodynamics*. CRC Press: NY (2011).

- Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
 - Ball, D. W. *Physical Chemistry* Cengage India (2012).
 - Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
 - Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
 - Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).
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MJ 6 LAB

- I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
- a. simple eutectic and
 - b. congruently melting systems.
- III. Distribution of acetic/ benzoic acid between water and cyclohexane.
- IV. Study the equilibrium of at least one of the following reactions by the distribution method:
- (i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$
 - (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$
- V. Study the kinetics of the following reactions.
1. Initial rate method: Iodide-persulphate reaction
 2. Integrated rate method:
 - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
 - b. Saponification of ethyl acetate.
 3. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.
- VI. Adsorption
- I. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

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

Major Course MJ -7**Analytical and Instrumental Chemistry****Qualitative and quantitative aspects of analysis:**

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Spectroscopy:

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

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Vibrational Spectrometry: Basic principles of instrumentation, sampling techniques.

Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra.

Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical methods:

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

Techniques used for the determination of pK_a values.

Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

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

Reference Books:

- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
- Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
- Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
- Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009.

- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
 - Ditts, R.V. *Analytical Chemistry; Methods of separation*, van Nostrand, 1974.
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MJ 7 LAB

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

I. Separation Techniques

1. Chromatography:

(a) Separation of mixtures

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

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

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

II. Solvent Extractions:

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

(ii) Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

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

5. Analysis of soil:

(i) Determination of pH of soil, (ii) Total soluble salt and (iii) Estimation of calcium, magnesium, phosphate, nitrate.

III Spectrophotometry

1. Determination of pK_a values of indicator using spectrophotometry.

2 Structural characterization of compounds by infrared spectroscopy.

3 Determination of dissolved oxygen in water.

4 Determination of chemical oxygen demand (COD).

5 Determination of Biological oxygen demand (BOD).

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

Reference Books:

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

SEMESTER VI**Major Course MJ -8****Quantum Chemistry, Molecular Spectroscopy & Photochemistry****Quantum Chemistry**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Molecular Spectroscopy:

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

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

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

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Reference Books:

- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
- House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
- Kakkar, R. *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).

MJ - 8 LAB**UV/Visible spectroscopy**

- I. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colourimetry

- I. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration
- II. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.
- III. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- IV. Determination of indicator constant.

Reference Books

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

Major Course MJ -9

Biomolecules and Organic Spectroscopy

Nucleic Acids

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

Amino Acids, Peptides and Proteins

Amino acids, Peptides and their classification. α -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis.

Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Carbohydrates

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Dyes

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Polymers

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

Organic Spectroscopy

General principles Introduction to absorption and emission spectroscopy.

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

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

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

Applications of IR, UV and NMR for identification of simple organic molecules.

Reference Books:

- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P) Ltd. Pub.
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Pragati Prakashan (2010).
- Kemp, W. *Organic Spectroscopy*, Palgrave.
- Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed. (2015).
- Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistry*. 6th Ed. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IV Edition*. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry*. XXVIII edition. Lange Medical Books/ McGraw-Hill.

MJ 9 LAB

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

Reference Books:

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

SEMESTER VII

Advanced Major Course AMJ -1

Electrochemistry

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

Quantitative Aspect of Electrochemistry: Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb₂O₃ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

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

Reference:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

AMJ 1 LAB

1. Determination of pH of a given solution using glass electrode.
2. Determination of cell constant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak acid.
3. Conductometric titration: strong acid vs. strong base, weak acid vs. strong base.
4. Potentiometric titration: strong acid vs. strong base, weak acid vs. strong base, potassium dichromate vs. mohr's salt.

Reference books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Advanced Major Course AMJ -2

Environmental and Industrial Chemistry

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

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

Atmosphere

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

Aquatic chemistry

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

Environmental impact analysis

Origin and Development: Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.

Components of EIA: EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.

Main participants in EIA Process: Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA. Public participation.

Environmental Appraisal and Procedures in India and EIA: Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.

