



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	-Yes -

Programme: UG0802/03 – Three/Four Year Bachelor of Science

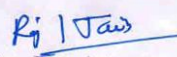
(Syllabus as per NEP-2020 and Choice Based Credit System)

(Academic Year 2025-26 onwards)

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SEMESTER-WISE PAPER TITLES WITH DETAILS

UG0802/03 – Three/Four Year Bachelor of Science								
S.No.	Level	Semester	Type	Chemistry	Credits			
				Course Title	L	T	P	Total
1.	5	I	MJR	UG0802/03 – CHM-51T-101 — Chemistry of s -& p-block elements. Noble Gases, Nuclear Chemistry, Fundamentals of organic chemistry, Stereochemistry, Mathematical concepts and Chemical kinetics.	4	0	0	4
2.	5	I	MJR	UG0802/03– CHM-51P-102 – Practical I	0	0	2	2
3.	5	II	MJR	UG0802/03 – CHM-52T-103 – Chemical bonding. Mechanism of Organic Reactions, Aromatic and Aliphatic Hydrocarbon, Alkyl Halides, States of Matter.	4	0	0	4
4.	5	II	MJR	UG0802/03 – CHM-52P-104 – Practical II	0	0	2	2
5.	6	III	MJR	UG0802/03 – CHM-63T-201 –	4	0	0	4
6.	6	III	MJR	UG0802/03 – CHM-63P-202 – Practical III	0	0	2	2
7.	6	IV	MJR	UG0802/03 – CHM-64T-203 –	4	0	0	4
8.	6	IV	MJR	UG0802/03 – CHM-64P-204 – Practical IV	0	0	2	2
9.	7	V	MJR	UG0802/03 – CHM-75T-301 – Hard & Soft Acids and Bases, Transition metal complexes, Spectroscopy, Organosulphur compounds, Synthetic Polymers, Drugs & Dyes. Electrochemistry.	4	0	0	4
10.	7	V	MJR	UG0802/03 – CHM-75P-302 – Practical V	0	0	2	2
11.	7	VI	MJR	UG0802/03 – CHM-76T-303 – Bioinorganic chemistry, Organometallic chemistry, Heterocyclic chemistry, Carbohydrates, Spectroscopy, Quantum Mechanics and MOT	4	0	0	4
12.	7	VI	MJR	UG0802/03 – CHM-76P-304 – Practical VI	0	0	2	2
13.	8	VII	MJR	UG0802/03 – CHM-87T-401 –	4	0	0	4
14.	8	VII	MJR	UG0802/03 – CHM-87P-402 – Practical VII	0	0	2	2


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15.	8	VIII	MJR	UG0802/03 – CHM-88T-403 –	4	0	0	4
16.	8	VIII	MJR	UG0802/03 – CHM-88P-404 – Practical VIII	0	0	2	2

PROGRAMME PREREQUISITES/ELIGIBILITY	
12 th standard pass in science from CBSE, RBSE or a recognized board of education.	
PROGRAMME OUTCOMES (POs)	
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. 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. 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. 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. Integrated M. Sc-Ph.D. courses at prestigious institutions: After completing this bachelor's degree course, students 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 Credit = 25 marks for examination/evaluation.**

❖ **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).
- 75% Attendance is mandatory for appearing in EoSE.
- 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.
- 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.

❖ **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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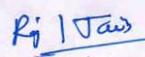
Examination scheme for Continuous assessment (CA)

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
			75 – 80%	4	3	3	1.5	1.5	1.5	1.5
			80 – 85%	5	4	4	2	2	2	2
			> 85%	7.5	5	5	2.5	2.5	2.5	2.5

Note:

- Continuous assessment will be the sole responsibility of the teacher concerned (under


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the heading assignment, interactive sessions/ group discussion among students may be conducted by the concerned teacher / PPT for selective topics may be assigned by the teacher 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 concern.
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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V – Semester – [Chemistry]

Examination Scheme for EoSE-

CA – Continuous Assessment

EoSE – End of Semester Examination

For Regular Students –

Type of Examination	Course Code / Nomenclature	Duration of Examination		Maximum Marks		Minimum Marks	
Theory	CHM-75T-301 - Hard & Soft Acids and Bases, Transition metal complexes, Spectroscopy, Organosulphur compounds, Synthetic Polymers, Drugs & Dyes. Electrochemistry.	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Practical	CHM-75P-302 – Practical -V	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16

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

PART – A: 20 Marks

Part A will be compulsory, consisting of 10 very short answer-type questions (with a limit of

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20 words) covering the entire syllabus, carrying two marks for each.

