Royal College of Arts Science and Commerce

(Autonomous)

Affiliated to University of Mumbai

Program: B.Sc.

Course : Chemistry

Syllabus for Semester: V and VI

Syllabus for Undergraduate Programme as per

National Education Policy (NEP-2020) with effect from the Academic Year 2026-2027

Table of Contents

(As per NEP 2020)

NEP Credit Structure for Science

Level	Sem	Major		Minor	OE	VSC	SEC	AEC	IKS	VEC	OJT/FP /RP/CC /CEP	Cumulative Credits	
		DSC	DSE										
4.5	I	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2	2		2	2	2		22	**UG Certificate Cumulative Credit:44**
	II	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2		2	2		2	2	22	
Exit Option: Award of UG Certificate in Major with 40 -44 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5	III	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	**UG Diploma Cumulative Credit:88**
	IV	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	
Exit Option: Award of UG Diploma in Major and Minor with 80-88 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5.5	V	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22+	**UG Degree Cumulative Credit:132**
	VI	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22	
	Total	**48**	**8**	**20**	**12**	**10**	**6**	**8**	**2**	**4**	**14**	**132**	

Program Structure for Semester V

(NEP 2020)

Vertical No		Paper Title	Credits
Sem. V			
1	Major	1. Concepts in Advanced Physical Chemistry - I	2
		2. Concepts in Advanced Inorganic Chemistry - I	2
		3. Concepts in Advanced Organic Chemistry - I	2
		4. IKS: Origin and Development of Drugs and Dyes	2
		5. Experimental techniques in Physical Chemistry - I	2
	Electives	Elective – 1	
		1. Concepts in Advanced Analytical Techniques -I	2
		2. Experimental Techniques in Chemical Analysis -I	2
		Elective – 2	
		1. Introduction to Heavy and Fine Chemicals - I	2
		2. Practical course in Heavy and Fine Chemicals -I	2
	VSC (Practical)	1. Chemical Synthesis and Analysis – I	2
		2. Chemical Synthesis and Analysis – II	2
2.	Field Project (To be selected from CEP topic list)		4
Credits			22

Program Structure for Semester VI

(NEP 2020)

Vertical No		Paper Title	Credits
Sem. VI			
1.	Mandatory	1. Concepts in Advanced Physical Chemistry - II	2
		2. Concepts in Advanced Inorganic Chemistry - II	2
		3. Concepts in Advanced Organic Chemistry - II	2
		4. Advanced Drugs and Dyes	2
		5. Experimental techniques in Physical Chemistry – II	2
	Electives	Elective – 1	
		1. Concepts in Advanced Analytical Techniques -II	2
		2. Experimental Techniques in Chemical Analysis -II	2
		Elective – 2	
		1. Introduction to Heavy and Fine Chemicals -II	2
		2. Practical course in Heavy and Fine Chemicals -II	2
	VSC (Practical)	1. Chemical Synthesis and Analysis - III	2
		2. Chemical Synthesis and Analysis - IV	2
2.	OJT		4
Credits			22
		Total Credits	44

Semester: V

B.Sc. (Sem.- V)

Category: Major

Title of Paper: Concepts in Advanced Physical Chemistry - I

Course/ Paper Title	**Concepts in Advanced Physical Chemistry - I**
Vertical	Major
Type	Theory
Course Code	RUSCHMJ501
Semester	5
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: The course aims to:

CLO1: Introduce the fundamental principles of **molecular spectroscopy**, electromagnetic radiation, electromagnetic spectrum, and molecular energy levels.

CLO2: Develop understanding of **rotational spectroscopy**, including dipole moment, rigid rotor model, isotopic shift, applications, and numerical determination of bond length.

CLO3: Explain the principles of **vibrational spectroscopy**, including vibrational modes, Hooke's law, force constant, zero-point energy, IR spectra of simple molecules, and related numerical problems.

CLO4: Provide knowledge of **chemical thermodynamics**, particularly colligative properties and their application in determining molar mass using elevation in boiling point and depression in freezing point.

CLO5: Introduce the concepts of **surface chemistry and polymer chemistry**, including adsorption phenomena, adsorption isotherms, classification of polymers, and determination of molecular mass using viscosity method.

Course Outcomes:

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

CO1: Explain the basic concepts of electromagnetic radiation, molecular energy levels, and spectroscopic transitions.

CO2: Apply principles of rotational spectroscopy to determine molecular parameters such as bond length and interpret rotational spectra.

CO3: Apply concepts of vibrational spectroscopy to calculate vibrational frequency, force constant, and interpret IR spectra of simple molecules.

CO4: Apply thermodynamic relations to determine molar mass of non-volatile solutes using elevation in boiling point and depression in freezing point methods.