Recommended Books/References:

- De.A.K.Environmental Chemistry, Wiley Eastern Ltd, 1990.
- Miller T.G.Jr., Environmental Science, Wadsworth publishing House, Meerut Odum.E.P.1971.
- Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
- S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewis publisher
- Environmental chemistry, Sharma and Kaur, 2016, Krishna publishers
- Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.
- Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freeman publication..
- G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa(2009).
- Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
- 11 Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern (1995)

AMJ 2 LAB

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).
2. Determination of Biological Oxygen Demand (BOD).
3. Determination of Chemical Oxygen Demand (COD).
4. Finding out percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by titration method (AgNO_3 and potassium chromate).
6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titration method.
7. Estimation of SPM in air samples.

Reference Books:

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

SEMESTER VIII**Advanced Major Course AMJ -3****Biochemistry**

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

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

Enzymes: Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction of Biocatalysis: Biocatalysis in Green Chemistry” and Chemical Industry.

Lipids: Classification, Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.

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

Herbal Technology

Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products. Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmetics and biopesticides, their Botanical names, plant parts used, major chemical constituents.

Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, Catharanthus roseus, Withania somnifera, Centella asiatica, Achyranthes aspera, Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.

Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation of some medicinal plants (Withania somnifera, neem and tulsi).

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman and Co.
- Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry. IV Edition. W.H. Freeman and Co.

- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill.
- Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario of Herbal Technology worldwide: An overview. Int J Pharm Sci Res; 4(11): 4105-17.
- Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications, Jaipur.
- Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 : 88.
- Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17 :987-1000.
- Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp 218.
- AYUSH (www.indianmedicine.nic.in). About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy. New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.
- Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition, SAUNDERS/ Elsevier.
- Sivarajan, V.V. and India, B. (1994). Ayurvedic Drugs and Their Plant Sources.. Oxford & IBH Publishing Company, 1994 - Herbs - 570 pages.
- Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. Motilal Banarsidass,; Fourth edition.
- Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan, Pune.

AMJ 3 LAB

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknown sample.
2. Action of salivary amylase at optimum conditions.
3. Effect of pH on the action of salivary amylase.
4. Effect of temperature on salivary amylase.
5. Effect of inhibitor on salivary amylase.
6. Study of the activity of Trypsin using fresh tissue extracts.
7. Effect of temperature, organic solvents, on semi-permeable membrane.
8. Isolation of Genomic DNA from E Coli.

Reference Books:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman and Co.
- Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IV Edition.W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/ McGraw-Hill.
- Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario of Herbal Technology worldwide: An overview. Int J Pharm Sci Res; 4(11): 4105-17.

- Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications, Jaipur.
- Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 : 88.
- Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17 :987-1000.
- Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp 218.
- AYUSH (www.indianmedicine.nic.in). About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy. New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.
- Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition, SAUNDERS/ Elsevier.
- Sivarajan, V.V. and India, B. (1994). Ayurvedic Drugs and Their Plant Sources.. Oxford & IBH Publishing Company, 1994 - Herbs - 570 pages.
- Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. Motilal Banarsidass,; Fourth edition.
- Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan, Pune.

Advanced Major Course AMJ -4

Green Chemistry

Introduction to Green Chemistry

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

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

Green Synthesis / Reactions:

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
5. Designing of Environmentally safe marine antifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C₂S₃); Green chemistry in sustainable development.

Reference Books:

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

AMJ 4 LAB

(Following is the list of suggestive experiments. However, depending upon available resources, experiments may be added/changes may be incorporated):

1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. Preparation of biodiesel from vegetable/ waste cooking oil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates Green Chemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atom economy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
6. Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
7. Mechanochemical solvent free synthesis of azomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex.
9. Photoreduction of benzophenone to benzopinacol in presence of sunlight.
10. Preparation and characterization of nanoparticles of silver using leaf/tea leaves and starch.
11. Synthesis of Benzimidazole using an aldehyde and o-phenylenediamine using water as solvent under microwave and ultrasound irradiation.
12. Solvent free synthesis of Coumarin.
13. Microwave/ Ultrasound assisted extraction of flavanoids from plant.

Reference Books:

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

Introductory Regular Course - IRC

Introductory Chemistry

Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO₂.

Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Significance of quantum numbers, orbital angular momentum and quantum numbers *ml* and *ms*. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (*ms*). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Chemical Bonding and Molecular Structure

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

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

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

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Aliphatic Hydrocarbons

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

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

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

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO₄, ozonolysis and oxidation with hot alkaline KMnO₄.

