SIDO KANHU MURMU UNIVERSITY, DUMKA

(A State University recognized under Section 2(f) & 12(B) of the UGC Act, 1956)

SYLLABUS

OF

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

FOR

CHEMISTRY

HONOURS/RESEARCH

Accordance with the

Implementation of FYUGP in State Universities of Jharkhand Regulations, 2024

Implemented from
Academic Session 2025-2029 Onwards

Member of Board of Studies to frame updated syllabus for UG Chemistry for the implementation of Four-Year Undergraduate Programme (FYUGP) as per Jharkhand Regulations,2024(Under NEP-2020) vide Notification No. JSHEC/NEP-04/2024-437 dated 04/12/2024 by the Principal Secretary, Department of Higher, Technical Education & Skill Development, Government of Jharkhand and as per the guidelines of Sido Kanhu Murmu University, Dumka.

Chairman :-
Dr. Sanjay Kumar Singh
Dean, Faculty of Science, S.K.M. University, Dumka
Associate Professor & Head, University Department of Chemistry, S.K.M. University, Dumka

10/10/2025

External Expert :-
Prof. Shailendra
University Professor & Head,
University Department of Chemistry,
Patna University, Patna

(Online)-

10/10/2025

Coordinator:-
Dr. Santosh Kumar Singh
Assistant Professor, University Department of Chemistry, S.K.M. University, Dumka

10/10/25

Members:-

1. **Dr. Hashmat Ali**
   Associate Professor, University Department of Chemistry, S.K.M. University, Dumka

10.10.25

2. **Dr. Ved Prakash Sahay**
   Assistant Professor & Head ,Department of Chemistry, S.P. College, Dumka

— 10.10.25

3. **Dr. N.K. Mandal**
   Principal I/C,
   Degree College, Jarmundi ,Dumka

— 10.10.25

4. **Dr. C.S. Azad**
   Assistant Professor,Department of Chemistry, Godda College, Godda

— 10/10/25

5. **Dr. Anil Kumar**
   Assistant Professor & Head ,Department of Chemistry, Sahibganj College, Sahibganj

6. **Sri Anil Kumar**
   Assistant Professor & Head ,Department of Chemistry, A.S. College, Deoghar

Anil Kumar
10/10/25

Methods of Analysis, along with an emphasis on laboratory safety, digital tools, and analytical skill development

Dr. Santosh Kumar Singh, Coordinator, presented the draft structure of the FYUGP syllabus prepared in accordance with the guidelines of the Jharkhand State Higher Education Council (JSHEC) and the UGC model curriculum. He explained the credit framework, semester-wise course pattern, and Learning Outcome-based Curriculum Framework (LOCF) designed to meet national standards.

The members held a detailed discussion on the following aspects:

1. Core Courses (Major): Alignment with NEP-2020 standards, ensuring coverage of fundamental areas such as Inorganic, Organic, Physical, and Analytical Chemistry, with an added focus on experimental and applied components.
2. Minor Courses: Integration of interdisciplinary subjects like Environmental Science, Physics, Biology, and Materials Science to promote cross-disciplinary understanding.
3. Research and Internship Components: Inclusion of research projects, field work, and internships in the 7th and 8th semesters to foster innovation and practical exposure.
4. Continuous Assessment and Evaluation: Adoption of a balanced approach between internal assessments, laboratory work, and end-semester examinations to ensure comprehensive evaluation.

All members actively contributed to refining the proposed syllabus and expressed their appreciation for the collective effort toward academic advancement. The Board unanimously agreed on the necessity to maintain a balance between academic depth and applied relevance while ensuring that the curriculum remains in line with national academic and industrial standards.

Board of studies meeting finally concluded with the Vote of Thanks by the Coordinator Dr. Santosh Kumar Singh, Assistant Professor , University Department of Chemistry, S.K.M. University, Dumka .

Members Present

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Dean, Faculty of Science, S.K.M. University, Dumka
Associate Professor & Head, University Department of Chemistry,
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External Expert:
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10/10/25

Semester wise Subject Combination for B.Sc. (CHEMISTRY)

Semester	Course Category	Code	Papers	Credits
First Semester	Major	MJ-1	Atomic Structure, Chemical Bonding & Redox Reactions	4
	Associated Core/Associated Vocational	AC-1A	Select any one subject from the Associated Core Table with the guidance of the Class Teacher.	4
	Multidisciplinary Course	MDC-1	**Choose any one of the following:** • Mathematical and Computational Thinking Analysis • Gender Studies • Goods and Services Tax (GST) • Pollution Control and Waste Management	3
	Ability Enhancement Course	AEC-1	Hindi (Compulsory)	2
	Skills Enhancement Course	SEC-1	Introduction to Computer and IT (Compulsory)	2
	Value Added Course	VAC-1	Understanding India (Compulsory)	3
	Indian Knowledge System	IKS-I	Indian Knowledge System (Compulsory)	2
Second Semester	Major	MJ-2	Theory-Mj-2: States Of Matter & Concept Of Ionic Equilibrium	4
	Associated Core/Associated Vocational	AC-2B	Select any one subject either from the Associated Core subjects not studied in Semester-I or from the Associated Vocational subjects, with the guidance of the Class Teacher.	4
	Multidisciplinary	MDC-2	**Choose any one of the following:** • Nutrition and Health education • Digital Marketing • Introduction to Indian Values and Ethics • Santhal Tribes and Culture	3
	Ability Enhancement	AEC-2	English (Compulsory)	2
	Skills Enhancement	SEC-2	Digital Communication and Data Management (Compulsory)	3
	Value Added Course	VAC-2	Environmental Studies (Compulsory)	2
	Indian Knowledge System	IKS-2	Social Awareness (Compulsory)	2
	Major	MJ-3	General Organic Chemistry And Hydrocarbons	4

Third Semester		MJ-4	THEORY-MJ-4: ACID, BASES, SALTS, METALLURGY, S & P-BLOCK ELEMENTS, INORGANIC POLYMERS	4
	Elective Course	ELC-1A	Elective Paper-1 from the Chosen Associated Core Subject in Semester I	4
	Multidisciplinary	MDC-3	**Choose any one of the following:** • Indian Philosophy • Indian Cultural Studies • Kautilya's Arthashastra • Vedic Mathematics	3
	Ability Enhancement	AEC-3	**Select One Language Course:** Students must choose **one** of the following languages: **Hindi, English, Bangla, Sanskrit, Urdu, Santali, Persian, or Maithili.** **Note:** Students are required to study **Paper-I** of the language they choose.	2
	Skills Enhancement	SEC-3	Computer Software, Programming and AI (Compulsory)	3
Fourth Semester	Major	MJ-5	Chemistry In Indian Knowledge System	4
		MJ-6	Thermochemistry & Chemical Thermodynamics-I	4
		MJ-7	Functional Groups Containing F, Cl, Br & O	4
	Elective Course	ELC-1B	Elective Paper-1 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4
	Ability Enhancement	AEC-4	Paper-2 of Selected Language course in Semester-III	2
	Value Added Course	VAC-3	Health& Wellness, Yoga Education, Sports & Fitness (Compulsory)	2
Fifth Semester	Major	MJ-8	d- &f- BLOCK ELEMENTS, COORDINATION CHEMISTRY & NON-AQUEOUS SOLVENTS	4
		MJ-9	Thermodynamics-2-Dilute Solutions, Equilibrium and Phase Equilibrium	4
		MJ-10	Functional Groups Containing N & S, Hetrocyclic Compounds, Alkaloids, Terpenes	4
		MJ-11	Organometallic And Bioinorganic Chemistry	4
	Elective Course	ELC-2A	Elective Paper-2 from the Chosen Associated Core Subject in Semester I	4
Sixth Semester	Major	MJ-12	Chemical Kinetics, Catalysis & Surface Chemistry	4
		MJ-13	Bio-Organic Chemistry: Amino Acids, Lipids, Enzymes, Nucleic Acids & Pharmaceutical Compounds	4

		MJ-14	Reaction Mechanisms & Electronic Spectra In Inorganic Chemistry	4
		MJ-15	Electrochemistry, Electrical And Magnetic Properties Of Materials	4
	Elective Course	ELC-2B	Elective Paper-2 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

- In the fourth year, students have two pathways: they can either complete their graduation with **Honours**, or with **Honours with Research**.
- Those who wish to graduate with **Honours only** must follow **Table-A**, while those opting for **Honours with Research** must follow **Table-B**.

TABLE-A FOR HONOURS ONLY

FOURTH YEAR

Seventh Semester	Major	MJ-16	Organic Spectroscopy, Carbohydrates & Dyes	4
		MJ-17	Industrial Chemicals And Environment	4
		MJ-18	Quantum Chemistry And Covalent Bonding	4
	Advance Major	AMJ-1	Analytical Chemistry	4
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4
Eighth Semester	Major	MJ-19	Molecular Spectroscopy & Photochemistry	4
		MJ-20	Group Discussion And Dissertation	4
	Advance Major	AMJ-2	Green And Sustainable Chemistry	4
		AMJ-3	Inorganic Materials & Nanochemistry	4
	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

TABLE-B FOR HONS WITH RESEARCH

FOURTH YEAR

Seventh Semester	Major	MJ-16	Organic Spectroscopy, Carbohydrates & Dyes	4
		MJ-17	Industrial Chemicals And Environment	4
		MJ-18	Quantum Chemistry And Covalent Bonding	4
	Research Methodology	RC-1	Research Methodology In Chemistry	4
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4
Eighth Semester	Major	MJ-19	Molecular Spectroscopy & Photochemistry	4
		MJ-20	Group Discussion And Dissertation	4
	Research Project/ Dissertation	RC-2	Research Project/Fieldwork/Dissertation	8

	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

Compulsory Summer Internship:

1. If a student exits after Semester II, IV, or VI:

To receive a Certificate/Diploma/Bachelor's Degree, students must complete a summer internship/project/dissertation worth 4 credits. This should be done during the summer break of any semester within the first three years.

Note: The Certificate/Diploma/Bachelor's Degree will not be awarded without completing this internship.

2. If a student exits after Semester VIII:

Under the National Education Policy (NEP), all students must complete a 4-credit summer internship to get a Bachelor's Hons/Hons with Research/P.G. Diploma Degree.

There are two ways to complete this requirement:

a. Two internships of 4 weeks each (2 credits each), or

b. One internship of 8 weeks (4 credits total)

The college will help arrange the internship, and students can complete it any time between Semester 1 and Semester 6 Summer Vacation.

Note: The Bachelor (Hons)/Hons with Research, or P.G. Diploma will not be awarded without completing the internship.

INSTRUCTIONS FOR QUESTION SETTER

1. **Semester Internal Examination Question Pattern** (15 Marks)

The **Semester Internal Examination (SIE)** will carry a total of **15 marks**, which includes **10 marks for the internal test** and **5 marks for class attendance**. The question paper will have **two groups**.

Group A will have: **Question 1:** Five very short answer questions (1 mark each, total 5 marks)

Group B will have: Two descriptive-type questions of 5 marks each, out of which students must answer **any one** (total 5 marks) The remaining **5 marks** will be based on **class attendance**, as per the following:

- Up to 45% attendance: 1 mark
- 46% to 54%: 2 marks
- 55% to 64%: 3 marks
- 65% to 74%: 4 marks
- 75% and above: 5 marks

2. **End Semester University External Examination Question Pattern** (60 Marks)

The **End Semester Examination (ESE)** will be of **60 marks** and will also have **two groups**.

Group A (Compulsory) will include: **Question 1:** Five very short answer questions (1 mark each, total 5 marks)

Questions 2 and 3: Two short answer questions (5 marks each, total 10 marks) **Group B** will contain **five descriptive-type questions** of **15 marks each**, out of which students must answer **any three** (total 45 marks)

Note: Questions may have sub-parts if needed in the theory examination.

3. End Semester University Practical Examination Question Pattern (25 Marks)

The **End Semester Practical Examination (ESE)** will be of **6 hours duration**. The total marks and evaluation should be done as per the following guidelines:

- **Experiment/Activity performed during the exam** – 15 marks
- **Practical record notebook** – 5 marks
- **Viva-voce (oral questions)** – 5 marks

Students must score **at least 10 marks** to pass the practical examination.

PROMOTION CRITERIA

- All students will be promoted in odd Semesters (I, III, V & VII).
- To get a promotion from Semester II to Semester III, from Semester IV to Semester V, and from Semester VI to Semester VII a student has to procure a minimum of 4 CGPA.
- However, it will be necessary to obtain a minimum credit (4) to pass in each of the subjects individually before completion of the course.

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

The passing in a subject will be based on the combined marks obtained in both the internal and external examinations of the semester. However, the student must pass the theory and practical examinations separately.

Question format for **10 Marks:**

Subject/ Code

F.M. =10 Exam Year

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.

Group A [5x1=5]

i. .....
ii. .....
iii. .....

