UNIVERSITY OF RAJASTHAN

JAIPUR-302004

THREE/FOUR-YEAR UNDERGRADUATE PROGRAMME

Name of Faculty	**Science**
Name of Discipline	**Chemistry**
Type of Discipline	**Major**
List of Programme offered as Minor Discipline	**-NA-**
Offered to Non-Collegiate Students	**NO**

Programme: UG0806 – Four Year Bachelor of Science (Chemistry)

(Syllabus as per NEP-2020 and Choice Based Credit System)

(Academic Year 2024-25 onwards)

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SEMESTER-WISE PAPER TITLES WITH DETAILS

UG0806 – Three/Four Year Bachelor of Science (Chemistry)								
S.No,	Level	Semester	Type	Chemistry	Credits			
				Course Title	L	T	P	Total
1.	5	I	MJR	UG0806 – CHM-51T-101 – Chemical Bonding and Chemistry of Representative and Transition elements.	4	0	0	4
2.	5	I	MJR	UG0806 – CHM-51T-102 – State of Matter, Chemical Kinetics and Thermodynamics.	4	0	0	4
3.	5	I	MJR	UG0806 – CHM-51P-103 – Practical I	0	0	2	2
4.	5	I	MJR	UG0806 – CHM-51P-104 – Practical II	0	0	2	2
5.	5	II	MJR	UG0806 – CHM-52T-105 – Organic reaction mechanism, Stereochemistry, Hydrocarbons, Aliphatic and aromatic halides	4	0	0	4
6.	5	II	MJR	UG0806 – CHM-52T-106 – Principles of Analytical methods	4	0	0	4
7.	5	II	MJR	UG0806 – CHM-52P-107 – Practical I	0	0	2	2
8.	5	II	MJR	UG0806 – CHM-52P-108 – Practical II	0	0	2	2
9.	6	III	MJR	UG0806 – CHM-63T-201 –Coordination Chemistry of Transition metal Complexes with kinetic & thermodynamic aspects, Electronic and Vibrational spectroscopy, Alcohols, Ethers, Phenols and Carbonyl Compounds, Chemical and Ionic Equilibrium, Solutions with their Colligative Properties	4	0	0	4
10.	6	III	MJR	UG0806 – CHM-63T-202 – Carboxylic Acids and its Functional derivatives, N-containing Organic Compounds, Concepts of Acid & Bases, Lanthanides and Actinides, Thermodynamics-II, Phase Equilibrium and Electrochemistry-I	4	0	0	4
11.	6	III	MJR	UG0806 – CHM-63P-203 – Practical I	0	0	2	2
12.	6	III	MJR	UG0806 – CHM-63P-204 – Practical II	0	0	2	2
13.	6	IV	MJR	UG0806 – CHM-64T-205 – Organic Synthesis via Enolates, NMR Spectroscopy, Heterocyclic Compounds, Fundamentals of Molecular	4	0	0	4

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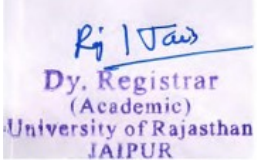
				Spectroscopy, Electrochemistry-II				
14.	**6**	**IV**	**MJR**	**UG0806 – CHM-64T-206 – Water Analysis, Chromatography, Conductometric, Potentiometric and Spectrophotometric Titrations, Nephelometry, Atomic Absorption spectrometry and Atomic Emission Spectrography.**	**4**	**0**	**0**	**4**
15.	**6**	**IV**	**MJR**	**UG0806 – CHM-64P-207 – Practical I**	**0**	**0**	**2**	**2**
16.	**6**	**IV**	**MJR**	**UG0806 – CHM-64P-208 – Practical II**	**0**	**0**	**2**	**2**
17.	**7**	**V**	**MJR**	**UG0806 – CHM-75T-301 –**	**4**	**0**	**0**	**4**
18.	**7**	**V**	**MJR**	**UG0806 – CHM-75T-302 –**	**4**	**0**	**0**	**4**
19.	**7**	**V**	**MJR**	**UG0806 – CHM-75P-303 – Practical I**	**0**	**0**	**2**	**2**
20.	**7**	**V**	**MJR**	**UG0806 – CHM-75P-304 – Practical II**	**0**	**0**	**2**	**2**
21.	**7**	**VI**	**MJR**	**UG0806 – CHM-76T-305 –**	**4**	**0**	**0**	**4**
22.	**7**	**VI**	**MJR**	**UG0806 – CHM-76T-306 –**	**4**	**0**	**0**	**4**
23.	**7**	**VI**	**MJR**	**UG0806 – CHM-76P-307 – Practical I**	**0**	**0**	**2**	**2**
24.	**7**	**VI**	**MJR**	**UG0806 – CHM-76P-308 – Practical II**	**0**	**0**	**2**	**2**
25.	**8**	**VII**	**MJR**	**UG0806 – CHM-87T-401 –**	**4**	**0**	**0**	**4**
26.	**8**	**VII**	**MJR**	**UG0806 – CHM-87T-402 –**	**4**	**0**	**0**	**4**
27.	**8**	**VII**	**MJR**	**UG0806 – CHM-87P-403 – Practical I**	**0**	**0**	**2**	**2**
28.	**8**	**VII**	**MJR**	**UG0806 – CHM-87P-404 – Practical II**	**0**	**0**	**2**	**2**
29.	**8**	**VIII**	**MJR**	**UG0806 – CHM-88T-405 –**	**4**	**0**	**0**	**4**
30	**8**	**VIII**	**MJR**	**UG0806 – CHM-88T-406 –**	**4**	**0**	**0**	**4**
31.	**8**	**VIII**	**MJR**	**UG0806 – CHM-88P-407 – Practical I**	**0**	**0**	**2**	**2**
32.	**8**	**VIII**	**MJR**	**UG0806 – CHM-88P-408 – Practical II**	**0**	**0**	**2**	**2**