PART – B: 60 Marks

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

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For Non-Collegiate Students –

Type of Examination	Course Code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Marks
Theory	CHM-75T-301 - Hard & Soft Acids and Bases, Transition metal Complexes, Spectroscopy, Organosulphur Compounds, Synthetic Polymers, Drugs & Dyes. Electrochemistry.	3 Hrs.	100	40
Practical	CHM-75P-302 – Practical -V	4 Hrs.	50	20

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

PART – A: 20 Marks

Part A will be compulsory, consisting of 10 very short answer-type questions (with a limit of 20 words) covering the entire syllabus, carrying two marks for each.

PART – B: 80 Marks

Part -B of the question paper will have four questions with internal choice comprising of question number 2-5 which will be divided into four units. There will be one question with internal choice from each unit. Each question will carry 20 marks.

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SYLLABUS

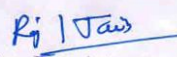
V – Semester – [Chemistry]

[UG0802/03]-[CHM-75T-301]- Hard & Soft Acids and Bases, Transition metal Complexes, Spectroscopy, Organosulphur Compounds, Synthetic Polymers, Drugs & Dyes. Electrochemistry

[UG0802/03]-[CHM-75P-302]- PRACTICAL-V

V – Semester – [Chemistry]

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits
V	CHM-75T-301	Hard & Soft Acids and Bases, Transition metal Complexes, Spectroscopy, Organosulphur Compounds, Synthetic Polymers, Drugs & Dyes, Electrochemistry.			7	4
V	CHM-75P-302	PRACTICAL-I			7	2
Level of Course	Type of the Course	Credit Distribution			Offered to NC Students	Course Delivery Method
		Theory	Practical	Total		


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7	Major	4	2	6	Yes	Through Lecture, Sixty (60) Lectures	Class room Teaching/Power- Point (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 credits) 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 C grade (40%).					
Course Objectives:		The main objective of this course is to provide students with a theoretical and conceptual understanding of the principles and applications of HSAB theory in predicting the stability and reactivity of chemical species. Furthermore, the coordination chemistry for transition metals including crystal field theory and ligand field theory is also explored. Principles and applications of electronic transitions (UV), vibrational modes (IR) including NMR Spectroscopic study are also incorporated in this course to determine the structures and dynamics of organic molecules. Structure, synthesis, and reactivity of sulfur-containing organic molecules along with structure, properties and applications of synthetic polymers are also included to enhance knowledge in this field. Chemistry and applications of synthetic drugs and industrial dyes along with the principles of electrochemistry, redox reactions, and applications such as batteries, fuel cells, and electroplating are also incorporated to provide knowledge. This course aims to furnish theoretical concepts with practical applications and to effectively prepare students for advanced studies, critical thinking skills and research in chemistry.					

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Detailed Syllabus

V – Semester – [Chemistry]

**CHM-75T-301-
(4 Hrs./week)**

Hard & Soft Acids and Bases, Transition metal complexes, Spectroscopy, Organosulphur compounds, Synthetic Polymers, Drugs & Dyes, Electrochemistry.

Unit-I

Hard & 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.

Metal-ligand bonding in Transition Metal Complexes:

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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.

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. Applications of UV-visible spectroscopy, electronic spectra.

Infrared (IR) spectroscopy - Molecular vibrations, modes of vibrations in diatomic, linear and non-linear polyatomic molecules. Force constant and its significance. 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. Applications of infrared spectroscopy in elucidation of structure of molecules.

Nuclear Magnetic Resonance (NMR) Spectroscopy:

Proton magnetic resonance (^1H -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 ^1H NMR data.

15 Lecture

Unit-III

Organosulphur Compounds: Nomenclature, structural features, methods of formation and chemical reactions of thiols, sulphonic acids, sulphonamides. Sulpha drugs: sulphacetamide, sulphaguanidine, sulphadiazine, sulphapyrimidine, sulphamethoxazole.

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.

Synthetic Polymers: Addition or chain-growth polymerization. Free radical and ionic polymerization. Ziegler-Natta catalyst condensation or step-growth polymerization. Polyesters, polyamides, phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins and polyurethanes. Natural and synthetic rubber.

Synthetic Drugs: Nomenclature, classification, drug actions metabolism of drugs, Antipyretics, Analgesic, Antiseptics Antimalarial etc.

Synthetic Dyes: Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of methyl orange, congo red, malachite green, crystal violet, phenolphthalein, fluorescein, alizarin and indigo.