Group B

2. ..... [5]

Note: There may be subdivisions in each question asked in Theory

Question format for **60 Marks:**

Subject/ Code

F.M. =60 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.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in Theory

SEMESTER - I

COURSE: MAJOR – 1(MJ-1) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ATOMIC STRUCTURE, CHEMICAL BONDING & REDOX REACTIONS
TEACHING HOURS: THEORY-45 PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. Atomic theory and its evolution.
2. Learning scientific theory of atoms, concept of wave function.
3. Elements in periodic table; physical and chemical characteristics, periodicity.
4. To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models.
5. To understand atomic theory of matter, composition of atom.
6. Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form different atoms.
7. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.
8. Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
9. Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
10. Importance of hydrogen bonding, metallic bonding.
11. Principles of Volumetric Analysis.

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Electronic configuration of various elements in periodic table

2. Predicting structure of molecules
3. How hydrogen bonding, metallic bonding is important in common materials' scientific applications to material fabrication

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Atomic Structure: (10 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ2. 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.

UNIT-II: Periodicity of Elements: (10 Lectures)

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 and p-block. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. , Atomic radii (Vander Waals) ,Ionic and crystal radii, Covalent radii (octahedral and tetrahedral) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy, Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity, Sanderson electron density ratio.

UNIT-III: Chemical Bonding: (22 Lectures)

a) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Lande equation with derivation, Madelung constant, expression for lattice energy, Kapustinskii equation. Born-Haber cycle and its application, Solvation energy.
b) Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone and bond pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid

orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory, Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules: N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions. Covalent character in ionic compounds; polarization, polarizing power and polarizability. Fajan rules. Ionic character in covalent compounds: Bond moment and dipole moment, ionic character from dipole moment and electronegativities.

c) Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators.

d) Weak Chemical Forces: Vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility, dissolution

UNIT-IV: Oxidation-Reduction and Volumetric Analysis: (3 Lectures)

Redox equations, Balancing by Ion electron method & Oxidation number method. Disproportionation Reaction. Principles involved in volumetric analysis(Acidimetry, Permagentometry, Dichromatometry).

SUGGESTED READINGS:

1. Lee, J.D. (2010), Concise Inorganic Chemistry, Wiley India.

2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.

3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.

4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.

5. Pfennig, B. W. (2015), Principles of Inorganic Chemistry. John Wiley & Sons.

6. Housecraft, C. E.; Sharpe, A. G., (2018), Inorganic Chemistry, 5th Edition, Pearson.

7. Wulfsberg, G (2002), Inorganic Chemistry, Viva Books Private Limited.

8. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, 5th Edition,Pearson.

9. Shiver, D.; Weller, M.; Overton, T.; Rourke, J.; Armstrong, F. (2014), Inorganic Chemistry, 6th Edition, Freeman & Company

10. Das, A. K.; Das, M. (2014), Fundamental Concepts of Inorganic Chemistry, 1st Edition, Volume CBS Publishers & Distributors Pvt. Ltd.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

1. Acid-Base Titrations

a. Estimation of oxalic acid present in the supplied sample.

b. Estimation of sodium hydroxide present in given sample.

c. Estimation of amount of acetic acid in vinegar solution.

d. Estimation of carbonate and hydroxide present together in mixture.

e. Estimation of carbonate and bicarbonate present together in a mixture.

f. Estimation of free alkali present in different soaps/detergents.

2. Oxidation-Reduction Titrimetry

a.Estimation of Fe(II) in supplied solution using standardized $KMnO_4$ solution.

b.Estimation of oxalic acid using standardized $KMnO_4$ solution.

c.Estimation of percentage of Fe(II) in Iron fillings with standard $K_2Cr_2O_7$

Reference Books:-

1.Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.

2.Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

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SEMESTER - II

COURSE: MAJOR – 2(MJ-2) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: THEORY-MJ-2: STATES OF MATTER & CONCEPT OF IONIC EQUILIBRIUM
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES: On completion of this course, the students will be able to understand:

COURSE OUTCOMES:

1. Familiarization with various states of matter.
2. Physical properties of each state of matter and laws related to describe the states.
3. Calculation of lattice parameters.
4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.
5. Understanding Kinetic model of gas and its properties.
6. Maxwell distribution, mean-free path, kinetic energies.
7. Behaviour of real gases, its deviation from ideal behaviour, equation of state, isotherm, and law of corresponding states.
8. Liquid state and its physical properties related to temperature and pressure variation.
9. Properties of liquid as solvent for various household and commercial use.
10. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simple salts.
11. Ionic equilibria – electrolyte, ionization, dissociation.
12. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Gaseous state: (18 Lectures)

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, their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η, variation of viscosity with temperature and pressure. 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: Deviation from ideal gas behaviour, Compressibility factor, Z , Variation of compressibility factor with pressure at constant temperature (plot of Z vs P) for different gases (H_2, CO_2, CH_4 and NH_3), Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour. Boyle's temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

UNIT-II: Liquid State: (5 Lectures)

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT-III: Solid State: (7 Lectures)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices, X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals.

UNIT-IV: Ionic Equilibrium: (15 Lectures)

Concept of Equilibrium. Le Charliers' principle and its applications. Relationships between K_p, K_c and K_x for reactions involving ideal gases (Kinetic derivation). Equilibrium between ideal gases and a pure condensed phase.

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 tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH of different salt solutions. Buffer solutions, Henderson

equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product.

Qualitative treatment of acid–base titration curves (calculation of pH at various stages). Theories of indicators, selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

SUGGESTED READINGS:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 8th Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)
5. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001 6 Commonly Asked Questions in Thermodynamics. CRC Press, 2011

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Surface Tension Measurements.

1. Determine the surface tension by (i) Drop number (ii) Drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration.
3. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions:
4. (i)sugar (ii) ethanol (iii) sodium chloride
5. Study the variation of surface tension with different concentration of sodium chloride solutions.

Viscosity measurements using Ostwald's viscometer.

1. Determination of viscosity of aqueous solution of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
2. Viscosity of sucrose solution with the concentration of solute.

Ionic Equilibrium and pH measurements

1. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

ii. Ammonium chloride-ammonium hydroxide

2. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

3. Determination of dissociation constant of a weak acid.

4. 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.

Reference Books:-

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5thEd., Pearson (2012)
5. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry,S. Chand & Co, New Delhi.
6. Kapoor, K.L. (2019), A T extbook of P hysical C hemistry, Vol.7, 1st Edition,McGraw Hill Education.
7. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), Experiments i n Physical Chemistry, 8th Edition, McGraw-Hill, New York.

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SEMESTER - III

COURSE: MAJOR – 3 (MJ-3) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: GENERAL ORGANIC CHEMISTRY AND HYDROCARBONS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centres.
5. Reactivity, stability of organic molecules, structure, stereochemistry.
6. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
7. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution vs. elimination.

COURSE OUTCOMES:

1. Design and syntheses of organic molecules.
2. Correlation of Reactivity, stability of organic molecules, structure, stereochemistry.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Basics of Organic Chemistry: (13 Lectures)

Organic Compounds: Classification and Nomenclature, Hybridization, shape of molecules, influence of hybridization on bond properties. Electron Displacement Effects: inductive, electromeric, resonance and mesomeric effects. Tautomerism, hyperconjugation and their applications. Dipole moment, Organic acids and bases, their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges, Electrophiles and Nucleophiles, Nucleophilicity and basicity, Types, shape and relative stability of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, annulenes, antiaromaticity, Y-aromaticity, homo-aromaticity, bonding in fullerenes, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes. Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT-II: Stereochemistry: (9 Lectures)

Concept of asymmetry, 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 mixtures, Relative and absolute configuration: D/L and R/S designations. Threo & Erythreo isomers.

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

UNIT-III: Chemistry of Aliphatic Hydrocarbons: (12 Lectures)

a) Alkanes: Formation of alkanes, Wurtz Reaction, Corey House Synthesis, Kolbe's Synthesis, Free radical substitutions: Halogenation - relative reactivity and selectivity. Lengthening and shortening of carbon chain in alkanes.

b) Alkenes and Alkynes: 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), reaction with NBS, 1, 2- and 1, 4- addition

reactions in conjugated dienes and, Diels Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Relative reactivity of alkenes and alkynes.,

UNIT-IV: Chemistry of Aromatic Hydrocarbons: (11 Lectures)

a) Aromatic Hydrocarbons: Aromaticity: 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 substituent groups.
b) Polynuclear Hydrocarbons: Reactions of naphthalene and anthracene: Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene.

SUGGESTED READINGS:

1) Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2) Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
3) F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
4) J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford Universitiy Press.
5) F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).
6) T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
7) Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
8) E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGrawHill.
9) L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
10) R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
11) Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand
12) Ali, Hashmat, Reaction Mechanism in Organic Chemistry ,S Chand

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

I. Common Procedures

1. Heating/Boiling with and without condenser, Filtration techniques, Separation techniques, Crystallization techniques.

2. Purification of organic compounds (say naphthalene & others) by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water d. Acetone e. Hexane f. Toluene

3. Determination of the melting and boiling points

a. Determination of the melting points of above compounds and unknown organic compounds
b. (Kjeldahl method and electrically heated melting point apparatus)
c. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds

Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method).

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SEMESTER - IV

COURSE: MAJOR – 4(MJ-4) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01

PAPER NAME: THEORY-MJ-4: ACID, BASES, SALTS, METALLURGY, s & p-BLOCK ELEMENTS, INORGANIC POLYMERS

TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. Acids, Bases and salts and various concepts of acid and base.
2. General Principles of Metallurgy
3. Chemistry of s and p-block elements.
4. Chemistry of noble gases.
5. Redox reactions in hydrometallurgy processes.
6. Structure, bonding of s and p block materials and their oxides/compounds.
7. Chemistry of boron compounds and their structures.
8. Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure and bonding.

COURSE OUTCOMES:

1. Extraction of metals through metallurgical operations and their uses.
2. Bonding of various s and p block elements.
3. Use of boron compounds.
4. Applications of acid-base concepts.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Acids, Bases and Salts: (12 Lectures)

Arrhenius concept of acid and base and its limitations, Bronsted-Lowry concept of acid and base and its limitations, Solvated proton, Relative strengths of acids and bases, Levelling effect and levelling solvents, Types

of acid-base reactions, Salts and their classifications, Lewis concept of acid and base and its limitations, Classification of Lewis acids and bases into hard and soft categories, Hard and Soft Acid Base (HSAB) principle and its implications, Theoretical basis of hardness and softness, Electronegativity and hardness and softness, Acid -base strength and hardness and softness, Lux-Flood concept of acid and bases.

UNIT-II: General Principle of Metallurgy: (8 Lectures)

Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Latimer diagrams and Frost diagrams and their applications, Ellingham diagrams for reduction of metal oxides using carbon or 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.

UNIT-III: Chemistry of s and p Block Elements: (10 Lectures)

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. 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. Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

UNIT-IV: Noble Gases: (9 Lectures) & Inorganic Polymers: (6 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6, Bonding in noble gas compounds (Valence bond and MO treatment for XeF2), Shape of noble gas compounds (VSEPR theory).

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

SUGGESTED READINGS:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N., Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.

4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry Fourth Ed., Pearson, 2010
7. Atkins, P. W and Shriver D. N. Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

I. Gravimetric Analysis:

a. Estimation of Nickel (II) using Dimethylglyoxime (DMG).

b. Estimation of Barium as $BaSO_4$

c. Estimation of Magnesium in pyrolusite

d. Estimation of Iron in Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

II.Inorganic Preparations:

i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

ii. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassiumdioxalatodiaquachromate (III)

iii. Tetraamminecarbonatocobalt (III) ion

iv. Potassium tris (oxalate) ferrate(III)

Reference Book:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

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SEMESTER - IV

COURSE: MAJOR – 5(MJ-5) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: THEORY-MJ-5: CHEMISTRY IN INDIAN KNOWLEDGE SYSTEM
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. Critically explore and analyze ancient Indian chemical sciences through textual, experimental, and technological perspectives.
2. Compare and contrast traditional chemical practices with modern chemical theories and methods.
3. Examine classical texts such as Rasaratna Samuccaya, Charaka Samhita, and Vaisheshika Sutras for chemical knowledge.
4. Investigate metallurgical, pharmaceutical, and alchemical practices with scientific rationale.
5. Develop experimental competence in indigenous chemical processes using modern safety and analytical techniques.