CO5: Explain adsorption phenomena, apply Langmuir and BET isotherms, classify polymers, and determine molecular weight using viscosity method

Unit I:

1.1. Molecular Spectroscopy (10 Hours)

1.1.1 Introduction: Definition of Spectroscopy, Electromagnetic radiation, Inter-conversion of units, Electromagnetic Spectrum, Molecular energy levels

1.1.2 Rotational Spectroscopy: Dipole moment and Polarisation of bond, Permanent dipole moment and induced dipole moment. Definition and conditions of rotational spectra, Bond length of simple diatomic molecule (rigid rotor). Rotational spectrum of a diatomic molecule, Isotopic shift in rotational spectra, limitations of rotational spectra, applications of rotational spectra. (Numerical expected)

1.1.3 Vibrational Spectrum: Definition and conditions of vibrational spectra, modes of vibrations, Hookes law, vibrational frequency, force constant, zero-point energy, conditions for obtaining vibrational spectrum, selection rule, vibrational spectra of simple harmonic oscillator.

1.1.4 Vibrational-Rotational spectrum of a diatomic molecule: vibrating rotor, energy levels, selection rule, nature of the spectrum, P and R branch lines, anharmonic oscillator, energy levels, selection rule, fundamental band, overtones. Applications of vibrational- rotational spectrum in determining force constant and its significance infrared spectra of simple molecules like H_2O and CO_2 (Numerical expected)

1.2. Chemical Thermodynamics: (5 Hours)

1.2.1 Colligative Properties: Vapour pressure and relative lowering of vapour pressure, (Numerical Expected)

1.2.2 Solution of Solid in Liquid:

Elevation in boiling point of a solution: Thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute. (Numerical Expected)

Depression in freezing point of a solution: Thermodynamic derivation relating the depression in the freezing point of a solution and molar mass of the non-volatile solute, Rast Method. (Numerical expected)

Unit II:

2.1. Surface Chemistry: (6 Hours)

2.1.1 **Adsorption:** Physical and Chemical Adsorption, types of adsorption isotherms, Langmuir's adsorption isotherm (Postulates and derivations expected). B.E.T. equation for multilayer adsorption, (derivation not expected), Determination of surface area of a n adsorbent using B.E.T. equation. ((Numerical expected)

2.1.2 **Colloids:** Introduction to the colloidal state of matter.

Electrical Properties: Origin of charges on colloidal particles, Concept of electrical double layer, Zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena – Electrophoresis, Electro-osmosis, Streaming potential, sedimentation potential.

Colloidal electrolytes: Micelle formation, Critical Micelle Concentration (CMC), Surfactants: Application of surfactants in detergents, food industry, and pesticide formulations.

2.2. Polymer chemistry: (5 Hours)

2.2.1 **Introduction to Polymers:** Classification of polymers based on source, structure, thermal response, and physical properties.

2.2.2 **The molar mass of polymers:** Number average molar mass, Weight average molar mass, Viscosity average molar mass, monodispersity, polydispersity, polydispersity index. Method of determination of molar mass of polymer by viscosity method using Ostwald Viscometer. (Numerical expected)

2.2.3 **Light Emitting Polymer:** Introduction, Characteristics, Method of preparation and applications.

2.3 Phase Equilibria (4 Hours)

2.3.1 Introduction: Gibbs Phase rule and terms involved it, condensed phase rule.

2.3.2 Three component System- Introduction of three component system and explanation of phase diagram with example of

Type I - Formation of one pair of partially miscible liquids.

Type II- Formation of two pairs of partially miscible liquids

Type III – Formation of three pairs of partially miscible liquids.

Reference Books:

1. K L Kapoor, A Textbook of Physical Chemistry - Dynamics of Chemical Reactions, Statistical Thermodynamics, Macromolecules and Irreversible Processes by, McGraw Hill Education. Volume 5 , 3rd Edition, 2014
2. Fred W Bilmeyer, Textbook of Polymer Science, John Wiley & Sons (Asia) Ple. Ltd., Singapore, 2007.
3. Colin N Banwell and Elaine M McCash, Fundamental of Molecular Spectroscopy, Tata McGraw Hill Publishing Co. Ltd. New Delhi, 4th Edn. 2008.
4. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Company, 2008.
5. Ira Levine, Physical Chemistry, Tata McGraw Hill Publishing Co.Ltd. 5th Edition, 2002
6. P.W. Atkins, The Elements of Physical Chemistry, Oxford University Press Oxford. 2nd Edition, 2003
7. P.C. Rakshit, Physical Chemistry, Sarat Book Distributors, Kolkata. 6th Edition, 2001,
8. R.J. Silbey, & R.A. Alberty, Physical Chemistry, John Wiley & Sons, Inc, 3rd edition, part I, 2001.
9. G.M. Barrow, Physical Chemistry, Tata McGraw Hill Publishing Co. Ltd. New Delhi. 6th Edition, 2025
10. S. Glasstone, Thermodynamics for Chemists, Affiliated East- West
    a. Press, New Delhi, 1964.
11. V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, Polymer Science, New Age International (P) Ltd., Publishers, 2005.

Title of Paper: Concepts in Advanced Inorganic Chemistry-I

Course/ Paper Title	**Concepts in Advanced Inorganic Chemistry-I**
Vertical	Major
Type	Theory
Course Code	RUSCHMJ502
Semester	5
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: The course aims to develop the learner's proficiency to

CLO1: Give an overview of molecular symmetry concepts and its importance in chemistry.