15 Lecture

Unit- IV

Photochemistry:

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus-Draper law, Stark -Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions-energy transfer processes (simple examples). Photochemical (hydrogen-bromine and hydrogen-chlorine reactions).

Electrochemistry: Types of reversible electrodes: Gas- metal ion, metal- metal ion, metal - insoluble salt- anion and redox electrodes, electrode reactions. Nernst's 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 cell: Reversible and irreversible cells, conventional representation of electrochemical cells. E.M.F. of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions (ΔG , ΔH and K). Polarization, over potential and hydrogen over-voltage. Structure of double- layer, theories by Helmholtz, Guoy-Chapman and Stern.

Concentration cells with and without transport, liquid-junction potential, application of concentration cells, valency of ions. Solubility product and activity coefficient, potentiometric titrations. Determination of pH using hydrogen, quinhydrone and glass electrodes, by potentiometric methods.

15 Lecture

Suggested Books and References:

1. Concise Inorganic Chemistry by J.D. Lee, Wiley.
2. Inorganic Chemistry by Catherine E. Housecroft and Alan G. Sharpe, Pearson.
3. Selected Topics in Inorganic Chemistry by Wahid U. Malik, G. D. Tuli and R. D. Madan, S. Chand, New Delhi.

4. Advanced Inorganic Chemistry: Volume I & II by Satya Prakash, G. D. Tuli, S. K. Basu and R. D. Madan, S. Chand, New Delhi.
5. Principles of Inorganic Chemistry by Puri, Sharma & Kalia, Vishal Publishing Co.
6. Spectroscopy of Organic Compounds P S Kalsi, New Age international Publisher.
7. Organic Spectroscopy by William Kemp Mac Millan.
8. Elementary organic Spectroscopy by Y. R. Sharma S Chand and Company Pvt Ltd.
9. Organic Chemistry by Leroy G. Wade, Jan W. Simek & Maya S. Singh, Pearson.
10. Organic Chemistry by I. L. Finar, Pearson.
11. Organic Chemistry by R.T. Morrison, R.N. Boyd & S.K. Bhattacharjee, Pearson.
12. Dyes and Drugs by Harold H. Trimm, William Hunter Jr., Taylor & Francis Ltd.
13. Introduction synthetic drugs and dyes by R.S. Rao, Gomathi Shridhar, Himalya Publishing House.
14. Polymer Chemistry: Synthesis and Characterisation By Prashant D. Ashtaputrey & Santosh D. Ashtaputrey, Prints Publication PVT. Ltd.
15. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma & M. S. Pathania, Vishal Publishing Co.
16. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
17. Physical Chemistry by W. Atkins, Oxford University Press.
18. Physical Chemistry by R. J. Silby and R. A. Alberty, John Wiley & Sons.
19. Physical Chemistry by G.M. Barrow, Tata McGraw-Hill.
20. Photochemistry by Gurdeep Raj, Krishana Prakashan.
21. Basic Concepts in Electrochemistry by Bhatu Shivaji Desale, Walnut Publication.
22. Introduction to Polymer Science and Technology by N.B. Singh and S.S. Das, New Age International Publisher.
23. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
24. A Textbook of Physical Chemistry by K. L. Kapoor (Volume 4), Macmillan Ltd

Suggested E-resources:

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

Online Lecture Notes and Course Materials:

All prescribed courses are available in digital form in the form of e-books, Adobe Acrobat documents (PDF), web page

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Detailed Syllabus

CHM-75P-302: Practical – V

(4 Hrs./week)

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Inorganic Chemistry**10 marks****Preparations:**

- Potassium trioxalatochromate(III) trihydrate, $K_3[Cr(C_2O_4)_3] \cdot 3H_2O$
- Hexammine nickel (II) chloride, $[Ni(NH_3)_6]Cl_2$
- Tris (Thiourea) copper (I) sulphate, $[Cu.3[CS(NH_2)_2] 2SO_4 \cdot 2H_2O$
- Prussian blue [Iron (III) hexacyano ferrate (II)], $KFe[Fe(CN)_6]$

Organic Chemistry**10 marks****Qualitative Analysis:**

Analysis of an organic mixture containing two solid components using H_2O , $NaHCO_3$ and $NaOH$ for separation and identification of components through the functional group analysis, determination of melting point and prepare their derivatives and further determine their melting points.