COURSE OUTCOMES:

1. Demonstrate in-depth understanding of key concepts in Indian alchemy, Rasashastra, and Ayurvedic chemistry.
2. Apply interdisciplinary approaches to critically analyze ancient chemical manuscripts.
3. Examine the scientific rationale behind IKS materials, processes, and instrumentation.
4. Translate theoretical insights into experimental practice through traditional chemistry demonstrations.
5. Evaluate environmental and sustainability aspects of traditional chemical knowledge.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Philosophical Foundations of Chemistry in IKS (9 Hours)

Historical development of Indian chemistry: Pre-Vedic to Medieval periods, Philosophical schools and atomic theories: Vaisheshika, Samkhya, Nyaya, Concept of atoms (Anu), molecules (Dvyanuka), motion, and transformation, Space, time, matter, and causality in Vaisheshika-Sutras, Classification of Dravyas and Gunas with chemical parallels

UNIT-II: Rasashastra and Alchemical Traditions (10 Hours)

Origin and goals of Rasashastra: health, longevity, immortality, Classification of Rasa, Dhatu, Mula, Uparasas, and Bhasmas, Processes of Shodhana, Marana, Bhasmikarana: scientific analysis, Case Study: Swarna Bhasma – preparation, modern chemical analysis, pharmacological evaluation, Mercury in Indian alchemy: symbolic vs. chemical understanding

UNIT-III: Advanced Indian Metallurgy and Material Chemistry (8 Hours)

Design of traditional furnaces (Kosthi, Musha): thermochemical insights, Metallurgical excellence in Zinc (Zawar), Iron (Delhi Pillar), Wootz Steel, Alloy technology: Panchaloha, Bidriware, Bronze, Ancient welding, quenching, and surface treatment techniques, Materials characterization using modern instrumentation (AAS, SEM, XRD) for ancient artifacts

UNIT-IV:

a) **Ayurvedic Chemistry and Pharmaceutical Science (9 Hours)**

Rasa-Aushadhi and Rasa preparation: compound classification, process optimization, Bhaishajya Kalpana: formulation science and solubility, bioavailability, Role of minerals, salts, and metals in disease management: chemistry behind Bhasma, Nano-scale interpretations of Bhasmas – TEM/XRD evidence, Ethics and toxicity management in ancient pharmacopeia

b) Applied Chemistry in IKS and Sustainability (9 Hours)

Chemistry of natural dyes and mordants: indigo, turmeric, madder, katha
Chemistry in ritual and lifestyle: incense, cosmetics, perfumery, alkali ash, Food processing, fermentation, and preservation: curd, pickles, kanji, Traditional water purification, eco-remediation (ash, sand, moringa), Integrating IKS in green chemistry and sustainable development goals

SUGGESTED READINGS:

1. History of Hindu Chemistry Vol. I & II by Acharya P.C. Ray, 2nd Edition, Oriental Book Agency
2. Indian Alchemy: Its Origin, Chemistry and Medical Uses by P.C. Ray, Reprint, Bharatiya Kala Prakashan
3. Metallurgy in India by R. Balasubramaniam, Latest, Aryan Books International
4. Rasa Ratna Samuccaya (Translation with notes) by K.K. Bhishagratna, Reprint, Chowkhamba Sanskrit Series
5. Science in India by B.V. Subbarayappa, NBT Edition, National Book Trust
6. Ayurvedic Pharmaceutics by K.R. Srikantha Murthy, 2nd Edition, Chaukhambha Orientalia
7. Vaiseshika Sutra of Kanada (English translation) by Nandalal Sinha, Reprint, MLBD
8. Chemistry and Chemical Techniques in Ancient India by Dharampal, 1st Edition, Other India Press
9. Knowledge Traditions and Practices of India by Kapil Kapoor (ed.), 1st, CBSE / Pearson
10. Nanotechnology and Bhasmas: A Chemical Perspective by S. Rajendran, Research Articles, Journals/ICMR

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Suggeted Experiments:

1. Preparation and characterization of Swarna/Mukta Bhasma (simulated) – Nanoparticles, Thermolysis
2. Extraction of Indigo dye and study of redox behavior – Natural dyes, oxidation-reduction
3. Shodhana of sulfur using ghee/milk – safety, yield, and purity testing – Elemental purification
4. Analysis of pH and microbial activity of Kanji – Fermentation and biochemistry
5. Surface analysis of copper before and after "Shodhana" using SEM/XRD (demo/report) – Metallurgy, material science
6. Herbal alkali preparation from plant ash and soap synthesis – Acid-base chemistry
7. Green distillation method using earthen apparatus (miniature) – Thermal distillation

8. Reproduction of ancient black iron oxide ink – Inorganic pigment chemistry
9. TLC analysis of Ayurvedic extracts (Triphala, Ashwagandha) – Phytochemical screening
10. Study of corrosion resistance of traditional alloys – Electrochemistry

Reference Books

1. A Handbook of Ayurvedic Medicinal Plants – L. D. Kapoor, CRC Press (Latest Edition)

2. Rasa-Jala-Nidhi: Or Ocean of Indian Chemistry and Alchemy (Volumes I to V) – Bhudeb Mukhopadhyay, Kessinger Publishing / Chaukhamba Publications

3. Science and Technology in Ancient India (Vol. I & II) – Edited by Debiprasad Chattopadhyaya, Indian National Science Academy (Latest Edition)

4. Indian Alchemy: Or Rasayana in the Light of Modern Science – Kaviraj Narendra Nath Sen Gupta, Chaukhambha Orientalia (Reprint Edition)

5. Metals in Ancient India – B. N. Mukherjee, Munshiram Manoharlal Publishers

6. Ayurveda: The Science of Self-Healing – Dr. Vasant Lad, Lotus Press (Latest Edition)

7. Indian Materia Medica (Volumes I & II) – K. M. Nadkarni, Popular Prakashan (Revised Edition)

8. Rasaratna Samuccaya – Translated & Annotated by Acharya Siddhinandan Mishra, Chaukhambha Orientalia (Hindi/Sanskrit Edition)

9. Bharatiya Rasashastra: Ek Samgraha – Dr. R. D. Tripathi, Chaukhambha Bharati Academy (2nd Edition, Hindi)

10. Laboratory Manual of Ayurveda Pharmaceutics – Published by CCRAS (Central Council for Research in Ayurvedic Sciences), Ministry of AYUSH, Government of India

SEMESTER - IV

COURSE: MAJOR – 6(MJ-6) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: THERMOCHEMISTRY & CHEMICAL THERMODYNAMICS-I
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

By the end of the course, students will be able to:

1. Understand the fundamental concepts of thermodynamic systems, variables, and processes (reversible, irreversible, cyclic).
2. Apply the First Law of Thermodynamics to calculate energy changes (work, heat, internal energy, enthalpy) in various processes.
3. Explore thermochemistry principles and perform enthalpy calculations using thermochemical data under varying conditions.
4. Comprehend the Second and Third Laws of Thermodynamics, focusing on entropy, its molecular basis, and absolute entropy.

Analyze free energy functions and partial molar quantities to understand chemical potential and thermodynamic behavior in mixtures.

COURSE OUTCOMES:

On successful completion of this course the student should know the:

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

1. *Classify and describe thermodynamic systems, state functions, and the nature of different thermodynamic processes.*
2. *Calculate heat (q), work (w), internal energy (ΔU), and enthalpy (ΔH) for various processes, including isothermal and adiabatic transformations.*

3. *Utilize thermochemical principles to compute enthalpy changes, bond energies, and predict temperature dependence using Kirchhoff's equation.*
4. *Explain and compute entropy changes, justify spontaneity, and interpret thermodynamic behavior using the Second and Third Laws.*
5. *Apply concepts of Gibbs and Helmholtz free energies, chemical potential, and partial molar properties to analyze equilibrium and mixing in ideal systems.*

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Introduction & First Law of thermodynamics: (10 Lectures)

Intensive and extensive properties, thermodynamic variables, state and path functions, isolated, closed and open systems, reversible, irreversible and cyclic processes. Zeroth law of thermodynamics. First law of Thermodynamics: Concept of heat, q, work, w, internal energy, enthalpy, relation between heat capacities, calculations of q, w, U and H for reversible and irreversible processes. Expression for work done under free expansion of gases for isothermal and adiabatic conditions.

UNIT-II: Thermochemistry: (10 Lectures)

Heat of reactions: standard states, enthalpy of formation of molecules and ions. Enthalpy of reactions (combustion, neutralization, solution etc) 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.

UNIT-III: Second & Third Law of Thermodynamics: (8 Lectures)

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.

UNIT-IV:

a) Free Energy Functions: (8 Lectures)

Gibbs and Helmholtz energy, variation of S, G, A with T, V, P, Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters, inversion temperature, Gibbs Helmholtz equation, Maxwell relations, thermodynamic equations of state.

b) Partial molar quantities: (9 Lectures)

Partial molar quantities, dependence of thermodynamic parameters on composition, Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

SUGGESTED READINGS:

1.Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).

2.Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).

3.Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

4.Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).

5.Laideler K. J. and Meiser J. M. Physical Chemistry Third Edition (International)1999

6.Levine I. N., Physical Chemistry, Fourth Edition), McGraw-Hill (International), 1995.

7.McQuarrie D. A. and Simon J. D. Physical Chemistry- A Molecular Approach, University Science Books, 1998.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

1. Checking the calibration of the thermometer

2. Purification of organic compounds by crystallization using the following solvents: a. Water b. Alcohol c. Alcohol-Water

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

5. 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 of benzoic acid in water and determination of *H*. *Any other experiment carried out in the class*.

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

5. Hashmat Ali: Reaction mechanism in organic Chemistry, S. Chand

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SEMESTER - IV

COURSE: MAJOR – 7(MJ-7) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: FUNCTIONAL GROUPS CONTAINING F, Cl, Br & O **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

After completion of the course, the learner shall be able to understand:

Learning objective:

1.Familiarization about classes of organic compounds and their methods of preparation.

2.Basic uses of reaction mechanisms.

3.Name reactions, uses of various reagents and the mechanism of their action.

4.Preparation and uses of various classes of organic compounds.

5.Organometallic compounds and their uses.

6.Organic chemistry reactions and reaction mechanisms.

7.Use of reagents in various organic transformation reactions.

COURSE OUTCOMES:

1.Elucidating reaction mechanisms for organic reactions.

2.Use of active methylene groups in organic mechanism and preparation of new organic compounds.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Chemistry of Halogenated Hydrocarbons: (10 Lectures)

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN^1, SN^2 and SNi mechanisms with stereochemical aspects and effect of solvent etc. Nucleophilic substitution vs. elimination.

Aryl halides: Preparation from diazonium salts. nucleophilic aromatic substitution, SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.

UNIT-II: Alcohols, Phenols, Ethers and Epoxides: (10 Lectures)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3°- alcohols, Bouveault-Blanc Reduction, Preparation and properties of glycols and glycerol. Pinacol-Pinacolone rearrangement.

Phenols: Preparation and properties, Acidic nature and factors affecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.

Ethers and Epoxides: Preparation and reaction with acids. Reaction of epoxides with alcohols, ammonia derivatives and LiAlH4

UNIT-III: Carbonyl Compounds: (11 Lectures)

Structure, reactivity and preparation of Carbonyl compounds. Nucleophilic additions, Nucleophilic addition elimination reactions with ammonia derivatives with mechanism. 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, LiAlH4, NaBH4, MPV, PDC and PGC), Addition reactions of unsaturated carbonyl compounds: Michael addition.

UNIT-IV:

a) Carboxylic Acids and their Derivatives: (10 Lectures)

Preparation, physical properties and reactions of monocarboxylic acids, Typical reactions of dicarboxylic acids,hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids,Preparation and reactions of acid chlorides, anhydrides, esters and amides, Comparative study of nucleophilic substitution at acyl group, Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement.

b) Chemistry of Active methylene groups: (4 Lectures)

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

SUGGESTED READINGS:

1. P Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman, New Delhi.
2. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
3. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
4. Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc (2009).
5. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
6. Kalsi, P. S. Organic reacations and their mechanisms, New Age Science (2010).
7. Clayden, J., Greeves, N., Warren, S., Wothers, P., Organic Chemistry, Oxford University Press Inc., New York (2001).
8. Reaction mechanism in Organic Chemistry, Hashmat Ali, S. Chand

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Experiments:-

1.Detection of extra elements in organic compounds.

2.Functional group test for nitro, amine and amide groups

3.Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.

4.Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Organic preparations:

a. Oxidation of Benzaldehyde to benzoic acid.
b. Hydrolysis of amides and esters.
c. Preparation of Semi carbazone derivatives of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
d. Preparation of methyl orange.

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SEMESTER - V

COURSE: MAJOR – 8(MJ-8) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: d- & f- BLOCK ELEMENTS, COORDINATION CHEMISTRY & NON-AQUEOUS SOLVENTS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

After completion of the course, the learner shall be able to understand:

1. Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes, chelate.
2. Transition metals, its stability, color, oxidation states and complexes.
3. Lanthanides, Actinides – separation, color, spectra and magnetic behavior
4. Bioinorganic chemistry – metal ions in biological system, its toxicity; hemoglobin.
5. Understanding the nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects.
6. Understanding the transition metals stability in reactions, origin of colour and magnetic properties.
7. Understanding the separation of Lanthanoids and Actinoids, its color, spectra and magnetic behavior.
8. The non-aqueous solvents and their role in chemical reaction.

COURSE OUTCOMES:

1. IUPAC nomenclature of coordination compounds/complexes.
2. Prediction of structure of complexes using various theories; color and magnetic properties of different complexes.
3. Use of lanthanide/actinide compounds in industries.
4. Different types of non-aqueous solvents and different types of chemical reactions taking place in them.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: d-Block Elements: Transition Elements: (15 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and 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. Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of chromium, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

UNIT-II: f-Block elements: Lanthanoids and Actinides: (10 Lectures)

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT-III: Coordination Chemistry: (25 Lectures)

Werner's theory, EAN rule, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect.valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbital splitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes

UNIT-IV: Non-Aqueous Solvents:(10 Lectures)

Solvents and their role during chemical reactions, Classification of solvents on the basis of various criteria, General properties of ionizing solvents, Different types of chemical reactions taking place in a solvent, Different types of chemical reactions taking place in liquid NH_3 and their comparison to those taking place in aqueous medium , liquid SO_2 as a solvent, liquid HF as a solvent, liquid N_2O_4 as a solvent and glacial acetic acid as a solvent.