CLO2: Apply Molecular orbital theory in bonding in heteronuclear diatomic molecules

CLO3: Explain crystal structures, packing density, lattice parameters and defects in solids

CLO4: Communicate about the principles of superconductivity and its applications

CLO5: Discuss the properties and applications of transition elements and interhalogen compounds

Course Outcome :

After the completion of the course the learner will be able to

CO1: Comprehend the principles of molecular symmetry and classify molecules according to their symmetry elements and point groups.

CO2: Apply molecular orbital theory to explain bonding in both homonuclear and heteronuclear diatomic molecules

CO3: Describe the structural features of solids, including crystal. lattices, packing arrangements, and common types of defects.

CO4: Explain the fundamental concepts of superconductivity, its characteristics, and practical applications

CO5: Discuss the chemistry, of inner transition elements and interhalogen compounds

Unit 1

1.1 Molecular Symmetry (5 Lectures)

1.1.1 Introduction and Importance of Symmetry in Chemistry. Symmetry elements and Symmetry operations.

1.1.2 Concept of a Point Group with illustrations using the following point groups :(i) C∞v (ii) D∞h (iii) C2V (iv) C3v (v)C2h and (vi)D3h .

1.2 Chemical Bonding (5 lectures)

1.2.1 Comparison between homonuclear and heteronuclear diatomic molecules Molecular Orbital theory for Bonding in Heteronuclear diatomic molecules like CO, NO and HCl

1.3 Solid State (5 Lectures)

1.3.1 Explanation of terms viz. crystal lattice, lattice point, unit cell and lattice constants.

1.3.2 Closest packing of rigid spheres (hcp,ccp), packing density in simple cubic and bcc lattices. Relationship between density, radius of unit cell and lattice parameters. (Numerical problems expected)

1.3.3 Defects in solids

UNIT 2

2.1 Superconductivity (3 Lectures)

2.1.1 Discovery of Superconductivity

2.1.2 Explanation of Terms like Superconductivity, transition temperature, Meissner effect.

2.1.3 Different types of superconducting material, Applications of superconductors

2.2 Inner Transition Elements (7 lectures)

2.2.1 **Introduction:** Position in periodic table and electronic configuration of lanthanides and actinides.

2.2.2 **Chemistry of Lanthanides with reference to**

1) lanthanide contraction and its consequences
2) Oxidation states
3) Ability to form complexes
4) Magnetic and spectral properties.

2.2.3 **Applications of lanthanides**

2.3 Chemistry of Interhalogen and Oxyacids of halogens Compounds (5 Lectures)

2.3.1 Introduction, Preparation, Properties and Bonding of Interhalogen of the type XY, XY3, XY5, XY7.

2.3.2 Preparation, Properties, Structure of oxyacids of halogens

References

1. Bunker PR, Jensen P. Fundamentals of Molecular Symmetry. CRC Press; 2018.
2. Ogden JS. Introduction to molecular symmetry. Oxford: Oxford University Press; 2006.
3. Smith DW. Inorganic Substances. Cambridge University Press; 1990.
4. Ballhausen CJ, Gray HB. Molecular Orbital Theory. 1964.
5. Barrett J, Malati MA. Fundamentals of inorganic chemistry: an introductory text for degree course studies. Chichester: Horwood Publishing; 1998.
6. Prakash. Advanced Inorganic Chemistry Volume I (LPSPE). S. Chand

Publishing; 2022
7. Bunker PR, Per Jensen, National Research Council Canada, National Research Council Canada. Monograph Publishing Program. Molecular symmetry and spectroscopy. Ottawa: NRC Research Press; 2006.
8. Bhatt V. Essentials of coordination chemistry: a simplified approach with 3D visuals. London: Elsevier: Academic Press; 2015.
9. Smart L, Moore E. Solid state chemistry: an introduction. Boca Raton: CRC Press; 2012
10. House JE. Introduction to Solid State Chemistry. Elsevier; 2024.
11. Sharma RG. Superconductivity: basics and applications to magnets. Cham, Switzerland: Springer; 2021.
12. Tinkham M. Introduction to Superconductivity. McGraw-Hill Science, Engineering & Mathematics; 1996
13. R Gopalan. Inorganic chemistry for undergraduates. Hyderabad: Universities Press; 2009
14. Smart L, Moore E. Solid state chemistry: an introduction. Boca Raton: CRC Press; 2012.
15. Mele P, Kosmas Prassides, Tarantini C, Palau A, Petre Badica, Jha AK, et al. Superconductivity. Springer Nature; 2019.
16. Cotton, Frank Albert Cotton, Wilkinson G. Advanced Inorganic Chemistry. 1988
17. Greenwood NN, A Earnshaw. Chemistry of the Elements. Butterworth-Heinemann; 2012
18. Huheey, Medhi. Inorganic Chemistry: Principles of Structure and Reactivity, 4e. Pearson Education India
19. G Singh. Chemistry of lanthanides and actinides. New Delhi: Discovery Publishing House; 2007.
20. Cotton S. Lanthanide and Actinide Chemistry. John Wiley & Sons; 2024.
21. Lee JD. Concise inorganic chemistry. Oxford; Malden, Ma: Blackwell Science; 2008.
22. Atkins PW. Shriver & Atkins' inorganic chemistry. Oxford; New York: Oxford University Press; 2010