PROGRAMME OUTCOMES (POs)

1. **Conceptual knowledge of chemical science**: Students will get acquainted with the conceptual knowledge of chemical science which will help them to understand the subject and it will be beneficial in long run.
2. **Training to manage unusual and unexpected incidents/disasters**: The knowledge of chemical science will help them to deal with unusual incidents in the neighborhood. Sudden explosion by chemicals and excessive misuse of unwanted substances can be managed with basic knowledge of chemistry as well as environmental pollution may be controlled by the students by spreading awareness in the society about the harmful pollutants viz; plastic, pesticides, harmful smog, unused drugs etc.

3. **Laboratory Experimental Skills**: As we know the fact that trials are an essential part of an exploration in our life therefore the students will gain practical experience by conducting experiments, using laboratory instruments and apparatus.
4. **Employment opportunities**: Students will acquire employment in the various national and private R & D sectors such as:
   - The students with the strong chemistry background can get jobs in chemical and related industries viz. Agrochemicals, Metallurgical, Fertilizer, Biofertilizer, Textile, Food, Ceramics, Cement, Petrochemicals, Pesticides, Plastics, Polymers, etc.
   - The students can find opportunities in Pharmaceutical companies, Forensic Lab,etc.
   - Petroleum, Soil Testing Labs, Environment consulting firms and other sectors such as Analytical Chemist, Chemical Product Officer, Radiologist and Toxicologist.
5. **Integrated M.Sc.-Ph.D. courses at prestigious institutions:** After completing this bachelor's degree course**, s**tudents can get engaged in integrated M,Sc.- Ph.D. courses or can get Master's degree in various interdisciplinary fields at prestigious institutions like CSIR, IISc, IITs, NCL (national chemical laboratories), IISERs, NISER etc.

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Examination Scheme:

1. 1 credit = 25 marks for examination/evaluation
2. For Regular Students there will be Continuous assessment, in which sessional work and the terminal examination will contribute to the final grade. Each course in Semester Grade Point Average (SGPA) has two components- Continuous assessment (20% weightage) and (End of Semester Examination) EoSE (80% weightage).
3. For Regular Students, 75% Attendance is mandatory for appearing in EoSE.
4. To appear in the EoSE examination of a course/subject student must appear in the mid-semester examination and obtain at least a C grade in the course/subject.
5. Credit points in a Course/Subject will be assigned only if, the regular student obtains at least a C grade in the CA (Continuous Assessment) and EoSE examination of a Course/Subject.
6. In case of the Non-Collegiate Students there will be no Continuous Assessment and credit points in a Course/Subject will be assigned only if, the Non-Collegiate Student obtains at least a C grade in the EoSE examination of a Course/Subject.

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Examination scheme for Continuous assessment (CA)

DISTRIBUTION OF CONTINUOUS ASSESSMENT (CA) MARKS

S. No.	CATEGORY	Weightage (out of total internal marks)		THEORY					PRACTICAL		
				CORE (Only Theory)	CORE (Theory + Practical)	AEC	SEC	VAC	CORE (Theory + Practical)	SEC	VAC
	Max Internal Marks			30	20	20	10	10	10	10	10
1	Mid-term Exam	50%		15	10	10	5	5	5	5	5
2	Assignment	25%		7.5	5	5	5	2.5	2.5	2.5	2.5
3	Attendance	25%		7.5	5	5	5	2.5	2.5	2.5	2.5
		Regular Class Attendance	= 75%	3	2	2	1	1	1	1	1
			75 – 80%	4	3	3	1.5	1.5	1.5	1.5	1.5
			80 – 85%	5	4	4	2	2	2	2	2
			> 85%	7.5	5	5	2.5	2.5	2.5	2.5	2.5

Note:

1. Continuous assessment will be the sole responsibility of the teacher concerned. [Under the heading assignment, Interactive sessions or group discussion among students may be conducted or PPT presentation of the selective topics may be assigned by the teacher concerned under the same at college level.]
2. For continuous assessment no remuneration will be paid for paper setting, evaluation, invigilation etc.
3. For continuous assessment paper setting and evaluation responsibility will be of teacher concerned.

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4. For continuous assessment no -Answer sheets/question papers etc. will be provided by the University.
5. Colleges are advised to keep records of continuous assessment, attendance etc.