Physical Chemistry**10 marks****Molecular Weight Determination**

- Determination of molecular weight of a non-volatile solute by Rast method/Beckmann freezing point method.
- Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy.
- Determination of molecular weight of organic compound by elevation of boiling point

Conductometry

- To determine the strength of the given acid using standard alkali solution (strong acid vs. strong base, weak acid vs. strong base, and strong acid vs. weak base).
- To determine the solubility and solubility product of a sparingly soluble electrolyte.
- To study the kinetics of saponification of ethyl acetate using standard sodium hydroxide. To determine the ionization constant of a weak acid.

Viva voce**5 marks****Practical Record****5 marks****Suggested Books and References:**

- Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.

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

Suggested E-resources:

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

Online Lecture Notes and Course Materials:

All prescribed courses are available in digital form in the form of e-books, Adobe Acrobat documents (PDF), web pages etc.

Course Learning Outcomes:

By the end of this course, students will get a clear understanding of various concepts related to the principles and applications of HSAB theory in predicting the stability and reactivity of chemical species. Further, students will get clear and deep understanding of a coordination chemistry of transition metals, including crystal field theory and ligand field theory. Principles and applications of electronic transitions (UV), vibrational modes (IR) including NMR spectroscopic study will provide knowledge to determine the structures and dynamics of molecules. Structure, syntheses, and reactivity of sulfur-containing organic molecules in addition to structure, properties, and applications of synthetic polymers, pharmaceuticals and industrial dyes will enhance the knowledge of students. They can understand the principles of electrochemistry, including redox reactions and practical applications such as batteries, fuel cells, and electroplating.

This course integrates theoretical knowledge with practical applications, equipping students for advanced studies, research and professional practice in the field of chemistry.

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VI– Semester

Examination Scheme for EoSE-

CA – Continuous Assessment EoSE – End of Semester Examination

For Regular Students –

Type of Examination	Course Code / Nomenclature	Duration of Examination		Maximum Marks		Minimum Marks	
Theory	CHM-76T-303. Bioinorganic chemistry, Organometallic chemistry, Heterocyclic chemistry, Carbohydrates, Spectroscopy, Quantum Mechanics and MOT.	CA	1 Hr.	CA	20	CA	8
		EoSE	3 Hrs.	EoSE	80	EoSE	32
Practical	CHM-76P-304 – Practical VI	CA	1 Hr.	CA	10	CA	4
		EoSE	4 Hrs.	EoSE	40	EoSE	16

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

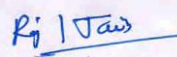
PART – A: 20 Marks

Part A will be compulsory, consisting of 10 very short answer-type questions (with a limit of 20 words) covering the entire syllabus, carrying two marks for each.

PART – B: 60 Marks

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

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For Non-Collegiate Students –

Type of Examination	Course Code and Nomenclature	Duration of Examination	Maximum Marks	Minimum Marks
Theory	CHM-76T-303 –Bioinorganic chemistry, Organometallic chemistry, Heterocyclic chemistry, Carbohydrates, Spectroscopy, Quantum Mechanics and MOT	3 Hrs.	100	40
Practical	CHM-76P-304 Practical VI	4 Hrs.	50	20

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

PART – A: 20 Marks

Part A will be compulsory, consisting of 10 very short answer-type questions (with a limit of 20 words) covering the entire syllabus, carrying two marks for each.

PART – A: 80 Marks

Part B of the question paper will have four questions with internal choice comprising of question number 2-5 which will be divided into four units. There will be one question with internal choice from each unit. Each question will carry 20 marks.

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SYLLABUS

[UG0802/03]-[CHM-76T-303]- Bioinorganic chemistry, Organometallic chemistry
Heterocyclic chemistry, Carbohydrates, Spectroscopy,
Quantum Mechanics and MOT

[UG0802/03]-[CHM-76P-304]- PRACTICAL-VI

VI – Semester – [Chemistry]

Semester	Code of the Course	Title of the Course/Paper			NHEQF Level	Credits	
VI	CHM-76T-303	Bioinorganic chemistry, Organometallic chemistry Heterocyclic chemistry, Carbohydrates, Spectroscopy, Quantum Mechanics and MOT			5	4	
VI	CHM-76P-304	PRACTICAL-VI			5	2	
Level of Course	Type of the Course	Credit Distribution			Offered to NC Students	Course Delivery Method	
		Theory	Practical	Total			
7	Major	4	2	6	Yes	Through Lecture, Sixty (60) Lectures	Class room Teaching/Power-Point (PPT)
List of Programme Codes in which offered as Minor Discipline		-NA-					
Prerequisites/Eligibility		Every student automatically promoted from V to VI semester after the V-Semester EoSE.					
Course Objectives:		The main objective of this course is to provide students with a theoretical understanding of advanced concepts in chemistry emphasizing both fundamental principles and practical applications. Bioinorganic chemistry is introduced to study the role of metals in biological systems and their coordination environments. Organometallic chemistry is explored including the structure, bonding and reactivity of metal-carbon bonds along with the					