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

- J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
 - F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
 - Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
 - James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
 - T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
 - Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
 - E. L. Eliel: Stereochemistry o f Carbon Compounds, Tata McGraw Hill.
 - I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
 - R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
 - Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand
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IRC LAB

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Section B: Organic Chemistry

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

Reference Books:

- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 6th&7th Edition.
- Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

Minor Course – MN 1**Physical and Organic Chemistry - 1****Section A: Physical Chemistry****Chemical Energetics**

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G° , Le Chatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases.

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

Section B: Organic Chemistry

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

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1 , S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols.

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

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

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

Alcohols (Upto 5 Carbons): *Preparation:* Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. **Phenols:** (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

Reference Books:

- T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.

- I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
 - R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
 - Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand..
 - G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
 - G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
 - J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage
 - Lening India Pvt. Ltd., New Delhi (2009).
 - B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
 - R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985)
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MN 1 LAB

Section A: Physical Chemistry

Thermochemistry 1. Determination of heat capacity of calorimeter for different volumes.

2.

Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

Ionic equilibria pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter. b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations:

Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

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

Reference Books

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).

Minor Course – MN 2**Physical and Inorganic Chemistry -2****GE- IV: CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS (Credits: 06)****Section A: Physical Chemistry****Chemical Kinetics**

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X-Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Section B: Inorganic Chemistry**General Principles of Metallurgy**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

s- and p-Block Elements

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred- Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of s- and p-Block Elements

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane). Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry. Hydrides of nitrogen (NH_3 , N_2H_4 , N_3H , NH_2OH)

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004)..
- J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
- B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
- R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
- F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
- D. F. Shriver and P. W. Atkins: Inorganic Chemistry, Oxford University Press. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.

MN – 2 LAB

Section A: *Physical Chemistry*

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

- Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
- Study of the variation of surface tension of a detergent solution with concentration.

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

- Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
- Study of the variation of viscosity of an aqueous solution with concentration of solute.

Section B: *Inorganic Chemistry*

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following: Cations : Pb^{2+} , Ag^+ , Bi^{3+} , Cu^{2+} , Cd^{2+} , Sn^{2+} , Fe^{3+} , Al^{3+} , Co^{2+} , Cr^{3+} , Ni^{2+} , Mn^{2+} , Zn^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , K^+ Anions : CO_3^{2-}

S^{2-} , S_2^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$

NO_3^-

CH_3COO^- , Cl^- , Br^- , I^- , SO_4^{2-}

PO_4^{3-}

BO_3^{3-}

$\text{C}_2\text{O}_4^{2-}$

F^- (*Spot tests should be carried out wherever feasible*)

Reference Books:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
 - A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
 - B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
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Minor Course – MN 3**Physical and Organic Chemistry -3****Section A: Physical Chemistry****Solutions**

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

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur)

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Conductometric titrations (only acid-base).

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G , H and S from EMF data.

Section B: Organic Chemistry**Stereochemistry**

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

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

Carboxylic acids and their derivatives Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction. **Carboxylic acid derivatives (aliphatic):** (Upto 5 carbons) *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts

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

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

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids:* ester of $-\text{COOH}$ group, acetylation of $-\text{NH}_2$ group,

complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

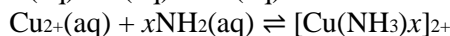
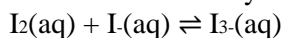
Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose).

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw- Hill (2007).
 - G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
 - J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
 - B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
 - R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
 - Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
 - Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman
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MN- 3 LAB

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



Conductance :- I. Determination of cell constant II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. III. Perform the following conductometric titrations: (i). Strong acid vs. strong base (ii). Weak acid vs. strong base (iii). Weak acid vs. strong base. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
- F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.