SUGGESTED READINGS:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
2. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
3. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
4. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

1 Experiment = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Analysis of Salt Mixture

Qualitative semi micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-},$C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+},Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+}, Mg^{2+}.Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^- , NO_3^- and Br- , NO_3- and I-.(Spot tests should be done whenever possible.)

Reference Books:

1.Vogel, A.I. A text book of Qualitative Analysis, ELBS 1986.

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SEMESTER - V

COURSE: MAJOR – 9(MJ-9) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: THERMODYNAMICS-2-DILUTE SOLUTIONS, EQUILIBRIUM AND PHASE EQUILIBRIUM
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. To understand the fundamental thermodynamic principles governing dilute solutions, colligative properties, and chemical equilibria.
2. To derive and interpret thermodynamic relationships using chemical potential, Gibbs free energy, and phase rule.
3. To analyze phase diagrams of one-, two-, and three-component systems and interpret real-world phase behavior (e.g., azeotropes, eutectics).
4. To apply the concepts of Raoult's Law, Henry's Law, and distribution law in laboratory and industrial chemical processes.
5. To evaluate the effect of external factors (temperature, pressure, concentration) on chemical equilibrium and phase transitions.

COURSE OUTCOMES:

After completing this course, students will be able to:

1. Apply Raoult's and Henry's laws and use thermodynamic equations to calculate colligative properties and determine molar masses of solutes.
2. Derive and interpret expressions involving chemical potential and Gibbs free energy for analyzing reaction spontaneity and equilibrium.
3. Analyze and interpret phase diagrams for pure substances and multi-component systems using the Gibbs Phase Rule and Clausius-Clapeyron equation.

4. Apply the Gibbs-Duhem-Margules equation and Nernst distribution law in real-world chemical separation and distillation techniques.
5. Explain the thermodynamic basis of chemical equilibria and quantitatively assess the variation of equilibrium constants with external conditions.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Dilute solutions: (10 Lectures)

Dilute solutions, lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Colligative properties of solutions, abnormal colligative properties, Van't Hoffs factor. Thermodynamic derivation using chemical potential to derive relations between the (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution. Azeotropes.

UNIT-II: Thermodynamics of Chemical Equilibrium (12 Lectures)
Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx.

UNIT-III: Phase Equilibria: (20 Lectures

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 nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.

UNIT-IV: Distribution law: (3 Lectures)

Nernst distribution law: its derivation and applications.
Reference Books:

SUGGESTED READINGS:

Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).

2. Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).

3. McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).

4. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).

5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.& Will, S.

6. Commonly Asked Questions in Thermodynamics. CRC Press: NY(2011).

7. Zundhal, S.S. Chemistry concepts and applications Cengage India(2011).

8. Ball, D. W. Physical Chemistry Cengage India (2012).

9. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP(2009).

10. Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).

11. Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Experiments:-

1. Distribution of acetic acid /benzoic acid between water & cyclohexane.
2. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
3. Study of equilibrium of at least one of the following reactions by the distribution method:

   a) $I_2(aq) + I^- \rightarrow I_3^-(aq)$ b) $Cu^{++}(aq) + n\,NH_3 \rightarrow [Cu(NH_3)n]^{2+}$

Reference Books:

1.Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

2.Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011)

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SEMESTER - V

COURSE: MAJOR – 10(MJ-10) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01

PAPER NAME: FUNCTIONAL GROUPS CONTAINING N & S, HETROCYCLIC COMPOUNDS, ALKALOIDS, TERPENES

TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

After completion of the course, the learner shall be able to understand:

1.Nitrogen containing functional groups and their reactions.

2.Familiarization with polynuclear hydrocarbons and their reactions.

3.Heterocyclic compounds and their reactions.

4.Alkaloids and Terpenes

5.Understanding reactions and reaction mechanism of nitrogen containing functional groups.

6.Understanding the reactions and mechanisms of diazonium compounds.

7.Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.

8.Understanding the structure, mechanism of reactions of selected heterocyclic compounds.

9.Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

COURSE OUTCOMES:

1.Use of benzene diazonium salt in organic synthesis.

2.Applications of heterocyclic compounds in pharmaceutics/drugs and the mechanism of actions.

3.Pharmaceutics/Biomedical applications of alkaloids and terpenes.

4.Nitrogen containing organic compounds/heterocyclic compounds in synthetic chemistry.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Nitrogen Containing Functional Groups (15 Lectures)

Preparation and important reactions of nitro and 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 synthetic applications.

UNIT-II: Sulphur Containing Compounds: (4 Lectures)

Preparation and reactions of thiols, thioethers including 1,3-dithiane and sulphonic acids

UNIT-III: Heterocyclic Compounds: (15 Lectures)

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.

UNIT-IV:

a) Alkaloids (6 Lectures)

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.

b) Terpenes (5 Lectures)

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

SUGGESTED READINGS:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
2. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
3. Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc (2009).
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Kalsi, P. S. Organic reacations and their mechanisms, New Age Science (2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press Inc., New York (2001).
7. Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).
8. Bansal R. K. Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, New Age, Third Edition (1999).
9. Ali, Hashmat, Reaction Mechanism in Organic Chemistry ,S Chand

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

1. Functional group test for nitro, amine and amide groups
2. Qualitative analysis of unknown organic compounds containing simple functional groups (nitro, amide, nitriles and isonitriles, amines)
3. 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: (Using conventional method and Using green chemistry approach).
4. Benzolyation of one of the amines (aniline, o-, m-, p- toluidines and o-, m-, p- anisidine) and one of the phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
5. Oxidation of ethanol/ isopropanol (Iodoform reaction).
6. Bromination (any one)
    a. Acetanilide by conventional methods.
    b. Acetanilide using green approach (Bromate-bromide method)

7. Nitration: (any one)
    a. Acetanilide/nitrobenzene by conventional method.
    b. Salicylic acid by green approach (using ceric ammonium nitrate).
8. Selective reduction of meta dinitrobenzene to m-nitroaniline.
9. Reduction of p-nitrobenzaldehyde by sodium borohydride.
10. Aldol condensation with either conventional or green method.
11. Benzil-Benzilic acid rearrangement.
12. Collected solid samples may be used for recrystallization, melting point and TLC.

Reference Books

1.J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.

2.S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.

3.A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.

4.S. M. Khopkar, Environmental Pollution Analysis: New Age Int. Publisher, New Delhi. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

5.Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

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SEMESTER - V

COURSE: MAJOR – 11(MJ-11) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ORGANOMETALLIC AND BIOINORGANIC CHEMISTRY
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

On completion of this course, the students will be able to understand:

1. 18-electron rule and its applications.
2. Organometallic compounds and their applications in organic synthesis and industries.
3. Bioinorganic chemistry – metal ions in biological system, its toxicity.
4. Understanding the bioinorganic chemistry of metals in biological systems.
5. Hemoglobin and its importance in biological systems

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Action of organometallic compounds in accelerating rate of chemical reactions.
2. Role of Mg^{2+} during photosynthesis by green plants.
3. Toxicity of various metals and mechanism of metal-biological system interaction.

Transport and storage of O_2 in human beings.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Organometallic Compounds: (10 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.

UNIT-II: Ferrocene & Zeise's salt: (8 Lectures)

Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. Preparation & structure of Zeise's salt. Evidences of synergic effect and comparison of synergic effect with that
in carbonyls.

UNIT-III: Metal Alkyls: (7 Lectures)

Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

UNIT-IV:

a. Bioinorganic Chemistry: (12 Lectures)
   A brief introduction to bio-inorganic chemistry. Geochemical effect on distribution of metals. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump, Role of Mg^{2+} ions in energy production and chlorophyll. Iron and its application in bio- systems, Haemoglobin, Myoglobin, Storage and transfer of iron. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

b. Catalysis by Organometallic Compounds (8 Lectures)

   Study of the following industrial processes and their mechanism:
   1. Alkene hydrogenation (Wilkinsons Catalyst)
   2. Hydroformylation (Co salts)
   3. Wacker Process
   4. Synthetic gasoline (Fischer Tropsch reaction)
   5. Synthesis gas by metal carbonyl complexes

SUGGESTED READINGS:

1. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999
3. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
4. Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann, 1997
5. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
6. Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
7. Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977
8. Miessler, G. L. & Donald, A. Tarr, Inorganic Chemistry 4th Ed.,Pearson, 2010.
9. Collman, James P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
10. Crabtree, Robert H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
11. Spessard, Gary O., &Gary L. Miessler. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Estimations

1. Determination of temporary hardness in supplied sample of water.
2. Determination of permanent hardness in supplied sample of water.
3. Determination of total hardness of water by Complexometry.
4. Estimation of Magnesium and Calcium in a mixture by Complexometry.
5. Estimation of Copper & Zn in mixture by Gravimetry.
6. Estimation of Cu & Ni in a mixture by Gravimetry

Reference Books:-

1.Vogel's Textbook of Practical Chemistry, 5th Edition – B.S. Furniss et al., Pearson Education

2.Practical Physical Chemistry – B. Viswanathan and P.S. Raghavan, Viva Books

3.Experimental Physical Chemistry – A.M. Halpern and G.C. McBane, W.H. Freeman

4.Advanced Practical Physical Chemistry – J.B. Yadav, Goel Publishing

5.Laboratory Manual of Physical Chemistry – Gurtu & Gurtu, S. Chand

6.Practical Chemistry – O.P. Pandey, D.N. Bajpai, S. Giri, S. Chand

7.Manual of Practical Physical Chemistry – K.K. Sharma & L.K. Sharma, Goel Publishing House

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SEMESTER - VI

COURSE: MAJOR – 12(MJ-12) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: CHEMICAL KINETICS, CATALYSIS & SURFACE CHEMISTRY
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

On completion of this course, the students will be able to understand:

1. To understand the fundamentals of chemical kinetics and reaction rate laws.To explore the principles and types of catalysis and their industrial applications.
2. To comprehend the physical and chemical nature of surfaces and adsorption phenomena.
3. To develop the ability to analyze kinetic data and derive rate laws.
4. To provide foundational knowledge for research in kinetics, catalysis.

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Analyze chemical reaction rates and deduce mechanisms from kinetic data.
2. Apply theories like transition state theory and collision theory to real systems.
3. Describe catalytic processes and their applications in industry and biology.
4. Understand and apply surface chemistry concepts to adsorption and colloidal systems.

Explore emerging areas such as enzyme catalysis and nanomaterials.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Chemical Kinetics – Basic Concepts (12 Lectures)

Introduction to reaction kinetics: Rate of reaction, rate constant, molecularity and order of a reaction.Integrated rate laws for zero, first, second and third order reactions (with derivation and examples).Pseudo-first order

reactions. Determination of order and rate constant using experimental methods: graphical, half-life and initial rate methods. Temperature dependence of reaction rates: Arrhenius equation, activation energy, and concept of transition state theory. Effect of pressure and ionic strength on reaction rates

UNIT-II: Complex Reactions and Reaction Mechanisms (10 Lectures)

Opposing (reversible), consecutive, and parallel reactions. Steady-state approximation and its application in reaction mechanisms. Chain reactions: Hydrogen-Bromine reaction and explosions. Unimolecular reactions (Lind's theory). Fast reactions: Relaxation methods and stopped-flow technique. Enzyme catalysis: Michaelis–Menten mechanism and Lineweaver–Burk plot.

UNIT-III: Catalysis (10 Lectures)

Introduction and types of catalysis: Homogeneous and heterogeneous.Acid-base catalysis and general vs specific acid/base catalysis.Enzyme catalysis: characteristics and mechanisms.Industrial catalysis: Hydrogenation, polymerization, Haber's process, etc.Auto-catalysis and inhibition of catalysis.Mechanisms of surface catalysis (Langmuir-Hinshelwood model).

UNIT-IV: Surface Chemistry and Adsorption (13 Lectures)

Adsorption: Physical vs chemical adsorption; Factors affecting adsorption.Freundlich and Langmuir adsorption isotherms (derivations and limitations).BET (Brunauer–Emmett–Teller) isotherm and surface area determination.Surface tension and surface energy.Colloids: Classification, preparation, properties (Tyndall effect, electrophoresis, coagulation), applications.Micelles and critical micelle concentration (CMC).

SUGGESTED READINGS:

1. P. Atkins and J. de Paula – *Physical Chemistry*, 10th Edition, Oxford University Press
2. K.J. Laidler – *Chemical Kinetics*, 3rd Edition, Pearson Education
3. K.L. Kapoor – *A Textbook of Physical Chemistry*, Volume 3 (Kinetics and Surface Chemistry), McGraw Hill
4. J. Rajaram and J.C. Kuriacose – *Kinetics and Mechanism of Chemical Reactions*, Pearson
5. S. Glasstone – *Textbook of Physical Chemistry*, Macmillan
6. B.R. Puri, L.R. Sharma, and M.S. Pathania – *Principles of Physical Chemistry*, Vishal Publishing Co.
7. Peter W. Atkins and Julio de Paula – *Elements of Physical Chemistry*, Oxford University Press
8. I. Levine – *Physical Chemistry*, McGraw Hill
9. M. M. Sharma and H. S. Fogler – *Elements of Chemical Reaction Engineering* (for advanced insights)

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

A. Chemical Kinetics Experiments

1. To study the kinetics of acid hydrolysis of methyl acetate using HCl as a catalyst.
2. To study the rate of reaction between potassium iodate and sodium sulphite using starch as indicator.
3. To study the kinetics of the reaction between acetone and iodine in acid medium.