B.Sc. (Sem.- V)

Category: Major Paper

Title of Paper: Concept in Advanced Organic Chemistry-I

Course/ Paper Title	**Concept in Advanced Organic Chemistry -I**
Course offered as	Major
Type	Theory
Course Code	RUSCHMJ503
Semester	5
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: (List some of the course objectives)

CLO1: To understand and analyse the concept of Functional group transformation and mechanism.

CLO2: To corelate the chirality of compounds without a stereo genic center.

CLO3: To know the nomenclature, reactivity, and significance of heterocycles.

CLO4: To learn the green synthesis and spectroscopy of organic compounds.

CLO5: To understand the chemistry of natural products.

Course Outcomes: (List some of the course outcomes)

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

CO1: Deduce the mechanism of organic reactions.

CO2: Analyze the photochemical retractions and significance of Agrochemicals.

CO3: Identify chiral molecule.

CO4: Assign nomenclature and synthesis of heterocycles.

CO5: Write the green synthesis and analyze the spectral data.

CO6: Correlate the structure and reactivity of Natural products.

Unit I

1.1 Mechanism of Organic Reactions (4L)

1.1.1 Neighboring group participation in nucleophilic substitution reactions: Participation of lone pair of electrons, kinetics and stereochemical outcome.

1.1.2 Acyl nucleophilic substitution (Tetrahedral mechanism):
Acid catalyzed esterification of carboxylic acids (AAC^2) and base promoted hydrolysis of esters (BAC^2).

1.1.3 Pericyclic reactions, classification, and nomenclature.
Electrocyclic reactions (ring opening and ring closing), Cycloaddition, sigmatropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type)

1.2 Photochemistry (3L)

1.2.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization.

1.2.2 Photochemical reactions of olefins: Photoisomerization, photochemical rearrangement of 1,4- dienes (di- π methane).

1.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages. Photo reduction (e.g. Benzophenone to Benzpinacol).

1.3 Agrochemicals (2L)

1.3.1 Advantages & disadvantages of agrochemicals

1.3.2 Synthesis & application of IAA (Indole Acetic Acid) & Endosulphan, Bio pesticides – Neem oil & Karanj oil.

1.4 Stereochemistry I (3L)

1.4.1 **Molecular chirality and elements of symmetry:** Mirror plane symmetry, inversion center, rotation - reflection (alternating) axis

1.4.2 **Chirality of compounds without a stereo genic center:** Cumulenes and Biphenyls.

1.5 Heterocyclic Chemistry and IUPAC Nomenclature (3L)

1.5.1 Reactivity of pyridine-N-oxide, quinoline and isoquionoline.

1.5.2 Preparation of pyridine-N-oxide, quinoline (Skraup synthesis) and iso-quinoline (Bischler- Napieralski synthesis).

1.5.3 Reactions of pyridine-N-oxide: halogenation, nitration and reaction with $NaNH_2$/liq.NH_3,

1.5.4 Reactions of quinoline and iso-quinoline; oxidation, reduction, nitration, halogenation and reaction with $NaNH_2$/liq.NH_3,

1.5.5 IUPAC nomenclature of the following classes of compounds (including compounds up to two substituents / functional groups):

1.5.6 **Bicyclic compounds** –

spiro, fused and bridged (up to 11 carbon atoms) – saturated and unsaturated compounds.

1.5.7 **Biphenyls**

Unit 2: (15L)

2.1 Synthesis of Organic Compounds (5L)

2.1.1 Introduction: Linear and convergent synthesis, criteria for an ideal synthesis, the concept of chemoselectivity and regioselectivity with examples, and calculation of yields.

2.1.2 **Multicomponent Synthesis:** Mannich reaction and Biginelli reaction. Synthesis with examples (no mechanism)

2.1.3 Green Chemistry and Synthesis:

Introduction: Twelve principles of Green Chemistry, examples of some green methods of organic synthesis (used of Microwave, Ultrasound and PTC) concept of Atom Economy and E-factor, calculations and their significance, numerical examples.

1. Green reagents: dimethyl carbonate
2. Green starting materials: D-glucose
3. Green solvents: supercritical CO_2
4. Green catalysts: Biocatalysts

2.2. Spectroscopy: (6L)

- **Introduction:** Electromagnetic spectrum, units of wavelength and frequency.
- **UV – Visible spectroscopy:** Basic theory, solvents, nature of UV-Visible spectrum, concept of chromophore, auxochrome, bathochromic and hypsochromic shifts, hyperchromic and hypochromic effects, chromophore-chromophore and chromophore- auxochrome interactions.
- **Mass spectrometry:** Basic theory; Nature of mass spectrum; Importance of molecular ion peak, isotopic peaks, base peak, nitrogen rule, rule of 13 for determination of empirical formula and molecular formula; General rules of fragmentation. Fragmentation of alkanes and aliphatic carbonyl compounds.