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III – Semester – Chemistry

Examination Scheme for EoSE-

CA – Continuous Assessment
EoSE – End of Semester Examination

Regular Students –

Type of Examination	Course Code / Nomenclature	Duration of Examination		Maximum Marks		Minimum Marks	
Theory	UG0806 – CHM - 63T-201– Coordination Chemistry of Transition metal Complexes with kinetic & thermodynamic aspects, Electronic and Vibrational spectroscopy, Alcohols, Ethers, Phenols and Carbonyl Compounds, Chemical and Ionic Equilibrium, Solutions with their Colligative Properties	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Theory	UG0806 – CHM-63T- 202 – Carboxylic Acids and its Functional derivatives, N-containing Organic Compounds, Concepts of Acid & Bases, Lanthanides and Actinides, Thermodynamics-II, Phase Equilibrium and Electrochemistry-I	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Practical	UG0806 – CHM-63P-203 – Practical I	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16

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Practical	**UG0806 – CHM-63P-204 – Practical II**	**CA**	**1 Hr.**	**CA**	**10**	**CA**	**4**
		EoSE	**4 Hrs.**	**EoSE**	**40**	**EoSE**	**16**

The question paper (EoSE – End of Semester Examination) will consist of two parts A & B

PART – A: 20 Marks

Part A will be compulsory having 10 very short answer-type questions (with a limit of 20 words) of two marks each.

PART – B: 60 Marks

Part B of the question paper shall be divided into four units comprising question number 2-5. There will be one question from each unit with internal choice. Each question will carry 15 marks.

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Non-Collegiate Students –

<u>This course is not applicable for Non-Collegiate Students</u>.

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Syllabus

CHM-63T-201 – **Coordination Chemistry of Transition metal Complexes with kinetic & thermodynamic aspects, Electronic and Vibrational spectroscopy, Alcohols, Ethers, Phenols and Carbonyl Compounds, Chemical and Ionic Equilibrium, Solutions with their Colligative Properties**

CHM-63T-202 – **Concepts of Acid & Bases, Lanthanides and Actinides, Carboxylic Acids and its Functional derivatives, N-containing Organic Compounds, Thermodynamics-II, Phase Equilibrium and Electrochemistry-I**

CHM-63P-203- **Practical lab I**

CHM-63P-204- **Practical lab II**

III – Semester – Chemistry

Semester	Code of the Course	Title of the Course/Paper	NHEQF Level	Credits
III	CHM-63T-201	Coordination Chemistry of Transition metal Complexes with kinetic & thermodynamic aspects, Electronic and Vibrational spectroscopy, Alcohols, Ethers, Phenols and Carbonyl Compounds, Chemical and Ionic Equilibrium, Solutions with their Colligative Properties	6	4
III	CHM-63T-202	Concepts of Acid & Bases, Lanthanides and Actinides, Carboxylic Acids and its Functional derivatives, N-containing	6	4

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		Organic Compounds, Thermodynamics-II, Phase Equilibrium and Electrochemistry-I					
III	**CHM-63P-203**	**Practical lab I**				**6**	**2**
III	**CHM-63P-204**	**Practical lab II**				**6**	**2**
Level of Course	**Type of the Course**	**Credit Distribution**			**Offered to NC Students**	**Course Delivery Method**	
		Theory	**Practical**	**Total**			
6	**Major**	**4+4**	**2+2**	**12**	**No**	**Lecturer, Sixty Lectures**	**Classroom teaching and through PPT.**
List of Programme Codes in which offered as Minor Discipline		**-NA-**					
Prerequisites/Eligibility		The students must have earned a minimum of 52 credits (26×2 cerdits) OR For promotion from the current year to next year it is mandatory to pass all the prescribed co-course of the previous year with the minimum of C grade (40 %).					
Course Objectives:		The main aim of this course is to provide students with a theoretical understanding of electronic and vibration spectroscopy, coordination chemistry of d-block element's having kinetics and thermodynamic aspects along with lanthanides and actinides chemistry. Moreover, our aim is to provide clear understanding of the organic reactions associated with the functional group of oxygen or nitrogen containing organic compounds and their interconversion. Concepts and theories of acids & bases, chemical and ionic equilibrium, solutions with their colligative properties are also included. Concepts related to the field of basic and applied thermodynamics 2nd and 3rd law and phase equilibrium as well as basics of electrochemistry are also added in the course to enrich the student knowledge.					

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Syllabus

CHM-63T-201 – Coordination Chemistry of Transition metal Complexes with kinetic & thermodynamic aspects, UV & IR spectroscopy, Alcohols, Ethers, Phenols and Carbonyl Compounds, Chemical and Ionic Equilibrium, Solutions with Colligative Properties.

Unit-I

Coordination Compounds:
Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complex.

Metal-ligand bonding in Transition Metal complexes:
Limitations of valence bond theory, an elementary idea of crystal-field theory, crystal-field splitting in octahedral, tetrahedral and square planar complexes, factors affecting the crystal-field parameters.

Magnetic properties of Transition Metal Complexes:
Types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes

Electron Spectra of Transition Metal Complexes:
Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

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Thermodynamic and Kinetic Aspects of Metal Complexes:
A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes.

15 Lecture

Unit-II

Electromagnetic Spectrum: An Introduction
Absorption Spectroscopy
Ultraviolet (UV) spectroscopy - Absorption laws (Beer-Lambert Law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of solvents on transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.

Infrared (IR) spectroscopy - Molecular vibrations, Hook's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristics absorption of various functional groups and interpretation of IR spectra of simple organic compounds.

15 Lecture

Unit-III

Alcohols - Classification and nomenclature.
Monohydric alcohols - Methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding, Acidic nature. Reactions of alcohol with mechanism.
Dihydric alcohols - methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol-pinacolone rearrangement. Trihydric alcohols - methods of formation, chemical reactions of glycerol.