B. Catalysis Experiments

5. To study the catalytic decomposition of hydrogen peroxide using MnO_2 or KI as catalyst.
6. To study the autocatalytic reaction of potassium permanganate and oxalic acid.

C. Surface Chemistry Experiments

7. To study adsorption of acetic acid on activated charcoal and verify Freundlich isotherm.
8. To study the adsorption of oxalic acid on activated charcoal and plot Langmuir isotherm.
9. To prepare a colloidal solution (e.g., arsenious sulphide or ferric hydroxide) and study its properties.

Reference Books:-

1. Vogel's Textbook of Practical Chemistry, 5th Edition – B.S. Furniss et al., Pearson Education
2. Practical Physical Chemistry – B. Viswanathan and P.S. Raghavan, Viva Books
3. Experimental Physical Chemistry – A.M. Halpern and G.C. McBane, W.H. Freeman
4. Advanced Practical Physical Chemistry – J.B. Yadav, Goel Publishing
5. Laboratory Manual of Physical Chemistry – Gurtu & Gurtu, S. Chand
6. Practical Chemistry – O.P. Pandey, D.N. Bajpai, S. Giri, S. Chand
7. Manual of Practical Physical Chemistry – K.K. Sharma & L.K. Sharma, Goel Publishing House

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SEMESTER - VI

COURSE: MAJOR – 13(MJ-13) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: BIO-ORGANIC CHEMISTRY: AMINO ACIDS, LIPIDS, ENZYMES, NUCLEIC ACIDS & PHARMACEUTICAL COMPOUNDS **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

On completion of this course, the students will be able to understand

1. Nature of amino acids, peptides and proteins and their biological significance.
2. Enzymes and their importance.
3. Nucleic acids and their biological role.
4. Structure of pharmaceutical compounds and their biological activity.

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Elucidating reaction mechanisms for organic reactions.
2. Nucleic acids and heredity
3. Lipids and their health implications
4. Enzymes and their applications.

Pharmaceutical compounds and their applications.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Amino acids, Peptides and Proteins: (20 Lectures)

Amino acids: Classification of Amino Acids, α-Amino acids- synthesis, ionic properties and reactions, Zwitter-ion structure, pKa -values, isoelectric point and electrophoresis.

Study of peptides: Determination of primary structure by end group analysis, Synthesis of peptides by using N-protecting, C-protecting and C-activating groups, Merrifield solid phase peptide synthesis.

Proteins: General characteristics, Classification of proteins, Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.

UNIT-II: Enzymes: (10 Lectures)

General characteristics, Mechanism of enzyme action, 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 and non- competitive inhibition including allosteric inhibition).

UNIT-III: Lipids (5 Lectures)

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol)

UNIT-IV:

a) Nucleic Acids (10 Lectures)

Definition and general characteristics, Components of nucleic acids, nucleosides and nucleotides, Structure of nucleic acids, The chemical basis of heredity- Replication of DNA, Synthesis of adenine, guanine, cytosine, uracil and thymine.

b) Pharmaceutical Compounds-Structure and Importance:(10 Lectures)

Definition, Classification, Structure and Therapeutic use of

Antipyretics: Paracetamol (with synthesis)

Analgesics: Ibuprofen (with synthesis)

Antimalarials: Chloroquine (with synthesis)

Antibiotics: Chloramphenicol (with synthesis)

SUGGESTED READINGS:

1. P Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman, New Delhi.
2. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
3. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons(1976).
4. Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc (2009).
5. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.
6. Kalsi, P. S. Organic reactions and their mechanisms, New Age Science (2010).

7. Clayden, J., Greeves, N., Warren, S., Wothers, P., Organic Chemistry, Oxford University PressInc., New York (2001).
8. Singh, J., Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).
9. Bansal R. K. Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, New Age, ThirdEdition (1999).
10. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry, Cengage Lening India Pvt. Ltd., New Delhi (2009).
11. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.
12. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
13. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
14. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
15. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.

Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Practical Experiments

(Minimum 8 experiments to be performed)

1. Preparation of α-amino acid derivative (e.g., N-acetyl glycine or benzoyl glycine).
2. Separation of amino acids by paper chromatography.
3. Determination of isoelectric point of glycine.
4. Colour reactions of amino acids and proteins (Ninhydrin test, Biuret test, Xanthoproteic test).
5. Estimation of proteins by Biuret or Lowry method.
6. Effect of pH and temperature on enzyme activity (e.g., action of salivary amylase on starch).
7. Study of enzyme inhibition (e.g., competitive inhibition using urease or sucrase).
8. Saponification of lipids and determination of saponification value.
9. Determination of iodine value of an oil/fat sample.
10. Tests for unsaturation and identification of lipid classes (qualitative).
11. Qualitative detection of functional groups in pharmaceutical compounds (e.g., phenol, amine, carboxylic acid in paracetamol, aspirin, ibuprofen).

Reference Books:

1. A.I. Vogel – Vogel's Textbook of Practical Organic Chemistry, Pearson
2. O.P. Pandey, D.N. Bajpai & S. Giri – *Practical Chemistry*, S. Chand
3. Brian Furniss et al. – Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson
4. Bahl & Bahl – Advanced Organic Chemistry, S. Chand
5. R.M. Felder & R.W. Rousseau – Elementary Principles of Chemical Processes, Wiley
6. Jayashree Ghosh – A Textbook of Pharmaceutical Chemistry, S. Chand
7. T.L. Gilman – *Pharmaceutical Chemistry*, McGraw-Hill
8. S.K. Jain & A.K. Sharma – *Practical Biochemistry*, CBC Publishers
9. Keith Wilson & John Walker – Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press

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SEMESTER - VI

COURSE: MAJOR – 14(MJ-14) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: REACTION MECHANISMS & ELECTRONIC SPECTRA IN INORGANIC CHEMISTRY
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. To develop a detailed understanding of reaction mechanisms in transition metal complexes, focusing on kinetics, substitution, and redox pathways.
2. To explore metal-ligand bonding using advanced theories beyond Crystal Field Theory, particularly emphasizing Molecular Orbital Theory.
3. To impart knowledge on electronic spectra and magnetic properties of transition metal complexes and familiarize students with interpretive tools such as Orgel and Tanabe-Sugano diagrams.
4. To introduce students to the structure, bonding, and reactivity of metal clusters, including boranes, carbonyl clusters, and metal-metal bonded species.
5. To provide in-depth knowledge of π-complexes involving carbonyls, nitrosyls, dinitrogen, and dioxygen, and understand their bonding, spectroscopic properties, and reactivity.

COURSE OUTCOMES:

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

1. Analyze and interpret reaction mechanisms in transition metal complexes, including acid/base hydrolysis and redox processes using Valence Bond and Crystal Field Theories.
2. Apply concepts of Molecular Orbital Theory to describe the electronic structures and bonding in octahedral, tetrahedral, and square planar complexes.
3. Predict and explain electronic transitions and magnetic behavior in transition metal complexes using term symbols, selection rules, and Tanabe-Sugano/Orgel diagrams.

4. Classify and describe metal clusters, including boranes and carbonyl halides, and explain metal-metal bonding in such compounds.
5. Explain the structure, bonding, and vibrational spectra of metal π-complexes (e.g., carbonyls, nitrosyls, N_2, O_2 complexes) and evaluate their reactivity and synthetic importance.
6. Interpret spectral data (UV-vis, IR) for elucidating the structure and geometry of transition metal complexes.

Correlate theoretical principles with practical coordination chemistry, forming a foundation for research in catalysis, bioinorganic chemistry, and organometallics.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Reaction Mechanism of Transition Metal Complexes (14 Lectures)

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer- sphere type reactions, cross reactions and Marcus-Hush theory, inner sphere type reactions

UNIT-II: Metal-Ligand Bonding in complexes (7 Lectures)

Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

UNIT-III: Electronic Spectra and Magnetic Properties of Transition Metal Complexes (14 Lectures)

Spectroscopic ground states, Term symbol, Selection rule, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d1- d9 states), calculations of dq and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

UNIT-IV:

a) Metal Clusters (5 Lectures)

Spectroscopic ground states, Term symbol, Selection rule, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d1- d9 states), calculations of dq and β

parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

b) Metal π-Complexes (12 Lectures)

Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes: tertiary phosphine as ligand.

SUGGESTED READINGS:

Reference Books:

1. F.A. Cotton and Wilkinson, Advanced Inorganic Chemistry, John Wiley.
2. J.E. Huhey, Harpes & Row; Inorganic Chemistry.
3. N.N. Greenwood and A. Earnshow, Chemisiry of the Elements, Pergamon.
4. A. B. P. Leve r, Inorganic Electron ion Spectroscopy, Elsevier.
5. R.L. Cariin, Magnetochemistry, Springer Vertag,
6. Q. Wilkinson, R.D. Gillars and J.A. Mc Cleverty, Comprehensive Coordination Chemistry eds., Pergamon.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Experiments *(Minimum 6 to be performed)*

1. Study of acid hydrolysis of *cis- and trans-*$[Co(en)_2Cl_2]$+ complexes.
2. Determination of relative reactivity and *trans-effect*.
3. Kinetic study of substitution of $[Co(NH_3)_5Cl]^{2+}$ by thiocyanate ion.
4. Base hydrolysis of $[Co(NH_3)_5Cl]^{2+}$.
5. Study of oxidation of $[Fe(CN)_6]^{4-}$ by cerium(IV) sulfate using iodometry.
6. Electronic Spectrum of d^9 Complex (e.g., $[Cu(H_2O)_6]^{2+}$)

7. Determination of λ_{max} and calculation of 10Dq.
8. Assignment of bands and correlation with Tanabe-Sugano diagram.
9. Comparison of $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{3-}$ spectra.
10. Synthesis of $[Ni(NH_3)_6]^{2+}$
11. Determination of geometry (octahedral/tetrahedral) from spectral data.

Reference Books:

1. J.D. Lee – *Concise Inorganic Chemistry*, Oxford University Press
2. G.L. Miessler and D.A. Tarr – *Inorganic Chemistry*, Pearson
3. K. De – *Inorganic Chemistry: Principles of Structure and Reactivity*, New Age
4. A.I. Vogel – *Vogel's Textbook of Quantitative Inorganic Analysis*, Longman
5. W. Palmer – *Experimental Inorganic Chemistry*, Cambridge University Press
6. M. Nakamoto – *Infrared and Raman Spectra of Inorganic and Coordination Compounds*, Wiley
7. S. F. A. Kettle – *Physical Inorganic Chemistry: A Coordination Chemistry Approach*, Oxford
8. J. Derek Woollins – *Inorganic Experiments*, Wiley-VCH
9. A. Basolo and R.G. Pearson – *Mechanisms of Inorganic Reactions*, Wiley

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SEMESTER - VI

COURSE: MAJOR – 15(MJ-15) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ELECTROCHEMISTRY, ELECTRICAL AND MAGNETIC PROPERTIES OF MATERIALS
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

After completion of the course, the learner can be able to understand:

1. Basic principle of laws of electrochemistry.
2. Understanding about chemical cells and their function.
3. Understanding about electrodes, EMF measurement.
4. Understanding about potentiometric titrations and their applications.

Basic ideas about polymers.

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Electrolyte and non-electrolyte.
2. Passage of electric current through the aqueous solution or molten state of electrolyte.
3. Non-spontaneous chemical reactions taking place at electrodes during electrolysis.
4. Mechanism of production of electric current due to spontaneous chemical reactions.

Classification and applications of polymers.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Conductance: (16 Lectures)

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-Huckel-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) hydrolysis constants of salts etc.

UNIT-II: Electrochemistry: (12 Lectures)

Quantitative aspects of Faraday's law. Applications of electrolysis in metallurgy and industry. Half-cell potential, 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 of different kind of half-cells. Electrified interfaces, overpotential, Electrocatalysis- influence of various parameters. Hydrogen electrode.

UNIT-III: Application of EMF measurements: (12 Lectures)

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/Sb_2O_3 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).

UNIT-IV: Electrical & Magnetic Properties of Atoms and Molecules: (5 Lectures)

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

SUGGESTED READINGS:

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

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Experiments

1. Conductometric titration of a strong acid vs strong base.
2. Conductometric titration of a weak acid vs strong base.
3. Determination of the solubility and solubility product of a sparingly soluble salt (e.g., $BaSO_4$ or AgCl).
4. Determination of the equivalent conductance at infinite dilution for a weak electrolyte using Kohlrausch's Law.
5. Determination of the degree of dissociation and dissociation constant of a weak acid by conductance measurements.
6. Determination of transference number of ions using the Hittorf method.
7. Potentiometric titration of a strong acid with a strong base using a glass electrode.
8. Potentiometric redox titration (e.g., $KmnO_4$ vs $FeSO_4$).
9. Determination of pH using a quinhydrone or glass electrode.
10. Determination of cell EMF and calculation of ΔG, ΔH, and ΔS.