	chemistry of inorganic polymers with their synthesis, properties and applications. The syntheses and reactivity of heterocyclic compounds and carbohydrates have been incorporated to achieve knowledge and deep understanding in these fields. Spectroscopic techniques are incorporated, viz. rotational and vibrational spectroscopy to understand molecular rotations and vibrations, raman spectroscopy for complementary vibrational analyses, electronic spectroscopy for studying electronic transitions in molecules. Principles of quantum mechanics and its applications in molecular orbital theory (MOT) are also introduced for understanding molecular structure and bonding. This course integrates theoretical concepts of spectroscopy and quantum mechanics to prepare students for advanced research and problem-solving in modern chemistry.
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Detailed Syllabus

VI– Semester – [Chemistry]

**CHM-76T-303-
(4 Hrs./week)**

Bioinorganic chemistry, Organometallic chemistry, Heterocyclic chemistry, Carbohydrates, Spectroscopy, Quantum Mechanics and MOT.

Unit-I

Bioinorganic chemistry:

Essential and trace elements to biological processes, Metalloporphyrin with special reference to hemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+} , Nitrogen fixation.

Organometallic Compounds:

Definition, nomenclature and classification of organometallic compounds. Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti, A brief account of metal ethylenic complexes and homogeneous hydrogenation, Mononuclear carbonyls and the nature of bonding in metal carbonyls.

Inorganic Polymers:

Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

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.

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Introduction to condensed five- and six-membered heterocycles. 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.

Carbohydrates: Introduction, classification, constitution and reaction of glucose and fructose, Mutarotation and its mechanism, Cyclic structure : pyranose and furanose forms, Haworth projection formulae, Configuration of monosaccharides, Determination of ring size, Conformational analysis of monosaccharides, Epimerization, Chain lengthening and chain shortening in aldoses. Interconversion of aldoses and ketoses.

Disaccharides: Structure determinations of maltose, lactose and sucrose.

Polysaccharides: Structure of starch and cellulose, glycosidic linkages.

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. and their respective energy levels.

15 Lecture

Unit-IV

Elementary Quantum Mechanics:

Black-body radiation, Planck's radiation law, Photoelectric effect, Heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects. Compton effect.

De Broglie hypothesis, The Heisenberg's uncertainty principle, Sinusoidal wave equation, Hamiltonian operator, Schrodinger wave equation and its importance, Physical interpretation of the wave function, Postulates of quantum mechanics, quantum number and their importance, Particle in a one-dimensional box.

Molecular orbital theory:

Basic ideas, criteria for forming M.O. from A.O. Construction of M.O's by LCAO method- H_2^+ ion, calculation of energy level from wave functions, physical picture of bonding and antibonding wave functions, concept of σ , σ^* , π , π^* orbitals and their characteristics. Hybrid orbitals - sp , sp^2 , sp^3 , calculation of coefficients of A.O.'s used in these hybrid orbitals. Introduction to valence bond model of H_2 , comparison of M.O. and V.B. models.

Suggested Books and References:

1. Bioorganic, bioinorganic and supramolecular chemistry by Kalsi and Ashu , New Age International.
2. Bioinorganic Chemistry by Ankita Das, Asim K Das and Mahua Das. Books & Allied.
3. Principal of bioinorganic Chemistry by Stphen J. Lippard, Jerem M. Berg, Universal Science Books.
4. Basic Organometallic Chemistry by B D Gupta, A. J. Elias, Universities Press
5. Organometallic Chemistry and Catalysis by Didier Astruc, Springer.
6. Organic Chemistry by R. T. Morrison and R. N. Boyed, Prentice Hall.
7. Organic Chemistry by I. L. Finar (Vol. I & II), ELBS.
8. Advanced Organic Chemistry by A. Bahl and B. S. Bahl, S. Chand.
9. Organic Chemistry by S. S. Gupta, Oxford University Press.
10. Modern Organic Chemistry by M.K. Jain and S. C. Sharma, Vishal Publishing Co.
11. Essentials of carbohydrate Chemistry by John F. Robyt, Springer
12. Heterocyclic Chemistry By R.R Gupta, Springer.
13. Heterocyclic Chemistry by R K Bansal New Age International Publishers.
14. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co.
15. Advanced Physical Chemistry by Gurdeep Raj, Goel Publishing House.
16. Atkins' Physical Chemistry by Atkins, Julio De Paula and James Keeler, Oxford.
17. Quantum Chemistry (2nd edition) by Donald A. McQuarrie, University Science Book Sausalito, California.