2.3 Natural Products (4L)

Introduction and broad classification of Natural products based on Chemical structure and physiological activity.

Terpenoids

Introduction, Isoprene rule, special isoprene rule and the gem-dialkyl rule.

Citral: Structural determination of citral.

Alkaloids: Introduction and occurrence, Hofmann's exhaustive methylation and degradation in**:** simple open chain and N – substituted monocyclic amines.

3 **Nicotine:** Structural determination of nicotine. (Pinner's work included) and Harmful effects of nicotine.

Reference Books:

1. Organic Spectroscopy (Second edition), J. Mohan, Narosa Publication.
2. Introduction to Spectroscopy (Fifth edition), D. L. Pavia, G. M. Lampman, G. S. Kriz, J. A. Vyvyan, Cengage Learning Publication.
3. Elementary Organic Spectroscopy (Third edition), Y. R. Sharma, S. Chand Publication.
4. Organic Chemistry (Eighth edition), P. Y. Bruice, Pearson education.
5. Spectrometric Identification of Organic Compounds (Fifth edition), R.M. Silverstein, Wiley publication.
6. Organic Chemistry of Natural Products, Vol I and Vol II (First edition), A.

Chatwal, Himalaya Publishing House.

7. Organic Chemistry Natural Products, Vol I and Vol II (First edition), O. P. Agarwal, Krishna Publications.
8. Chemistry of Natural Products (First edition), S. V. Bhat, B. A. Nagasampagi, M. Sivakumar, Springer Narosa Publication.
9. Organic Chemistry (Seventh edition), R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Pearson Education.
10. Organic Chemistry, Vol II, (Fifth edition), I. L. Finar, Pearson Education.
11. Natural Products Chemistry (First edition), K. Nakanishi, T. Goto, Academic Press.

B.Sc. (Sem.- V)

Category: IKS

Title of Paper: Origin and Development of Drugs and Dyes

Course/ Paper Title	**Major IKS**
Course offered as	IKS
Type	Theory
Course Code	RUSCHMJIKS501
Semester	5
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: (List some of the course objectives)

CLO1: To know the origin and Development of medicinal Chemistry.

CLO2: To know the terminologies of medicinal Chemistry.

CLO3: To understand the origin, terminologies, and Chemistry of colorants.

CLO4: To learn the Chemistry of substrate for colorants.

Course Outcomes: (List some of the course outcomes)

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

CO1: To Illustrate the origin and Development of medicinal Chemistry.

CO2: Define and differentiate the terminologies used in medicinal Chemistry.

CO3 Correlate the chemistry between origin, colorants and terminologies used.

CO4: Identify and demonstrate the substrate for different colorants.

Unit 1: (15L)

1.1 General Introduction to Drugs-Indian Perspective: (5L)

- Origin of Medicinal Chemistry: Relation between Wellness, disease, cure and recovery. Indian systems of medicine, Ayurveda, Unani, Siddha, Naturopathy, Homeopathy, Allopathy etc.

1.2 Basic Medicinal Chemistry: (4L)

- Definition of a drug, sources of drugs, requirements of an ideal drug, classification of drugs. Generic name, Brand name, Systematic name, Oral and Parenteral routes with advantages and disadvantages.

1.3. Definition of medicinal terms: (6L)

- Pharmacon, Pharmacology, Pharmacophore, Prodrug, Half – life efficiency, LD50, ED50, GI50 Therapeutic Index.
- Brief idea of the following terms: Receptors, Agonists, Antagonists, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, Pharmacopoeia.

Unit 2: (15L)

2.1 General introduction to colorants: (6L)

- Definition of dyes, requirements of a good dye i.e. Colour, Chromophore and Auxochrome, Solubility, Linearity, Coplanarity, Fastness, Substantivity, Economic viability.
- Definition of fastness and its properties and Mordants with examples.
- Explanation of nomenclature or abbreviations of commercial dyes with at least one example.
- Suffixes – G, O, R, B, K, L, C, S, H, 6B, GK, 6GK, Naming of dyes by colour index (two examples) used in dye industries.

2.2 Natural and Synthetic Dyes: (4L)

- Natural Dyes: Definition and limitations of natural dyes.
- Examples and uses of natural dyes w.r.t Heena, Turmeric, Saffron, Indigo, Madder, Chlorophyll with names of the chief dyeing material/s in each natural dye. [structures not expected],
- Synthetic dyes: Definition of synthetic dyes, primaries and intermediates.