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H Jeffery and others) 5th Ed. The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Ditts, R.V. Analytical Chemistry – Methods of separation
4. Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
5. Harry R. Allcock, Frederick W. Lampe and James E. Mark, Contemporary Polymer Chemistry, 3rd ed. PrenticeHall (2003)
6. Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
7. Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
8. Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
9. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005) 10. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)

10. Seymour/ Carraher's Polymer Chemistry, 9th ed. By Charles E. Carraher, Jr. (2013).
11. Synthesis of organometallic compounds: A practical guide, S. Komiya, Wiley.

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SEMESTER - VII

COURSE: MAJOR – 16(MJ-16) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ORGANIC SPECTROSCOPY, CARBOHYDRATES & DYES
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

On completion of this course, the students will be able to understand

1. Understanding structure of molecules on the basis of spectroscopic techniques.
2. Understanding the significance and structure of carbohydrates.
3. Understanding the structure, mechanism of action of selected dyes.

COURSE OUTCOMES:

On successful completion of this course the student should know:

1. Use of spectroscopic techniques in the elucidation of structure of
2. Structures of monosaccharides, disaccharides and polysaccharides.
3. Synthesis of dyes ,food colours and their applications

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Organic Spectroscopy:(22 Lectures)

General principles and introduction to absorption and emission spectroscopy.

a) UV-VIS Spectroscopy: Basic principle, Absorption laws, Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption bands- Hyperchromic and Hypochromic shifts, Effect of solvent on electronic spectra, Woodward-Fieser rules and their applications in

the calculation of λ_{max} of

a) α, β-unsaturated aldehydes, ketones, carboxylic acids and esters
b) Conjugated dienes with or without extended conjugation.
c) Distinction between cis- and trans- isomers

b) IR Spectroscopy: Basic principle, Molecular vibrations, Fingerprint region and its significance, Group frequency region and its importance, Infrared absorption frequencies of organic molecules with functional groups containing O, N and S (such as ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams, thiols, thioethers, etc.); Effect of H-bonding, resonance/conjugation and ring-size on IR absorptions.

c)NMR Spectroscopy: Basic principle, Reference in proton magnetic resonance spectroscopy and Chemical shift, Chemical shifts of H atoms bonded to carbon atoms (aliphatic, olefinic aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides, mercapto), Spin-spin coupling, Chemical exchange, effect of deuteration.

d) Mass Spectrometry: Basics of fragmentations in organic compounds. Discussion of molecular ion peak, base peak and metastable ions, McLafferty rearrangement. Nitrogen rule, Index of hydrogen deficiency. Application of fragmentation in characterization of organic compounds.

e) Electronic Spectroscopy:

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence.

f) Atomic Absorption spectroscopy: Theory and application (with some example).

g) Problem Solving: Problems on structure elucidation of organic compounds based on

spectral data. Applications of IR, UV, NMR and Mass spectra for identification of simple organic molecules. Solving problems for the elucidation of molecular structure with the help of mixed spectral data.

UNIT-II: Carbohydrate: (14 Lectures)

Occurrence,Definition, classification and their biological importance.

a) 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.

b) Disaccharides: Structure elucidation of maltose, lactose and sucrose.

c)Polysaccharides: Elementary treatment of starch, cellulose and glycogen excluding their structure elucidation.

UNIT-III: Dyes, Food Colours:(9 Lectures)

Classification, Colour and constitution, Mordant and Vat Dyes, Chemistry of dyeing,

Synthesis and applications of

a) Azo dyes: Methyl Orange and Congo Red (mechanism of Diazo Coupling)

b) Triphenyl Methane Dyes: Malachite Green, Rosaniline and Crystal Violet

c)Phthalein Dyes: Phenolphthalein and Fluorescein,

d)Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin,

Natural and synthetic food colours with examples, Natural food colours carotenoids, chlorophyll, anthocyanin, betanin and turmeric, Preparation of Natural food colours (Red Pink, Green, Orange, yellow, Blue, Purle, Brown,Tan and Black. . Synthesis and study of Tartrazine, Quinoline yellow, Sunset yellow, Amarnanth, Erythrosine, Indigo carmine.

SUGGESTED READINGS:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
2. Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons(1976).
3. Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc (2009).
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.
5. Clayden, J., Greeves, N., Warren, S., Wothers, P., Organic Chemistry, Oxford University PressInc., New York (2001).
6. Singh, J., Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).
7. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry, Cengage Lening India Pvt. Ltd., New Delhi (2009).
8. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
9. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
10. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
11. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.
12. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
13. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
14. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
15. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
16. .Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman
17. Ali, Hashmat, Reaction Mechanism in Organic Chemistry ,S Chand
18. Sourav Kumar,Chemistry in daily life,Crown Publishing (2025)

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Experiments: -

1. Interpretation of UV, IR, NMR, and Mass Spectra of known organic compounds.
2. Structure elucidation exercises using mixed spectral data (UV, IR, NMR, MS).
3. Identification of functional groups using IR spectra.
4. Simulation software (if available): Use of tools like Chem Sketch or online NMR prediction software for interpreting spectra.
5. Detection of reducing and non-reducing sugars (Fehling's and Benedict's tests).
6. Osazone formation for identification of glucose and fructose.
7. Mutarotation of glucose using polarimeter (if available).
8. Hydrolysis of disaccharides (e.g., sucrose) and identification of products by TLC or qualitative test.
9. Synthesis of methyl orange (azo dye) and observation of pH-dependent color change.
10. Synthesis of phenolphthalein (phthalein dye) and study of pH effect.
11. Preparation of natural dyes from turmeric, spinach (chlorophyll), beetroot (betalains), and hibiscus (anthocyanins).
12. Paper chromatography/TLC of natural food colors.
13. Synthesis of Tartrazine or Congo Red (demonstration or lab scale).
14. Dyeing of cotton/wool fabrics using synthesized dyes (mordant and vat method).

Reference Books: -

1. Pavia, Lampman, Kriz & Vyvyan – *Introduction to Spectroscopy*, Cengage Learning
2. Silverstein, Webster & Kiemle – *Spectrometric Identification of Organic Compounds*, Wiley
3. Y.R. Sharma – *Elementary Organic Spectroscopy*, S. Chand & Co.
4. William Kemp – *Organic Spectroscopy*, Macmillan
5. Furniss, Hannaford, Smith & Tatchell – *Vogel's Textbook of Practical Organic Chemistry*, Pearson
6. Ahluwalia & Chatwal – *College Practical Chemistry*, Himalaya Publishing
7. G.R. Chatwal – *Synthetic Dyes*, Himalaya Publishing
8. P.S. Kalsi – *Spectroscopy of Organic Compounds*, New Age International
9. N.K. Vishnoi – *Advanced Practical Organic Chemistry*, Vikas Publishing
10. Mann & Saunders – *Practical Organic Chemistry*, Longmans

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SEMESTER - VII

COURSE: MAJOR – 17(MJ-17) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: INDUSTRIAL CHEMICALS AND ENVIRONMENT
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Industrial Gases and Inorganic Chemicals (14 Lectures)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium,hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards inhandling the following chemicals: hydrochloric acid, nitric acid, sulphuricacid, caustic soda, common salt, borax, bleaching powder, sodiumthiosulphate, hydrogen peroxide, potash alum, chrome alum, potassiumdichromate and potassium permanganate.

UNIT-II: Environment and its segments (30 Lectures)

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.Pollution by SO_2 , CO_2, CO, NOx, H_2S and other foul smelling gases.Methods of estimation of CO, NOx, SOx and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen,

chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.Water purification methods.

Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

UNIT-III: Energy & Environment (10 Lectures)

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission,
Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution:
Disposal of nuclear waste, nuclear disaster and its management.

SUGGESTED READINGS:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, WileyPublishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBSPublishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand &Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd,New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd,New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books,New Delhi (2005)
10. Physico-Chemico Examination of water,wastewater and industrial effluents By N. Manivasakam and S. K. Singh ,Pragati Prakashan,Meerut, India.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Experiments: -

1. Estimation of available chlorine in bleaching powder (iodometric method).
2. Estimation of strength of hydrogen peroxide by redox titration using $KMnO_4$.
3. Preparation and standardization of hydrochloric acid and determination of purity.
4. Analysis of borax for boron content using Mannitol-acid titration method.
5. Quantitative estimation of sulphate ion in an industrial sample (gravimetric or turbidimetric method).
6. Determination of percentage purity of sodium thiosulphate by iodometric titration.
7. Determination of free acidity in industrial alum sample (potash or chrome alum).
8. Study of safe handling techniques and storage requirements for chlorine and phosgene (demonstration/discussion-based activity).
9. Measurement of pH, conductivity and total dissolved solids (TDS) of water samples (tap, industrial effluent, pond).
10. Estimation of dissolved oxygen (DO) in water using Winkler's method.
11. Estimation of Chemical Oxygen Demand (COD) of an effluent sample.
12. Estimation of Biological Oxygen Demand (BOD) of a water sample over 5-day incubation.
13. Estimation of sulphur dioxide (SO_2) from air using West-Gaeke method.
14. Colorimetric estimation of nitrate/nitrite (Nox) in a water or air sample.
15. Analysis of heavy metals (Pb^{2+}/Cd^{2+}) in wastewater using spot test or colorimetric kit (demonstration-based).

Reference Books:-

1. Vogel's Textbook of Quantitative Chemical Analysis – J. Bassett, R.C. Denney, G.H. Jeffery & J. Mendham (ELBS / Pearson)
2. Laboratory Manual of Environmental Chemistry – S. M. Khopkar, New Age International
3. Environmental Chemistry – A.K. De, New Age International
4. Quantitative Inorganic Analysis – A.I. Vogel, Longman
5. Practical Chemistry – O.P. Pandey, D.N. Bajpai, S. Giri, S. Chand
6. Environmental Chemistry (9th Ed.) – Stanley Manahan, CRC Press
7. Standard Methods for the Examination of Water and Wastewater – American Public Health Association (APHA)
8. Physico-Chemico Examination of water,wastewater and industrial effluents By N. Manivasakam and S. K. Singh ,Pragati Prakashan,Meerut, India.

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SEMESTER - VII

COURSE: MAJOR – 18(MJ-18) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: QUANTUM CHEMISTRY AND COVALENT BONDING
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. To make students understand the limitations of classical mechanics and the need of quantum chemistry
2. To familiarize the students with the postulates of quantum chemistry
3. To explain how to apply the postulates to derive equations for various models and extend to hydrogen atom and hydrogen like atoms.
4. To explain the valence bond and molecular orbital theories and their applications to simple molecules
5. To explain the use of some computational software

COURSE OUTCOMES:

1. Explain the limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.
2. Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
3. Set up Schrodinger equations for different types of systems
4. Explain the concept of covalent bonding based on valence bond theory and molecular orbital theory.
5. Perform calculations using different software and plot different wavefunctions and probability distribution curves.
6. Perform simple calculations using appropriate quantum mechanical methods in different computational software

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Quantum Chemistry (Hours: 22)

Postulates of quantum mechanics, quantum mechanical operators and commutation rules, 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; wave functions, probability distribution functions, nodal properties, Extension to two and three- dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar coordinates (derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).

UNIT-II: Hydrogen Atom (08 Hours)

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Zeeman effect, Introduction of spin quantum number and magnetic spin quantum number Setting up of Schrödinger equation for many electron atoms (He, Li), Indistinguishability of electrons and Pauli exclusion principle, Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

UNIT-III: Covalent bonding (15 Hours)

Setting up of Schrödinger equation, Born-Openheimer approximation, LCAO-MO treatment of H^{2+} and its qualitative extension to H_2, Valence bond (VB) treatment of H_2, Comparison of LCAO-MO and VB wave functions of H_2 and their refinements, Qualitative description of LCAO-MO of homonuclear and heteronuclear diatomic molecules-HF and LiH.

SUGGESTED READINGS:

1. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
2. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier.
3. McQuarrie, D.A. (2016), Quantum Chemistry, Viva Books.
4. Chandra, A. K. (2001), Introductory Quantum Chemistry, Tata McGraw-Hill.
5. House, J.E. (2004), Fundamentals of Quantum Chemistry, 2nd Edition, Elsevier

6. Suggested Readings
7. Atkins, P.W.; Friedman, R. (2010), Molecular Quantum Mechanics, 5th Edition, Oxford University Press.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

One Activity/ Experiment = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Activity/Experiments:-

1. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbital using software like EXCEL.
2. Using a software such as ArgusLab, Avogadro, PyMOL, AutoDock etc to plot HOMO, LUMO and ESP maps of various molecules.
3. Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n - commenting on the number of points of zero probability and then correlate them with the correspondence principle.
4. Plot the electron density contour maps of sigma molecular orbitals for diatomic homonuclear molecules.
5. Plotting of the wave function and probability curve for simple harmonic motion and interpret the results for first two levels.
6. Plotting energy as a function of distance for simple harmonic motion - parabolic curve.
7. Using software such as ArgusLab, Avogadro, PyMOL, and AutoDock etc or any other recent open source software to calculate properties such as dipole moment and Mulliken charges using quantum mechanical methods.