Phenols
Nomenclature, structure and bonding. Preparation of Phenols. Physical properties and acidic character. Comparative acidic strength of alcohols and phenols. Reactions of phenols- electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Fries rearrangement, Claisen rearrangement, Gattermann synthesis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Ethers and Epoxides
Methods of formation, physical properties. Chemical reactions - cleavage and autooxidation. Ziesel's method.
Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

Aldehydes and Ketones
Structure of the carbonyl group. Syntheses of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, syntheses of ketones from nitriles and from carboxylic acids. Physical properties.
Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Wittig reaction, Mannich reaction. Oxidation of aldehydes, Baeyer-Villiger oxidation of ketones, Cannizzaro reaction, MPV (Meervein-Pondrof-Verley), Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions, Halogenation of

enolizable ketones. Use of acetals and 1,3-dithiane as protecting group.

15 Lecture

Unit-IV

Chemical Equilibrium:
Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le Chatelier's principle. Reaction Isotherm and reaction isochore. Clapeyron equation and Clausius-Clapeyron equation, applications.

Ionic Equilibrium: 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.

Solutions, Dilute Solutions and Colligative Properties:
Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient.
Dilute solution, colligative properties, Raoult's law, relative lowering of vapor pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression in freezing point. Thermodynamic derivation of relation between molecular weight and elevation of boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, degree of dissociation and association of solutes.

15 Lecture

Suggested Books and References:

1. Concise Coordination Chemistry by R. Gopalan and V. Ramalingam, Vikas Publishing House Pvt, Ltd.
2. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Willey.
3. Concise Inorganic Chemistry by J. D. Lee, Wiley-India.
4. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
5. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
6. Concepts and Models of Inorganic Chemistry, B.E. Douglas, D. McDaniel, & J. Alexander, Wiley.
7. Organic Chemistry by R. T. Morrison & R. N. Boyed, Prentice Hall.
8. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, TRINITY Press.
9. Organic Chemistry by I. L. Finar, (Vol. I & II) ELBS.
10. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
11. A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International Publishers.
12. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford.

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Syllabus

CHM-63T-202 – Concepts of Acids & Bases, Lanthanides and Actinides, Carboxylic Acids and its Functional derivatives, N-containing Organic Compounds, Thermodynamics-II, Phase Equilibrium and Electrochemistry-I.

Unit I

Acids and Bases:
Theories: Arrhenius, Bronsted-Lowry, Lux-Flood. Solvent system concept and Lewis's concept of acids and bases.

Hard and Soft Acids and Bases (HSAB):
Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.

Chemistry of Lanthanide and Actinide Elements:
Electronic structure, oxidation states, ionic radii and lanthanide contraction, complex formation, occurrence

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and isolation, lanthanide compounds.
General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, similarities between the later actinides and the later lanthanides.

15 Lecture

Unit II

Carboxylic Acids
Structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Preparation of carboxylic acids. Reactions of carboxylic acids, Hell-Volhard-Zelinsky reaction. Reduction of carboxylic acids, mechanism of decarboxylation.
Methods of formation and chemical reactions of halo acids. Hydroxy acids - malic, tartaric and citric acids. Dicarboxylic acids: methods of formation and effect of heat and dehydrating agents (succinic, glutaric and adipic acids).

Carboxylic Acid Derivatives
Structure, nomenclature and synthesis of acid chlorides, esters, amides (urea) and acid anhydrides. Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.
Preparation of carboxylic acid derivatives, chemical reactions, mechanisms of esterification and hydrolysis (acidic and basic).

Organic Compounds of Nitrogen
Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid.
Amines: Structure, nomenclature and preparation of alkyl, and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Physical properties, stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts. Gabriel-phthalimide reaction and Hoffmann bromamide reaction with mechanism.
Reactions of amines, electrophilic aromatic substitution in aryl amines, reactions of amines with nitrous acid. diazotisation and mechanism. Synthetic transformations of aryl diazonium salts, azo coupling and its applications.

15 Lecture

Unit III

Thermodynamics –II
Second Law of Thermodynamics: Need for the law, different statements of the law. Carnot cycle and its efficiency, Carnot-Theorem. Thermodynamic scale of temperature.
Concept of Entropy: Entropy as a state function, entropy as a function of V&T, entropy as a function of P&T, entropy change in physical change, Clausius inequality and entropy as a criteria of spontaneity and equilibrium. Entropy changes in ideal gases and mixing of gases.
Third Law of Thermodynamics: Nernst heat theorem, statement and concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions: Gibbs function (G) and Helmholtz function **(A)** as: thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change. Variation of G and A with P, V and T.
Phase Equilibrium: Statement and meaning of the terms: phase, component and degree of freedom,

derivation of Gibbs phase rule, phase equilibria of one component system - water, CO_2 and Sulphur systems.

Phase equilibria of two component system - solid-liquid equilibria simple eutectic Bi-Cd, Pb-Ag systems, desilverization of lead.

15 Lecture

Unit IV

Electrochemistry – I

Electrical transport-conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution.

Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald's dilution law, its uses and limitations. Debye- Huckel-Onsager's equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf 's method and moving boundary method.