- Important milestones in the development of synthetic dyes – Emphasis on Name of the Scientist, dyes and the year of the discovery is required. (structure is not expected)

2.3. Dye Fibres (3L)

- Natural fibres: cellulosic and proteinaceous fibres, Structural features of wool, silk and cotton and names of dyes applied
- Semi-synthetic fibres: definition and examples [structures not expected] Synthetic fibres: Nylon, Polyesters and Polyamides structures and names of dyes applied.
- Blended fabrics: definition and examples [structures not expected]

2.4 Dyestuff Industry - Indian Perspective (2L)

- Growth and development of the Indian Dyestuff Industry
- Strengths, Weaknesses, Opportunities and Challenges of the Dyestuff industry in India
- Make in India - Future Prospects of the Dye Industry

Reference Books:

1. Davis William & Thomas Lemke; Foye's principles of medicinal chemistry. 6th Edition; Indian edition by B I Publication Pvt Ltd, Lippmcolt Williams & Wilkins. 2008
2. Wilson & Gisovolds; Text book of organic medicinal & pharmaceutical chemistry; 11th Edition,1998
3. Ashutosh Kar; Medicinal chemistry. New Age International Pvt. Ltd Publisher. 4th edition. 2006
4. Rotella Burger; Medicinal Chemistry & Drug Discovery; Sixth edition volume II. Wiley, 2003
5. Venkatraman K.; Chemistry of Synthetic Dyes, Vol I – IV; Academic Press, 1972
6. H.A., Robert E Krieger; The Chemistry of Synthetic Dyes and Pigments, Lubs; Publishing Company, NY ,1995
7. Shenai V.A.; Chemistry of Dyes and Principles of Dyeing; Sevak Publications, 1973
8. Joseph Benny; Environmental Studies, Tata McGraw Hill Education, 2005

B.Sc. (Sem.- V)

Category: Major practical

Practical: Experimental techniques in Physical Chemistry – I

Course/ Paper Title	**Experimental techniques in Physical Chemistry - I**
Vertical	Major
Type	Practical
Course Code	RUSCHMJP501
Semester	5
No. of Credits	2
No. of lecture Hours/week	4 hours
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives:

CLO1: To understand molecular weight determination by the Rast Method and analyze reaction kinetics graphically.

CLO2: To develop skills in analytical techniques like potentiometry, conductometry, pH-metry, and colorimetry.

CLO3: To understand concepts of solubility, kinetics, adsorption, and acid–base equilibria.

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

CO1: Determine molecular weight and evaluate reaction order and rate constant from data.

CO2: Apply techniques such as potentiometry, conductometry, pH-metry, and colorimetry for quantitative chemical analysis

CO3: Explain and interpret concepts of solubility, kinetics, adsorption, and acid–base equilibria through experimental results.

Non-Instrumental Experiments:

1. To determine the molecular weight of compound by Rast Method.
2. To interpret the order of reaction graphically from the given experimental data and calculate the specific rate constant.
3. To study the variation in the solubility of calcium hydroxide in the presence of sodium hydroxide, and hence determine the solubility product of calcium hydroxide at room temperature
4. To determine the molecular weight of polymer polyvinyl alcohol (PVA) by viscosity measurement
5. To investigate the adsorption of acetic acid on activated charcoal and test the validity of Freundlich adsorption isotherm.

Instrumental Experiments:

1. To determine the Solubility product and solubility of AgCl potentiometrically using concentration cell
2. To determine the velocity constant of alkaline hydrolysis of ethyl acetate by conductometric method.
3. To find out the strength of sodium carbonate solution by titrating it against HCl pH metrically.
4. To study the adsorption of certain dyes such as methyl violet, picric acid or malachite on charcoal colorimetrically.
5. To study the effect of substituent on dissociation constant of weak acid with respect to acetic acid and monochloroacetic acid (cell constant to be given).
6. To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and cerric sulphate potentiometrically
7. To determine acidic and basic dissociation constants of amino acid and hence to isoelectric point.

References:

1. M. James and F.E. Prichard, Practical Physical Chemistry Longman publication, 3rd edition,1974
2. R.C. Das and B. Behra, Experiments in Physical Chemistry, Tata Mc Graw Hill, 1983
3. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2006
4. J. N. Gurtu and R Kapoor, Advanced Experimental Chemistry., S. Chand and Co. Vol I, 1980
5. V.D.Athawale, Experimental Physical Chemistry, New Age International (P) Limited, 2001
6. B. D. Khosla, V. C. Garg and A. Gulati, Senior Practical Physical Chemistry, R Chand and Co. 2011

B.Sc. (Sem.- V)

Category: DSE

Title of Paper: Concepts in Advanced Analytical Techniques - I

Course/ Paper Title	Concepts in Advanced Analytical Techniques – I
Course offered as	DSE
Type	Theory
Course Code	RUSCHDSE501
Semester	5
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives:

CLO1: Understand quality concepts, QA/QC, Good Laboratory Practices and Good Manufacturing Practices in analytical chemistry.

CLO2: Apply basic sampling methods and sample handling techniques.

CLO3: Understand principles of titrimetric methods including neutralization, complexometric (using EDTA), and redox titrations.

CLO4: Understand principles and instrumentation of atomic spectroscopy techniques such as Flame Photometry and Atomic Absorption Spectroscopy.

CLO5: Learn the fundamentals of turbidimetry, nephelometry, and fluorescence/phosphorescence spectroscopy.