Suggested E-resources:

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

Online Lecture Notes and Course Materials:

All prescribed courses are available in digital form in the form of e-books, Adobe Acrobat documents (PDF), web pages etc.

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Syllabus

CHM-76P-304: Practical VI

4 Hrs./week

Inorganic chemistry

10 marks

Quantitative Analysis:

- Determination of Dissolved Oxygen in water.
- Determination of Chemical Oxygen Demand (COD)
- Determination of Biological Oxygen Demand (BOD)
- Percentage of available chlorine in bleaching powder.
- Estimation of total alkalinity of water samples (CO_3^{2-} , HCO_3^-) using double titration method.
- Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
- Separation and estimation of Mg (II) and Fe (II) by solvent extraction method.
- Separation and estimation of Mg (II) and Fe (II) by ion exchange method.

Organic Chemistry

10 marks

Synthesis of Organic Compounds

- Acetylation:** acetylation of salicylic acid, aniline, glucose and hydroquinone.
- Benzoylation:** benzoylation of aniline and phenol.
- Aliphatic electrophilic substitution:** preparation of iodoform from ethanol or acetone

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- d. **Nucleophilic addition elimination:** preparation of semicarbazone of acetone, ethyl methyl ketone, cyclohexanone and benzaldehyde.
- e. **Aromatic electrophilic substitution:**
 - **Nitration:** Preparation of m-dinitrobenzene
 - Preparation of p-nitroacetanilide
 - **Halogenation:** Preparation of *p* – bromoacetanilide
 - Preparation of 2, 4, 6 – tribromophenol
 - **Diazotization/coupling:** Preparation of methyl orange or methyl red
- f. **Oxidation:** Preparation of benzoic acid from toluene or benzaldehyde
- g. **Reduction:**
 - Preparation of aniline from nitrobenzene
 - Preparation of m-nitroaniline from m-dinitrobenzene

Physical Chemistry

10 marks

1. pH-metry

a. pH metric titrations of

- i. Strong acid vs. strong base
- ii. Weak acid vs. strong base

b. Determination of dissociation constant of a weak acid.

c. Preparation of buffer solutions:

- i. Sodium acetate-acetic acid
- ii. Ammonium chloride-ammonium hydroxide

d. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

2. Potentiometry

- a. Strong acid vs. strong base
- b. Weak acid vs. strong base
- c. Potassium dichromate vs. Mohr's salt

3. Spectrophotometry or Colourimetry:

To verify Beer-Lambert law and determine the concentration of the given aqueous solution of $KMnO_4/K_2Cr_2O_7/CuSO_4$ of unknown concentration.

Viva voce

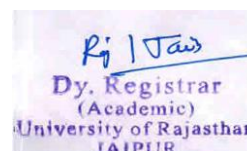
5 marks

Practical Record

5 marks

Suggested Books and References:

1. Vogel's Qualitative Inorganic Analysis, A. I. Vogel Prentice Hall.
2. Vogel's Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, ELBS.



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

Suggested E-resources:

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

Online Lecture Notes and Course Materials:

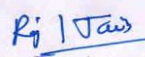
All prescribed courses are available in digital form in the form of e-books, Adobe Acrobat documents (PDF), web pages etc.

Course Learning Outcomes:

By the end of this course, students will get a clear understanding of bioinorganic chemistry including the role of metals in biological systems and their coordination environments. They will get acquainted with the structure, bonding, reactivity and the applications of organometallic complexes along with the synthesis, properties, and applications of heterocyclic compounds. Furthermore, the structure, functions and reactions of carbohydrates will provide knowledge in this field. Students will get knowledge in spectroscopic techniques through analysis of molecular rotation using the rotational spectrum, examine molecular vibrations through the vibrational spectrum and Raman spectrum and further interpret electronic spectra for electronic transitions in molecules. They will grasp the fundamentals of quantum mechanics and its application in quantum molecular orbital theory (MOT) to explain molecular bonding and structure.

This course provides students with both theoretical knowledge and practical skills, essential for advanced studies and research in modern chemistry.

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