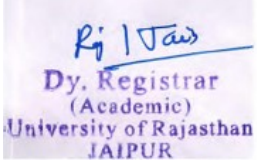
Applications of conductivity measurements:

Determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

15 Lecture

Suggested Books and References:

1. Basic Inorganic Chemistry, F.A. Cotton, G. Wilkinson, & P.L Gaus, Willey.
2. Concise Inorganic Chemistry by J. D. Lee, Wiley-India.
3. Inorganic Chemistry by Catherine E. Housecroft, & Alan G Sharpe, Pearson Education Ltd.
4. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
5. Concepts and Models of Inorganic Chemistry, B.E. Douglas, D. McDaniel, & J. Alexander, Wiley.
6. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J March, & M. B Smith Wiley.
9. Organic Chemistry by R. T. Morrison & R. N. Boyed, Prentice Hall
10. Reaction Mechanism in Organic Chemistry by S. M. Mukherji & S. P. Singh, TRINITY Press.
11. Organic Chemistry by I. L. Finar, (Vol. I & II) ELBS.
12. Physical Chemistry by R. J. Silbey, R. A. Alberty & M. G. Bawendi, John Wiley & Sons.
13. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
14. An Introduction to Chemical Thermodynamics by R. P. Rastogi & R. R. Mishra, Vikas Publishing House.
15. A Text Book of Physical Chemistry: A. S. Negi and S. C. Anand, New Age International Publishers.
16. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
17. Elements of Physical Chemistry, P. Atkins and J. De Paula, Oxford.
18. A Textbook of Physical Chemistry, Application of Thermodynamics, by K. L. Kapoor, (Volume-3) McGraw Hill.
19. An Introduction to Electrochemistry by Samuel Glasstone, BSC Publishers.
20. Electrochemistry and its Applications by G. Whitmore, Sarup & Sons.



21. Physical Chemistry by G.M Barrow, Tata McGraw-Hill.
22. Fundamentals of Electrochemistry by Morris Sylvin, Sarup & Sons.
23. Solutions, Phase Equilibrium, Conductance & Electrochemistry by Puri, Sharma, Pathania and Kaur, Vishal Publishing Co.
24. Phase Equilibria, Phase Diagrams and Phase Transformations by Mats Hillert, Cambridge University Press.

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Syllabus

CHM-63P-203: Practical I **4 Hrs./week**

Inorganic Chemistry

Quantitative (Gravimetric) (*any three*)

a) Estimation of Barium (as sulphate)
b) Lead (as chromate)
c) Zinc (as Zinc ammonium phosphate)
d) Magnesium (as Magnesium hydrogen phosphate, $MgHPO_4$)

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Organic Chemistry

(i) Identification of simple organic compound and preparation of its suitable derivative.

15 marks

Chemical Dynamics experiments:

a) To find the velocity constant of the hydrolysis of methyl acetate catalyzed by an acid.
b) To determine the order of saponification of ethyl acetate by NaOH.
c) To find out the rate constant and order of reaction between potassium persulphate and potassium iodide,
d) To study the reaction between acetone and iodine.

Viva voce **5 marks**

Practical Record **5 marks**

Suggested Books and References:

1. Vogel's textbook of practical organic chemistry including **Qualitative** organic Analysis, by A. I. Vogel Longman, London and New York. Prentice Hall.
2. A. I. Vogel, Vogel's **Quantitativ**e Inorganic Analysis Including Elementary Instrumental Analysis, ELBS.
3. Advance Practical Inorganic Chemistry by Gurdeep Raj, Goel Publishing House.
4. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
5. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
6. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD
7. 7.Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis,V. K Ahluwalia. Universities Press, Hyderabad.
8. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House

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Syllabus

CHM-63P-204: Practical II 4 Hrs./week

Inorganic Chemistry **10 Marks**

Inorganic Preparations (*any four*) **of coordination compounds and their characterization:**

(a) Chloropentamminecobalt(III) chloride.

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(b) Pyridine complex of copper.
(c) Tetramminecopper(II) sulphate.
(d) Mercury tetrathiocyanatocobaltate.
(e) Prussian blue.
(f) Hexaamminenickel(II) chloride.

Organic preparation **10 Marks**

Simple one step organic preparation-

The students are expected to perform at least five of the following preparations:

(a) Preparation of m-dinitrobenzene from nitrobenzene.
(b) Preparation of acetanilide from aniline.
(c) Preparation of aspirin from salicylic acid.
(d) Preparation of o-and p-bromo acetanilide from acetanilide.
(e) Preparation of o-and p-bromo aniline from o-and p-bromoacetanilide.
(f) Partial reduction of m-dinitrobenzene into m-nitro aniline.
(g) Preparation of methyl orange from sulphanilic acid

Physical Chemistry **10 Marks**

Transition temperature:

a) Determination of transition temperature by thermometric and dialometric method.

Molecular weight determination:

a) Determination of molecular weight of non-volatile solute by cryoscopic method and application of technique for determination of the Van't Hoff factor or degree of dissociation of an electrolyte.

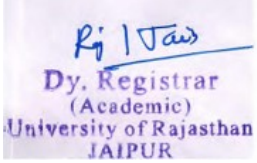
Viva voce **5 marks**

Practical Record **5 marks**

Suggested Books and References:

1. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
2. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD
4. 4.Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
5. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD
6. 6.Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
7. 7.Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
8. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, N

Suggested E-resources:



All the above suggested books are available as **e- books.**

Online Lecture Notes and Course Materials:

All prescribed syllabus is available digitally in the form of e-books, Adobe Acrobat documents (PDF), web page ,etc.

Course Learning Outcomes:

By the end of this degree programme, student will achieve the essential conceptual knowledge in the field of chemical sciences and will be able to conduct experiments and demonstrate efficiency with appropriate lab skills, techniques and instrumentations.