CLO6: Develop knowledge of quantification methods and analytical applications of these spectroscopic techniques.

Course Outcomes:

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

CO1: Apply QA/QC practices and select appropriate reagents for analysis.

CO2: Perform proper sampling, collection, and preparation of samples.

CO3: Construct and interpret neutralization, complexometric, and redox titration curves.

CO4: Explain working principles and components of various spectroscopic techniques.

CO5: Apply turbidimetric, nephelometric, and fluorescence methods for analysis.

CO6: Compare techniques and perform quantitative analysis in real sample applications.

Unit I

1.1 Quality in Analytical Chemistry [3L]

- Concepts of Quality, Quality Control and Quality Assurance
- Introduction to Good laboratory Practices (GLP) and Good manufacturing Practices (GMP)
- Chemical Standards and Certified Reference Materials; Importance in chemical analysis
- Quality of material: Various grades of laboratory reagent.

1.2 Significance of Sampling in Analytical Chemistry [3L]

- Terms involved in Sampling
- Purpose of sampling
- Types of Sampling: Random and systematic sampling
- Sampling of static and flowing liquids
- Collection, preservation, and dissolution of the sample.

1.3 Classical Methods of analysis – Titrimetry [9L]

1.3.1 Neutralization titration

- Introduction, Titration curve for Strong acid vs Strong base

1.3.2 Complexometric titrations

- Introduction, construction of titration curve
- Use of EDTA as titrant and its standardisation, absolute and conditional formation constants of metal EDTA complexes, Selectivity of EDTA as a titrant. Factors enhancing selectivity with examples. Advantages and limitations of EDTA as a titrant.
- Metallochromic indicators, theory and examples.

1.3.3 Redox titrations

- Introduction
- Construction of the titration curves and calculation of E system in aqueous medium in case of one electron system
- Theory of redox indicators
- Use of diphenyl amine as redox indicator.

Unit 2: (15L)

2.1 Atomic Spectroscopy [7]

- Introduction
- Flame Photometry – Principle and Instrumentation
- Atomic Absorption Spectroscopy – Principle and Instrumentation
- Quantification methods of FES and AAS – Calibration curve method, Standard addition method
- Comparison between FES and AAS.
- Applications, Advantages and Limitations

2.2 Turbidimetry and Nephelometry [4]

- Introduction and Principle
- Factors affecting scattering of radiation
- Instrumentation and Applications

2.3 Molecular Fluorescence and Phosphorescence Spectroscopy [4]

- Introduction and Principle
- Relationship of Fluorescence intensity with concentration
- Factors affecting Fluorescence and Phosphorescence
- Instrumentation and applications
- Comparison of Fluorimetry and Phosphorimetry

Category: Semester V DSE Practicals

Experimental techniques in Chemical Analysis – I

Course/ Paper Title	Experimental techniques in Chemical Analysis - I
Course offered as	DSE
Type	Practical
Course Code	RUSCHDSEP501
Semester	5
No. of Credits	2
No. of lecture Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives:

CLO1: To develop practical skills in classical analytical techniques such as acid-base, redox, and complexometric titrations.

CLO2: To understand the principles and applications of instrumental methods including spectrophotometry, flame photometry, and turbidimetry.

CLO3: To enhance the ability to interpret experimental data, construct graphs, and evaluate analytical results.

Course Outcomes:

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

CO1: Perform quantitative analysis of chemical substances using titrimetric and instrumental methods with accuracy and precision.

CO2: Apply appropriate analytical techniques (e.g., spectrophotometry, chromatography, flame photometry) for different types of samples.

CO3: Demonstrate proper laboratory practices, including solution preparation, standardization, and safe handling of chemicals.

List of experiments

1. Spectrophotometric analysis of fluoride in the given sample solution
2. Estimation of persulphate in the given sample by back titration using Fe(II) ammonium sulphate solution. (Standardization is expected)
3. Estimation of Fe (II) in given sample using diphenylamine indicator.
4. Estimation of sodium carbonate by pH metric titration against HCl (demonstration of two inflection points). (First Derivative Graph)
5. Determination of % purity of Boric acid by titrimetric analysis (Standardization is Expected)
6. To separate the mixture of Indicator by Paper Chromatography (any one)
   - Methyl Red + Methylene Blue
   - Methyl Red + Bromocresol Green
   - Phenolphthalein + Methyl Orange
   - Bromothymol Blue + Methyl Red
7. To determine the amount of sulphate in given water sample turbidimetrically.
8. To determine sodium in a sample by flame photometry.
9. Estimation of free acid in vegetable oil by titrimetry.
10. Estimation of dye by colorimetry.
11. Estimation of total hardness of water sample.
12. Determination of pKa of an organic Indicator (Methyl Orange).