Reference Books-

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
3. Steiner, E. The Chemical Maths Book Oxford University Press (1996).
4. Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
5. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
6. Noggle, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).

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SEMESTER - VIII

COURSE: MAJOR – 19(MJ-19) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: MOLECULAR SPECTROSCOPY & PHOTOCHEMISTRY
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Molecular Spectroscopy:(35 Lectures)

Quantization of molecular energies, Boltzmann distribution, Interaction of electromagnetic radiation with molecules and various types of spectra, Born- Oppenheimer approximation.

a) Rotation spectroscopy: The rotation of molecules and classification of molecules on the basis of principal moments of inertia, Rotational spectra of rigid diatomic molecules, Selection rules, Intensities of spectral lines, Determination of bond lengths of diatomic and linear triatomic molecules, Effect of isotopic substitution on rotational spectra, Centrifugal distortion and rotational spectra of non-rigid rotor.

b) 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, Breakdown of Born-Oppenheimer approximation – interaction between rotations and vibrations of molecules, Vibration-rotation spectroscopy, diatomic vibrating rotator, P, Q, R branches.

c) Raman spectroscopy: Introduction, Raman effect, Classical and quantum theories of Raman effect, Rotational Raman spectra, Effect of nuclear spin on rotational Raman spectra, Vibrational Raman spectra, Stokes & anti-Stokes lines and their intensity difference, Rule of mutual exclusion.

d) Electronic Spectroscopy: Franck-Condon principle, Electronic transitions, Selection rules for electronic transitions, Electronic spectra of diatomic molecules, Vibrational coarse structure of electronic spectra,

Rotational coarse structure of electronic spectra, Singlet & triplet states of molecules and their characteristics, Fluorescence and phosphorescence, Dissociation and predissociation, Electronic spectra of polyatomic molecules.

UNIT-II: Photochemistry:(10 Lectures)

Laws of photochemistry, Quantum yield, Jablonski diagrams, Franck-Condon principle, Law of photochemical equivalence, Quantum efficiency, Low and high quantum efficiency, Kinetics of photochemical reactions (H_2 + Br_2 = HBr, 2HI = H_2 + I_2), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and its applications).

SUGGESTED READINGS:

1. Laideler K. J. and Meiser J. M. Physical Chemistry Third Edition (International)1999.
2. Levine I. N., Physical Chemistry, Fourth Edition), McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. Physical Chemistry- A Molecular Approach, University Science Books, 1998.
4. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
5. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
6. Laideler K. J. and Meiser J. M. Physical Chemistry Third Edition (International)1999.
7. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age (revised second edition).
8. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Experiments:-

1. Verify Lambert-Beer's law and determine the concentration of
2. $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration
3. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
4. Interpretation of IR spectra of organic/inorganic compounds.
5. Identification of functional groups via group frequencies.

6. Analysis of rotational spectra of diatomic molecules.
7. Calculation of bond length and moment of inertia from given spectra.
8. Photoreduction of potassium ferrioxalate and comparison with actinometer.
9. Determination of quantum yield of a photochemical reaction.
10. Study of kinetics of $H_2 + Br_2 \rightarrow HBr$ or decomposition of HI under UV light (via simulation or data).

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical PhysicalChemistry, R. Chand & Co.: New Delhi (2011).

2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments inPhysical Chemistry 8th Ed.; McGraw-Hill: New York (2003).

3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry3rd Ed.; W.H. Freeman & Co.: New York (2003).

4. Manual of Biochemistry Workshop, 2012, Department of Chemistry,University of Delhi.

5. Arthur, I. V. Quantitative Organic Analysis, Pearson.

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SEMESTER - VIII

COURSE: MAJOR – 20(MJ-20)
PAPER NAME: DISSERTATION
TOTAL CREDITS: THEORY-03, PRACTICAL-01
TEACHING HOURS: THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

Course Objectives:

Enhance students' communication skills through active participation in seminars and group discussions. Prepare them for academic and professional environments where effective communication and teamwork are vital for success. Foster confidence, clarity, and coherence in expressing ideas, enabling students to engage meaningfully in collaborative and interdisciplinary settings.

Course Outcomes:

1. Develop effective verbal and non-verbal communication skills through seminars and group discussions.
2. Demonstrate confidence, clarity, and coherence in presenting and articulating ideas.
3. Collaborate successfully in academic and professional settings, applying interpersonal skills and teamwork strategies in diverse and interdisciplinary environments.

PART 'A'

Course Contents:

The Head of the Department and faculty members will assign topic to the students from the course content of semester VII and VIII. Students will have to work under the supervision of a teacher of the department. Each and every student has to submit electronically typed hardbound dissertation along with the raw data on a week before the examination.

Evaluation Process: Presentation and the report submitted by the students will be evaluated by one external member and one internal member. The External Member may be a Permanent faculty members working in

the postgraduate department of the university or other colleges or Retired Professor/Associate Professor/Assistant Professor of the university.

Distribution of marks:

Dissertation Report	25 marks
Presentation	50 marks
Subject Knowledge	25 marks

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SEMESTER - VII

COURSE: ADVANCE MAJOR – 1(AMJ-1) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: ANALYTICAL CHEMISTRY **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OUTCOMES:

1. Familiarization with fundamentals of analytical chemistry.
2. Basics of spectroscopic, thermal, electrochemical techniques
3. Learning basics of separation techniques and its applications.
4. Understanding analytical tools, statistical methods applied to analytical chemistry.
5. Understanding principle of UV-Vis spectroscopy and its applications.
6. Understanding principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials.
7. Understanding basics of electro-analytical techniques and its applications.
8. Understanding principles of separation technology and its use in advanced instrumentations.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Qualitative and Quantitative Aspects of Analysis: (4 Lectures)

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT-II: Spectroscopy Instrumentation (8 Lectures)

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

Vibration spectroscopy: 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

UV-Visible Spectrometry: Basic principles of instrumentation, 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.

UNIT-III: Thermal Analysis (4 Lectures)

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture.

UNIT-IV:

a) Electroanalytical Methods (5 Lectures)

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

b) Separation Techniques (12 Lectures)

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 non-aqueous media.

Chromatography techniques: 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 using LC, GLC, TLC and HPLC.

c) Sample Analysis: (12 Lectures)

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food

preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

Analysis of cosmetics: Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

SUGGESTED READINGS:

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

2 Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing California, USA, 1988.

4 Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.

5 Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Saunder College Publications, (1998).

6 Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood
John Wiley 1979.

7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

9.N. Manivasakam and S.K. Singh,Physico-Chemico Analysis of water,wastewater and industrial effluents ,Pragati Prakashan,Merrut, India.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Suggested List of Experiments:-

1. Determination of Ca and Mg from their salt mixtures using TG data. (Alternate: Data interpretation from provided TG/DTG graphs if instrument unavailable.)
2. Determination of dissociation constant (pKa) of a weak acid (e.g., acetic acid).

3. Extraction of metal ion (e.g., Cu^{2+} or Fe^{3+}) using suitable organic solvent and determination of distribution coefficient.
4. Separation of metal ions (Fe^{3+}, Al^{3+}, Cr^{3+}) using paper chromatography or TLC,
5. Separation of amino acids or sugars by paper chromatography. (Demonstration of HPLC or GLC if instruments are available.)
6. Measurement of pH of soil sample using pH meter.
7. Estimation of Ca^{2+} and Mg^{2+} as $CaCO_3$ by complexometric titration using EDTA
8. Determination of pH, acidity and alkalinity of water sample.
9. Estimation of dissolved oxygen (DO) using Winkler's method.
10. Detection of adulterants in common food items (turmeric, chilli powder, coffee, pulses, etc.).
11. Identification of preservatives and synthetic colours in food items using chemical tests.
12. Estimation of aluminium, zinc, chloride, sulphate in deodorants and antiperspirants.
13. Determination of magnesium oxide, calcium oxide, zinc oxide in talcum powder using complexometric titration.

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed., G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney – Pearson Education
2. Quantitative Chemical Analysis – Daniel C. Harris, W.H. Freeman and Co.
3. Fundamentals of Analytical Chemistry – Skoog, West, Holler, Crouch – Cengage
4. Instrumental Methods of Analysis – H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle – CBS Publishers
5. Analytical Chemistry: Principles and Techniques – John H. Kennedy, Saunders College Publishing
6. A Textbook of Analytical Chemistry – G.R. Chatwal, Anand – Himalaya Publishing
7. Practical Chemistry – O.P. Pandey, D.N. Bajpai, S. Giri – S. Chand
8. Laboratory Manual in Analytical Chemistry – H. Kaur – Pragati Prakashan
9. Physico-Chemico Examination of water,wastewater and industrial effluents By N. Manivasakam and S. K. Singh ,Pragati Prakashan,Meerut, India.

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SEMESTER - VIII

COURSE: ADVANCE MAJOR – 2(AMJ-2) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: GREEN AND SUSTAINABLE CHEMISTRY **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

1. Green chemistry and its principles.
2. Green synthesis and reactions.
3. Green chemistry for sustainable solutions.
4. Understanding principles of green chemistry.
5. Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
6. Atom economy and design of chemical reactions using the principle.
7. Understanding the use of green chemistry principle and processes in laboratory reactions.

COURSE OUTCOMES:

1. Use of green chemistry in designing new laboratory experiments.
2. Use of principle of atom economy and design experiments using the principle.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Introduction to Green Chemistry (4 Lectures)

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis (15 Lectures)

Twelve principles of Green Chemistry with their explanations and examples; 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); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids.

Energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

UNIT-III: Examples of Green Synthesis/ Reactions (18 Lectures)

1.Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural.

2.Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols).

Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.

Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2-dihydrotriazine derivatives; benzimidazoles.

3.Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction.

4.Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate; Use of “Clayan”, a nonmetallic oxidative reagent for various reactions; Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.

UNIT-IV: Future Trends in Green Chemistry (8 Lectures)

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions ss; Green chemistry in sustainable development.

SUGGESTED READINGS:

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

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of Suggested Experiments:-

1. Preparation of biodiesel from vegetable/ waste cooking oil.
2. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates Green Chemistry.
3. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atom economy.
4. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
5. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
6. Mechanochemical solvent free synthesis of azomethines
7. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu (II) complex.
8. Photoreduction of benzophenone to benzopinacol in presence of sunlight.

References:

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

6. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
7. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York,
9. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford UniversityPress (1998).
10. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
11. Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
12. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7 (2013).
13. Cann, M.C. and Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
14. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, Second Edition, 2010.

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SEMESTER - VIII

COURSE: ADVANCE MAJOR – 3(AMJ-3) **TOTAL CREDITS:** THEORY-03, PRACTICAL-01
PAPER NAME: INORGANIC MATERIALS & NANOCHEMISTRY **TEACHING HOURS:** THEORY-45, PRACTICAL-30

EVALUATION			
	External Exam	**Internal Exam**	**Practical**
Full Marks	**60**	15 (10 Written + 5 Attendance/Overall Class Performance)	**25**
Duration of Exam	3 Hours	1 Hour	6 Hours
Pass Marks	30 Marks		10 marks

COURSE OBJECTIVES:

The objectives of this course are as follows:

1. To make students understand the diverse roles of inorganic materials in the industry and to give an insight into how these raw materials are converted into products used in day-to-day life.
2. To make students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction.
3. To develop the interest of students in the frontier areas of inorganic and material chemistry.

COURSE OUTCOMES:

By studying this course, the students will be able to:

1. State the composition and applications of the different kinds of glass.
2. State the composition of cement and discuss the mechanism of setting of cement.
3. Defend the suitability of fertilizers for different kinds of crops and soil.
4. Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
5. Describe the principle, working and applications of different batteries.
6. Evaluate the synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Silicate Industries (6 Hours)

Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

UNIT-II: Fertilizers(5 Hours)

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime and potassium nitrate.

UNIT-III: Surface Coatings(12 Hours)

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC)and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing.

Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

UNIT-IV:

a) Batteries (9 Hours)

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li- ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

b) Introduction to nanoscience, nanostructure and nanotechnology: (13 Hours)

Basic idea; Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures, Spheroid, Wire, Rod, Tube, and Quantum Dot. Carbon nanotubes and inorganic nanowires. Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod and disc shapes nanoparticles.

Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self- assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

SUGGESTED READINGS:

1. 1West, A. R. (2014),Solid State Chemistry and Its Application, Wiley
2. Smart, L. E.; Moore, E. A. (2012),Solid State Chemistry An Introduction, CRC Press Taylor & Francis.
3. Atkins,P.W.; Overton,T.L.; Rourke, J.P.;Weller,M.T.;Armstrong, F.A.(2010),Shriver and Atkins Inorganic Chemistry, W. H. Freeman and Company.
4. Kent, J. A. (ed) (1997), Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. Poole Jr.; Charles P.; Owens, Frank J.(2003), Introduction to Nanotechnology, John Wiley and Sons.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

List of suggested Experiments:-

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
4. Analysis of (Cu, Ni) in alloy or synthetic samples (methods involving Gravimetry and Spectrophotometry).
5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, and Potentiometry).
6. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

7. Synthesis of silver nanoparticles by green and chemical approach methods and its characterization using UV-visible spectrophotometer

Reference Books:-

1. Svehla, G.(1996),Vogel's Qualitative Inorganic Analysis, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. Determination of Calcium and Magnesium in Limestones and Dolomites, Anal. Chem., 1952, 24 (7), 1186–1187.
3. Ghorbani, H. R.; Mehr, F.P.; Pazoki, H.; Rahmani B. M. Synthesis of ZnO Nanoparticles by Precipitation Method. Orient J Chem 2015;31(2).
4. Orbaek, W.; McHale, M.M.; Barron, A.R. Synthesis and characterization of silver nanoparticles for an undergraduate laboratory, J. Chem. Educ. 2015, 92, 339−344.

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SEMESTER - VII

COURSE: RESEARCH METHODOLOGY – 1(RM-1) **TOTAL CREDITS:** THEORY-04
PAPER NAME: RESEARCH METHODOLOGY IN CHEMISTRY **TEACHING HOURS:** THEORY-60

EVALUATION		
	External Exam	**Internal Exam**
Full Marks	**75**	25 (20 Written + 5 Attendance/Overall Class Performance)
Duration of Exam	3 Hours	1 Hour
Pass Marks	40 Marks	

COURSE OBJECTIVES:

1. To introduce students to the fundamentals of scientific research, especially within the field of chemistry.
2. To develop skills in formulating a research question, reviewing literature, and planning experiments.
3. To train students in writing research proposals and selecting appropriate methodologies.
4. To familiarize students with techniques for data analysis, referencing, ethical research practices, and scientific communication.

COURSE OUTCOMES:

1. Understand the purpose and structure of a research proposal.
2. Conduct an effective literature review using online and offline databases.
3. Formulate a clear hypothesis or research question.
4. Design experiments using proper methodology, instrumentation, and controls.
5. Apply fundamental techniques for data collection and interpretation in chemistry.
6. Demonstrate awareness of ethical issues in research and academic integrity.
7. Draft and present a comprehensive research proposal with proper formatting and citations.

PART 'A'

THEORY COURSE CONTENTS:

UNIT-I: Fundamentals of Research in Chemistry (9 Hours)

Definition, Scope, and Importance of Research, Types of Research: Basic, Applied, Interdisciplinary, Research in Chemical Sciences: Areas and Trends, Identification and Formulation of a Research Problem, Setting Objectives and Hypothesis Formulation

UNIT-II: Literature Review and Information Sources (6 Hours)

Purpose and Process of Literature Review, Layout of a Research Paper, Journals in chemistry, Impact factor of journals, Use of Encyclopaedias, Research Guides, Handbook etc., Academic databases for concerned discipline. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. software for detection of Plagiarism.

UNIT-III: Research Planning (12 Hours)

Research Design and Planning, Sampling Techniques and Control Experiments, Variables, Parameters, and Standardization, Use of Laboratory Notebooks and Research Logs, Safety Measures and Risk Assessment in Chemical Research.

UNIT-IV:

a) Reporting and Thesis writing: 7 Lectures

Structure and components of scientific reports - Types of report - Technical reports and thesis - Significance - Different steps in the preparation - Layout, Structure and Language of typical reports - Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation - Planning - Preparation - Practice - Making presentation - Use of visual aids - Importance of effective communication

b) Techniques and Tools in Chemical Research (9 Hours)

Instrumentation Overview: Spectroscopy (UV-Vis, IR, NMR), Chromatography (GC, HPLC), Electrochemical Methods, Computational Tools in Chemistry: Molecular Modeling, ChemDraw, Origin, Excel, Data Collection and Analysis: Accuracy, Precision, Errors, Interpretation and Presentation of Results

c) Writing a Research Proposal and Scientific Communication (9 Hours)

Structure and Format of a Research Proposal (Title, Abstract, Introduction, Objectives,Methodology, Budget, Timeline, References),Drafting and Revising a Proposal, Writing Abstracts and Research Papers, Preparing Posters and Presentations for Conferences, Ethics in Research and Academic Writing

SUGGESTED READINGS:

1. Kothari, C.R. – Research Methodology: Methods and Techniques, New Age International, 2nd Ed.
2. Leedy, P.D. & Ormrod, J.E. – Practical Research: Planning and Design, Pearson Education.
3. Day, R.A. & Gastel, B. – How to Write and Publish a Scientific Paper, Cambridge University Press.
4. Turabian, K.L. – A Manual for Writers of Research Papers, Theses, and Dissertations, University of Chicago Press.
5. ACS Style Guide – Effective Communication of Scientific Information, American Chemical Society.
6. Ranjit Kumar – Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications.

Bates, B. – Writing with Precision: How to Write So That You Cannot Possibly Be Misunderstood, Penguin.

PART 'B'

PRACTICAL COURSE CONTENTS:

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hours duration. Evaluation of Practical Examination may be as per the following guidelines:

Two Experiments = 20 marks

Practical record notebook = 03 marks

Viva-voce = 02 marks

Course Objectives:

- To expose students to practical aspects of scientific research in chemistry.
- To enable students to design and conduct small-scale experiments or survey-based investigations.
- To develop skills in scientific presentation, data handling, and reporting.
- To encourage field-based and lab-based observational learning in research contexts.

Course Outcomes:

- Demonstrate capability in planning and executing small experimental designs or field surveys.
- Interpret and analyze experimental or observational data with scientific reasoning.
- Present research findings in oral/poster format and submit written reports.
- Identify and comply with ethical practices in chemical research.

Components of Practical / Field / Presentation Work (30 Hours):

1. Designing a Mini Research Project: Framing objectives, hypothesis, and methodology based on any chemistry topic.

2. Field Visit / Laboratory Exposure: Visit to chemical research labs/industries/institutes or demonstration of instrumental techniques.
3. Experimental Planning and Data Collection: Performing basic chemistry experiments relevant to the research theme .
4. Data Analysis and Interpretation: Tabulation, graphical analysis, and drawing inferences
5. Preparation of Research Proposal / Report: Structuring a written proposal or short report
6. Presentation and Viva-Voce: Oral/poster presentation of the project followed by viva .

Reference Books:

1. Kothari, C.R. – *Research Methodology: Methods and Techniques*, New Age International Publishers, 2nd Edition
2. Ranjit Kumar – *Research Methodology: A Step-by-Step Guide for Beginners*, SAGE Publications
3. Day, R.A. & Gastel, B. – *How to Write and Publish a Scientific Paper*, Cambridge University Press
4. Turabian, K.L. – *A Manual for Writers of Research Papers, Theses, and Dissertations*, University of Chicago Press
5. ACS Style Guide – *Effective Communication of Scientific Information*, American Chemical Society
6. Bates, B. – *Writing with Precision: How to Write So That You Cannot Possibly Be Misunderstood*, Penguin Books
7. Sundaram, K.P.M. & Datt, R. – *Research and Report Writing*, S. Chand & Co.
8. McMillan, V.E. – *Writing Papers in the Biological Sciences*, Bedford/St. Martin's
9. Lampman, G.M., Pavia, D.L., Kriz, G.S., & Engel, R.G. – *Introduction to Organic Laboratory Techniques: A Small Scale Approach*, Brooks/Cole
10. Pallavi Jain & Ashutosh Jain – *Scientific Writing and Communication Skills*, S. Chand Publishing

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SEMESTER - VIII

COURSE: RESEARCH PROJECT/DISSERTATION – 1(RP/D-1) **TOTAL CREDITS:** 08
PAPER NAME: RESEARCH PROJECT/DISSERTATION **Full Marks**=200, **Pass Marks**=80

Guidelines for distribution of marks may be as follows or as appropriate:

Assessment of project synopsis/ Field Visit: 50 marks

Assessment of project thesis/dissertation: 100 marks

Viva-voce/Presentation: 50 marks

Course Objectives:

1. To facilitate students in conducting independent research projects in the field of Chemistry, allowing them to apply theoretical knowledge to practical experimentation.
2. To guide students in developing research skills, including problem identification, formulation of hypotheses, experimental design, data collection, analysis, and interpretation.
3. To foster critical thinking and analytical skills among students through the exploration of research methodologies and scientific literature.
4. To enhance students' communication abilities by requiring them to effectively present their research findings through written reports and oral presentations.
5. To cultivate ethical awareness and responsibility in research practices, including proper citation, acknowledgment of sources, and adherence to ethical guidelines and regulations.

Course Outcomes:

1. Students will demonstrate proficiency in designing and conducting independent research projects in Chemistry, from problem identification to data analysis.
2. Students will develop advanced skills in critical thinking, analytical reasoning, and problem-solving through the exploration of complex scientific questions.
3. Students will exhibit competency in utilizing various research methodologies and techniques appropriate for addressing specific research questions in Chemistry.
4. Students will effectively communicate their research findings through well-organized written reports and articulate oral presentations.
5. Students will demonstrate ethical conduct in research, including proper citation practices, avoidance of plagiarism, and adherence to ethical guidelines and regulations governing scientific research in Chemistry.

Course Contents:

Students who achieve a minimum of 75% marks across the first six semesters and express a desire to engage in undergraduate research may opt for a research stream during their fourth year of study. The Head of the Department (HOD) is responsible for assigning a supervisor to these students, chosen from the permanent faculty members holding a PhD degree. Subsequently, students, in consultation with their supervisor, select a research problem relevant and problem solving in nature to the local community/Industry, environment and

may be related to innovation/novel method/idea with interdisciplinary approach to submit a synopsis or research proposal to the department for review.

Following this, the HOD convenes a meeting of the Departmental Research Council, where students present their synopsis or research proposal for approval or rejection. Upon approval, students commence their research work under the guidance of their supervisor and in accordance with the approved proposal.

At the conclusion of the semester, Each and every student has to submit the soft copy and the electronically typed hardbound copy of the project thesis/Dissertation with the Plagiarism Report strictly adhering to the University Grants Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations, 2018 F. 1-18/2010(CPP-II). Published in THE GAZETTE OF INDIA: EXTRAORDINARY [PART III—SEC. 4] dated 23rd July, 2018 [web link :https://www.ugc.gov.in/pdfnews/7771545_academic-integrity-Regulation2018.pdf and the originality declarations of the supervisor and the student along with the raw data as date notified/affixed by the Head of the Department.

The department then forwards the thesis to an external evaluator, who provides a report on the work. Following receipt of the external report, the department shall arrange an open viva voce examination for the student, with both external and internal members present to assess the student's work.

The Department Research Committee shall be constituted from the following persons:

1. HOD of the Department–Chairmen
2. Dean, Faculty of Science- External member
3. HOD, University Department- External member
4. At list two permanent faculty member of the department (Nominated by HOD)- Members External members can be any of the following:
5. Permanent professors working in the postgraduate department of the university or other colleges who have the qualification to become PhD supervisors.

OR

Retired Professor/Associate Professor/Assistant Professor of the university who has been supervising PhD scholar/s.

OR

Professor/Associate Professor/Assistant Professor of the outside university who has been supervising PhD scholar/s.

Note- Minimum three external examiner lists will be sent by HOD through concerned College Principal to the Controller of Examination, SKMU, Dumka for final approval. In that list priority will be given as per order mentioned above.

Assessment of project synopsis	75 marks
Assessment of project Thesis	100 marks
Viva-voce	25 marks

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The project thesis shall be evaluated under the heads as per the standard LaTex/Word format made available by the Head of the Department which may include the following sections:

1. **Title Page:**

- **Title of the thesis**
- **Author's name**
- **Affiliation**
- **Date**

2. **Abstract:**

- **A brief summary of the research work, including the objectives, methods, results, and conclusions.**

3. **Table of Contents:**

- **Lists all the major sections and subsections of the thesis, along with their respective page numbers.**

4. **List of Figures and Tables:**

- **Enumerates all the figures and tables included in the thesis, along with their page numbers.**

5. **Introduction:**

- **Provides background information on the research topic.**
- **States the research problem and objectives.**
- **Reviews relevant literature and previous research in the field.**
- **Outlines the structure of the thesis.**

6. **Experimental Methods:**

- **Describes the experimental procedures and methodologies used in the research.**
- **Includes details on materials, equipment, and techniques employed.**
- **Provides sufficient information to allow for replication of the experiments.**

7. **Results and Discussion:**

- **Presents the findings of the research.**
- **Organizes results logically, often using figures, tables, and graphs.**
- **Analyses and interprets the results in the context of the research objectives.**
- **Discusses the implications of the findings and their significance in the field.**

8. **Conclusion:**

- **Summarizes the key findings of the research.**
- **Restates the research objectives and addresses whether they were achieved.**
- **Offers insights into the broader implications of the research.**

- **Suggests avenues for future research.**

9. References:

- **Lists all the sources cited in the thesis, following a specific citation style (e.g., APA, MLA, Chicago).**
- **Includes journal articles, books, conference proceedings, and other relevant literature.**

10. Appendices:

- **Contains additional supplementary information that is relevant to the thesis but not essential to the main text.**
- **Includes raw data, detailed experimental procedures, calculations, or any other supporting material.**

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