With the completion of this course, students will be able to understand various concepts related to periodic trends, properties and applications of d -and f-block elements, Furthermore, student will gain knowledge related to organic reactions based on O/N- containing functional groups with their practical utility. Moreover, theories of acids & bases, chemical and ionic equilibrium, solutions with their colligative properties are also added therefore students can relate their applications in our day to day lives. Concepts related to the field of basic and applied thermodynamics 2nd and 3rd law and phase equilibrium as well as basics of electrochemistry are also added in the course to enrich the student knowledge. The topics of basic and applied thermodynamics and solutions with their colligative properties will also fruitful for the students to gain awareness in physical science so that students will be benefited in the long run.

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IV – Semester – Chemistry

Examination Scheme for EoSE-

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CA – Continuous Assessment
EoSE – End of Semester Examination

Regular Students –

Type of Examination	Course Code / Nomenclature	Duration of Examination		Maximum Marks		Minimum Marks	
Theory	CHM - 64T-205– Organic Synthesis via Enolates, NMR Spectroscopy, Heterocyclic Compounds, Fundamentals of Molecular Spectroscopy, Electrochemistry-II	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Theory	CHM-64T- 206 – Water Analysis, Chromatography, Conductometric, Potentiometric and Spectrophotometric Titrations, Nephelometry, Atomic Absorption spectrometry and Atomic Emission Spectrography.	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Practical	CHM-64P-207 – Practical I	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16
Practical	CHM-64P-208 – Practical II	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16

The question paper (EoSE) will consist of two parts A & B

PART – A: 20 Marks

Part A will be compulsory having 10 very short answer-type questions (with a limit of 20 words) of two marks each.

PART – B: 60 Marks

Part B of the question paper shall be divided into four units comprising question number 2-5. There will be one question from each unit with internal choice. Each question will carry 15 marks.

Non-Collegiate Students –

This course is not applicable for Non-Collegiate Students.

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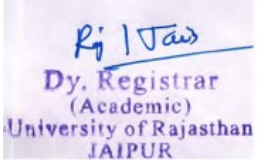
IV– Semester – Chemistry



Semester	Code of the Course	Title of the Course/Paper				NHEQF Level	Credits
IV	CHM-64T-205	Organic Synthesis via Enolates, NMR Spectroscopy, Heterocyclic Compounds, Fundamentals of Molecular Spectroscopy, Electrochemistry-II				6	4
IV	CHM-64T-206	Water Analysis, Chromatography, Conductometric, Potentiometric and Spectrophotometric Titrations, Nephelometry, Atomic Absorption spectrometry and Atomic Emission Spectrography.				6	4
IV	CHM-64P-207	Practical lab I				6	2
IV	CHM-64P-208	Practical lab II				6	2
Level of Course	Type of the Course	Credit Distribution			Offered to NC Students	Course Delivery Method	
		Theory	Practical	Total			
6	Major	4+4	2+2	12	No	Lecturer, Sixty Lectures	PPT, Laboratory Exposure
List of Programme Codes in which offered as Minor Discipline		-NA-					
Prerequisites/Eligibility		Every student automatically promoted from the 3rd to 4th semester.					
Course Objectives:		The main objective of this course is to provide deep understanding in the organic synthesis involves enolate as intermediates and fundamentals of molecular spectroscopy along with chemistry of N, O and S heteroatom containing organic compounds. Furthermore, electrochemistry having various reversible electrodes with theory, design operation and applications are incorporated to provide interdisciplinary nature of this field. Moreover, some instrumental methods of chemical analysis such as water analysis, various titrations and atomic absorption spectrometry and emission spectroscopy are incorporated to enrich the student's knowledge.					

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Syllabus

IV – Semester (2024-2025)

Course Code	Course Title	Duration of Examination		Maximum Marks		Minimum Marks	
CHM-64T-205-	Organic Synthesis via Enolates, NMR Spectroscopy, Heterocyclic Compounds, Fundamentals of Molecular Spectroscopy, Electrochemistry-II	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
CHM-64T-206-	Water Analysis, Chromatography, Conductometric, Potentiometric and Spectrophotometric Titrations, Nephelometry, Atomic Absorption spectrometry and Atomic Emission Spectrography.	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
CHM-64P-207-	Practical lab I	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16
CHM-64P-208-	Practical lab II	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16

Course Objectives: The main objective of this course is to provide deep understanding in the organic synthesis involves enolate as intermediates and fundamentals of molecular spectroscopy along with chemistry of N, O and S heteroatom containing organic compounds. Furthermore, electrochemistry having various reversible electrodes with theory, design operation and applications are incorporated to provide interdisciplinary nature of this field.

Moreover, Some instrumental methods of chemical analysis such as water analysis, various titrations and atomic absorption spectrometry and emission spectroscopy are incorporated to enrich the student's knowledge.

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Syllabus

CHM-64T-205- Organic Synthesis via Enolates, NMR Spectroscopy, Heterocyclic Compounds, Fundamentals of Molecular Spectroscopy, Electrochemistry-II

Unit-I

Organic Synthesis via Enolates: Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Claisen condensation, Keto-enol tautomerism in ethyl acetoacetate. Synthetic applications of ethyl acetoacetate and malonic ester.

Nuclear Magnetic Resonance (NMR) Spectroscopy:
Proton magnetic resonance (^{1}H-NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals. Interpretation of NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone. Problems pertaining to the structure elucidation of simple organic compounds using ^{1}H NMR data.