Jharkhand, NEP, FYUGP 2022 onwards

FORMAT OF QUESTION PAPER FOR SEMESTER INTERNAL EXAMINATION

Question format for 10 Marks:

Subject/ Code		Exam Year
F.M. =10	Time=1Hr.	
General Instructions:		
i. Group A carries very short answer type compulsory questions.		
ii. Answer 1 out of 2 subjective/ descriptive questions given in Group B .		
iii. Answer in your own words as far as practicable.		
iv. Answer all sub parts of a question at one place.		
v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[5x1=5]
i.	.....
ii.	.....
iii.	.....
iv.	.....
v.	.....
<u>Group B</u>		
2.	.....	[5]
3.	.....	[5]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 20 Marks:

Subject/ Code		Exam Year
F.M. =20	Time=1Hr.	
General Instructions:		
i. Group A carries very short answer type compulsory questions.		
ii. Answer 1 out of 2 subjective/ descriptive questions given in Group B .		
iii. Answer in your own words as far as practicable.		
iv. Answer all sub parts of a question at one place.		
v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[5x1=5]
i.	.....
ii.	.....
iii.	.....
iv.	.....
v.	.....
2.	.....	[5]
<u>Group B</u>		
3.	.....	[10]
4.	.....	[10]
Note: There may be subdivisions in each question asked in Theory Examination.		

Jharkhand, NEP, FYUGP 2022 onwards

FORMAT OF QUESTION PAPER FOR END SEMESTER UNIVERSITY EXAMINATION**Question format for 50 Marks:**

F.M. =50	Subject/ Code	Exam Year
Time=3Hrs.		
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 3 out of 5 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[5x1=5]
i.	
ii.	
iii.	
iv.	
v.	
<u>Group B</u>		
2.	[15]
3.	[15]
4.	[15]
5.	[15]
6.	[15]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 60 Marks:

F.M. =60	Subject/ Code	Exam Year
Time=3Hrs.		
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 3 out of 5 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[5x1=5]
i.	
ii.	
iii.	
iv.	
v.	
2.	[5]
3.	[5]
<u>Group B</u>		
4.	[15]
5.	[15]
6.	[15]
7.	[15]
8.	[15]
Note: There may be subdivisions in each question asked in Theory Examination.		

Jharkhand, NEP, FYUGP 2022 onwards

Question format for 75 Marks:

F.M. = 75	Subject/ Code	Exam Year
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 4 out of 6 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[5x1=5]
i.	
ii.	
iii.	
iv.	
v.	
2.	[5]
3.	[5]
<u>Group B</u>		
4.	[15]
5.	[15]
6.	[15]
7.	[15]
8.	[15]
9.	[15]
Note: There may be subdivisions in each question asked in Theory Examination.		

Question format for 100 Marks:

F.M. = 100	Subject/ Code	Exam Year
General Instructions:		
i. Group A carries very short answer type compulsory questions. ii. Answer 4 out of 6 subjective/ descriptive questions given in Group B . iii. Answer in your own words as far as practicable. iv. Answer all sub parts of a question at one place. v. Numbers in right indicate full marks of the question.		
<u>Group A</u>		
1.		[10x1=10]
i.	
ii.	
iii.	
iv.	
v.	
vi.	
vii.	
viii.	
ix.	
x.	
2.	[5]
3.	[5]
<u>Group B</u>		
4.	[20]
5.	[20]
6.	[20]
7.	[20]
8.	[20]
9.	[20]
Note: There may be subdivisions in each question asked in Theory Examination.		

Jharkhand, NEP, FYUGP 2022 onwards

3. Marks distribution will be as shown in Table No.- 11

Table No. 11: Marks distribution pattern

Subjects	FM		Semester Internal	End Semester	
Common Courses	100		---	100	
Introductory Courses	100		---	100	
Vocational Courses including Internship	100		---	100	
Non- Practical Subjects	100		25	75	
Practical Subjects	T	P	T	T	P
	75	25	15	60	25

Pass Marks in 176 Credit Course i.e. UG Hons. /Research Programme:

- i. The pass marks in 176 credit courses will be 40% of the total marks obtained in each Course offered by the student.

Table No. 12: Full Marks (FM) & Pass Marks (PM) pattern for Subjects

Subjects/ Major subjects	FM	PM
Non- Practical Subjects	100	40
Practical Subjects: Theory Paper	75	30
Practical Subjects: Practical Paper	25	10
Practical Subjects: Practical Paper	50	20
Practical Subjects: Practical Paper	75	30