15 Lecture

Unit-II

Heterocyclic Compounds
Introduction: Molecular orbital diagram and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reactions in pyridine and derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.
Introduction to condensed five- and six-membered heterocyles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher-indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis, Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

15 Lecture

Unit-III

Spectroscopy:
Introduction: Electromagnetic radiation, spectrum, basic features of different spectrometers, statement of the Born-Openheimer approximation, degrees of freedom.

Rotational Spectrum: Diatomic molecules, Energy levels of a rigid rotator (semi-classical principles),

selection rules, spectral intensity, using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotator, isotope effect.

Vibrational Spectrum: Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman Spectrum: Basic principles and applications, concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum: Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Frank Condon principle. qualitative description of σ, π and n M.O. their energy levels and the respective transitions.

15 Lecture

Unit-IV

Electrochemistry –II

Types of reversible electrodes: Gas–metal- ion, metal-metal ion, metal-insoluble salt anion and redox electrodes, electrode reactions, Nernst equation, derivation of cell E.M.F. and single electrode potential, standard hydrogen electrode, reference electrodes, standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells - reversible and irreversible cells, conventional representation of electrochemical cells.

EMF of a cell and its measurements, Computation of cells EMF. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K), polarization, over potential and hydrogen overvoltage.

Concentration cell with and without transport, liquid junction potential, application of concentration cells. Valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a, determination of pH using hydrogen quinhydrone and glass electrodes, by potentiometric methods.

15 Lecture

Suggested Books and References:

1. Organic Chemistry by S. S, Gupta, Oxford University Press.
2. Organic Reaction Mechanisms by V. K.Ahluwalia, Narosa Publishing House, New Delhi.
3. Organic Chemistry – Reactions and Reagents Complete Theoretical Organic Chemistry, by O. P Agarwal, Covering Goel Publishing House, Meerut.
4. Organic Chemistry by R.T Morrison. & R. N Boyed., Prentice Hall.
5. Organic Chemistry by I. L Finar, (Vol. I & II) ELBS.
6. Advanced Organic Chemistry by A Bahl. & B. S Bahl., S. Chand.
7. Organic Chemistry by C. N Pillai., Oxford University Press.
8. Modera Organic Chemistry by M. K Jain & S.C. Sharma, Vishal Publishing Co.
9. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure by J March, & M. B Smith Wiley.

10. Stereochemistry of Organic Compounds by V. K. Ahluwalia, Springer.
11. Heterocyclic Chemistry – Third Edition by Thomas L. Gilchrist, Pearson.
12. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Campus Book House.
13. Spectrometric Identification of Organic Compounds by Robert Silverstein, Wiley.
14. Fundamentals of Molecular Spectroscopy by P. S. Sindhu, New Age International.
15. Introduction to Spectroscopy – Fifth Edition by Pavia, Lampman, Kriz & Vyvyan Cengage India Private Limited.
16. Modern Spectroscopy – Fourth Edition by J. Michael Hollas, John Wiley & Sons.\
17. Spectroscopy by B. K. Sharma, Goel Publishing House.
18. An Introduction to Electrochemistry by Samuel Glasstone, BSC Publishers.
19. Electrochemistry and its Applications by G. Whitmore, Sarup & Sons.
20. Physical Chemistry by G.M Barrow, Tata McGraw-Hill.
21. Fundamentals of Electrochemistry by Morris Sylvin, Sarup & Sons.
22. Solutions, Phase Equilibrium, Conductance & Electrochemistry by Puri, Sharma, Pathania and Kaur, Vishal Publishing Co.

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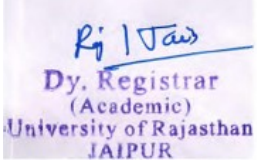

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Syllabus

CHM-64T-206-4 Hrs./week **Water Analysis, Chromatography, Conductometric, Potentiometric and Spectrophotometric Titrations, Nephelometry, Atomic Absorption spectrometry and Atomic Emission Spectrography.**

Unit-I

Water Analysis

Water pollutants and their analysis: Water analysis, analysis of water for dissolved oxygen, B.O.D. and C.O.D. Biological treatment methods. Prevention of water pollution by treatment of industrial wastes with special reference to cement, fertilizer and dyeing industries.

Air pollution: General consideration types of air pollutants, unit of measurement, sampling monitoring and analysis of CO and SO_2 in atmosphere, effect of air pollutants on plants and human health, method for pollution control, especially for pollution by automobiles.

15 Lecture

Unit-II

Chromatography: Principles of absorption and partition chromatography, techniques and application of column, paper and thin layer chromatography. Electrophoresis and its applications in separation of amino acids.

Ion exchange methods: General discussion, action of ion exchange resins, column operation, experimental techniques, types of ion exchange resins, determination of the following pairs by ion exchange techniques: (a) chloride and bromide (b) nickel and cobalt.

15 Lecture

Unit-III

Conductometric titrations: The basis of conductometric titrations. Apparatus and measurement, application of conductometric titrations. High frequency titrations, advantages of the techniques, some examples of high frequency titrations.

Potentiometric titrations: Introduction, electrodes, instrumentation, potentiometric titrations, differential

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potentiometric titrations, automatic potentiometric titrations, location of end points, determination of some metals through potentiometric titrations.

15 Lecture

Unit-IV

Spectrophotometric titrations: Basic principle. instrumentation experimental techniques, spectrophotometric analysis of Fe (III), Co (I), Ni (II), Fe (II) in presence of Al (III) with EDTA.
Nephelometry & Turbidimetry: General discussion, instrumentation, some nephelometry determination (a) sulphate (b) phosphate

Flame Emission and Atomic Absorption Spectrometry: Basic principle, instrumentation. Nebulization, flames and flame temperatures, interferences, flame spectrometric techniques.
Atomic Emission Spectrography: Spectroscopic sources, instruments for emission spectrographic analysis, qualitative and quantitative spectrographic analysis. Qualitative spectrographic analysis of a non-ferrous alloy and complex organic mixture.

15 Lecture

Suggested Books and References:

1. Instrumental Methods of Chemical analysis (Analytical Chemistry), Chatwal, R Gurdeep, S Anand, Himalaya Publishing House.
2. Analytical Chemistry Chatwal, R. Gurdeep, Himalaya Publishing House.
3. Skoog and West's Fundamentals of Analytical Chemistry by M. Donald, A Douglas, F. Holler James, F. West et al, 2022, Cengage Learning India Pvt. Ltd.
4. Basic Concepts of Analytical Chemistry – Fourth Edition by S. M. Khopkar, New Age International Publisher.
5. Instrumental Methods of Chemical Analysis (Analytical Chemistry) by B. K. Sharma, Goel Publishing House.
6. Environmental Chemistry by A. K. De, New Age International Publisher.
7. Fundamental Concepts of Environmental Chemistry by G. S. Sodhi, Narosa Publishing House.

Suggested E-resources: All the above suggested books are available as **e- books.**

Online Lecture Notes and Course Materials:

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Syllabus

CHM-64P-207: Practical lab I 4 Hrs./week

Inorganic Chemistry

Ex. 1 **Qualitative analysis** of mixture containing six radicals one of which should be a rare earth metal ion. The mixture may contain radicals of any combination including interfering acid radicals and insoluble.

10 marks

Ex. 2 **Quantitative analysis:** Estimation of *any three* of the following mixtures by volumetric and gravimetric methods.

a) Copper-Zinc
b) Zinc-Nickel
c) Copper-Nickel **10 marks**

Organic Chemistry

Ex. 3. **Quantitative Estimations**

(a) Determination of neutralization equivalent of an organic acid.
(b) Determination of Saponification value of an ester/oil.
(c) Determination of iodine value of an oil to measure unsaturation.
(d) Estimation of glucose by titration with Fehling's solution/ Benedict solution. **10 marks**

Viva voce **5 marks**

Practical Record **5 marks**

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Suggested Books and References:

1. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
2. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD
4. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.
5. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD
6. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
7. Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd.
8. Laboratory Techniques in Organic Chemistry by V. K Ahluwalia, I K International, New Delhi.

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Syllabus

CHM-64P-208- Practical lab II **4 Hrs./week**

A) Conductometry: **10 Marks**

a) To find out the strength of strong acid by titrating it against strong alkali.
b) To find out the strength of weak acid by titrating it against a strong alkali.

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c) To find out the strength of hydrochloric acid and acetic acid in a mixture of both, by titrating it against sodium hydroxide.
d) Determination of equivalent conductivity of an electrolyte at different dilutions.

B) Spectrophotometery or Colourimetry: 10 Marks

a) Verify Lambert Beer Law & determine the concentration of the given aqueous solution of unknown concentration of salt ($KMnO_4$, $CuSO_4$, $K_2Cr_2O_7$)

C) pH metric titrations:

a) To find out the strength of strong acid by titrating it against strong base.
b) To find out the strength of strong acid by titrating it against weak base.
c) To find out the strength of weak acid by titrating it against strong base.
d) Find out the strength of HCl and CH_3COOH in a mixture of both by titrating it against NaOH.

D) Determination of DO, COD and BOD of different water samples.

Viva voce 5 marks

Practical Record 5 marks

Suggested Books and References:

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2. Advanced Practical Physical Chemistry J. B. Yadav, Goel Publishing House.
3. Practical Physical Chemistry B. D Khosla, S. Chand & Company.
3. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD

4.Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, V. K Ahluwalia. Universities Press, Hyderabad.

5. Advanced Practical Organic Chemistry by N K Vishnoi, Vikas Publishing House PVT LTD

6.Vogel's Textbook of Quantitative Chemical Analysis, A. I. Vogel, Pearson Education Ltd

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Suggested E-resources: All the above suggested books are available as **e- books.**

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Course Learning Outcomes:

With the completion of this degree programme, student will achieve the essential conceptual knowledge in the field of chemical sciences and will be able to conduct experiments and demonstrate efficiency with appropriate lab skills, techniques and instrumentations.

By the end of this course, students will be able to understand the use of enolates as reagents in organic synthesis, fundamentals of molecular spectroscopy along with chemistry of monocyclic and fused heterocyclic organic compounds with their applications. Furthermore, student will get awareness about standard and various reversible electrodes along with their theory, design, operation, applications and the interdisciplinary nature of the electrochemistry.

Instrumental methods of chemical analysis such as water analysis, various titrations and atomic absorption spectrometry and emission spectroscopy will provide knowledge in the field of analytical chemistry by the above prescribed course.

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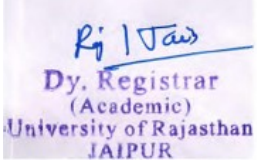

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