Reference Books:

1. Fundamentals of Analytical Chemistry – Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch
2. Basic Concepts of Analytical Chemistry – S M Khopkar
3. Principles of Instrumental Analysis – Douglas A. Skoog et al.
4. Analytical Chemistry – Gary D. Christian
5. Vogel's Textbook of Quantitative Chemical Analysis – Arthur I. Vogel et al.
6. Quality Assurance in Analytical Chemistry – Eurachem
7. Instrumental methods of chemical analysis – Gurdeep R. Chatwal, Sham K Anand
8. Analytical Chemistry Problems and Solutions – S. M. Khopkar

B.Sc. (Sem.- V)

Title of Paper: Heavy and Fine Chemicals -I

Course/ Paper Title	Heavy and Fine Chemicals -I
Vertical:	Elective
Course Code	RUSCHDSE502
Type:	Theory
Credit:	2 credits
Hours Allotted:	30 Hours
Marks Allotted:	50 Marks

Course Objectives (CLOs):

CLO1: To **understand** the classification, scope, and industrial significance of heavy and fine chemicals, including the overview of Indian chemical industry.

CLO2: To **Gain knowledge** of the preparation, properties, and industrial applications of important inorganic chemicals and fertilizers.

CLO3: To **analyse** the economic and environmental aspects involved in chemical manufacturing processes and project planning.

CLO4: To **understand** the chemistry in synthesis and applications of fine chemicals such as perfumes, flavours, solvents and pharmaceutical intermediates.

CLO5: To **develop** insights into modern industrial practices including green chemistry, nano-encapsulation, and fluorination techniques.

Course Outcomes :(**Course Learning Outcomes)**

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

CO1: Classify heavy and fine chemicals and explain their industrial importance, including key players in the Indian chemical industry.

CO2: Describe the preparation, properties, and applications of silicates, nitric acid, sodium dichromate, chromium trioxide, and fertilizers.

CO3: Evaluate factors affecting the economics of chemical manufacturing processes and prepare a basic project report for an MSME chemical unit.

CO4: Explain the synthesis, classification, and industrial applications of perfumes, flavours, and industrial solvents, including green solvent concepts.

CO5: Apply concepts of sustainability such as green chemistry and nano-encapsulation in modern chemical industries and fluorination techniques and reactions.

Unit 1:

1.1 Introduction to Heavy and Fine Chemicals

- Introduction, commercial classification of chemicals, Classification of heavy and fine chemicals.
- Overview of Heavy and Fine Chemical Industry
- Introduction to Major Indian chemical industries (GSFC, GNFC, Tata Chemicals, RCF, FACT etc.).
- Contribution of Heavy and fine chemical industries to GDP of India.

1.2 Silicates:

- Introduction to silicates
- Properties, structure, and types of silicates. Preparation of sodium silicate**.**
- Applications of sodium silicate

1.3 Manufacture and applications of the following:

- Nitric acid
- Sodium dichromate
- Chromium trioxide

1.4 Fertilizers: Preparation, properties, and uses of-

- Urea
- Superphosphates
- Ammonium nitrate
- Ammonium Sulphate

Unit 2:

2.1 Brief idea about the economic aspects of chemical manufacturing processes with respect to

- Location
- Raw materials
- Energy
- Capital
- Manpower

- Ecological aspects
- Tax benefits.

2.2 Brief account of perfumes and flavours.

- Perfumes: Introduction, classification (ethers, esters, and essential oils) composition, formation, blending and applications. Synthesis of α and β - ionone‘s from citral.
- Flavours: Introduction, classification (natural and synthetic), applications of vanillin, vanillin., coumarin, (structures), synthesis of vanillin
- Nano-encapsulation of flavours: cyclodextrin inclusion complexes for controlled release — industrial applications (food, pharma).

2.3 Industrial solvents:

- Introduction – Classification of solvents (Q3C Class I/II/III) as per ICH guidelines.
- Brief idea of green solvents
- Manufacture and uses of ethyl acetate, isopropyl alcohol, Acetone.

2.4 Introduction to drugs and drug intermediates

- Classification of drugs with one example each.API and drug intermediate terminology. India's dominance in generic APIs,
- Synthesis and uses of the following i) p-acetyl amino benzenesulphonyl chloride from Aniline ii) Ethambutol iii) Miconazole iv) Diazepam.

2.5 Fluoroaromatics:

- Introduction, important reagents used for fluorination, Halex reaction, Super Halex reaction, Preparation of ortho-fluorotoluene and 3-chloro-4-fluoro aniline.

Reference Books:

1. C. D. Dryden: Outlines of Chemical Technology, edited & revised by M. Gopala Rao & Marshall Sittig East West Press, New Delhi.2008.

2. Faith Keyes and Clerk ‘s Industrial Chemicals, 4th Edn., Wiley Inter-science 1975.

3. Kirk & Othmer: Encyclopeadia of Chemical Technology, John Wiley and sons. Fourth Edition, Volume 5, John Wiley & Sons, New York, 1992.

4. Industrial Inorganic Chemistry- Büchner, Schliebs, Winter, translated by David R. Terrell, VCH/Wiley publisher New York., 2nd edition, 2000

5. Industrial Organic Chemistry- K. Welssermel, H. J. Arpe, VCH Publishers, New York.

6. B. Pearson- Speciality Chemical Innovations in Industrial Synthesis.

7. Text Book of Organic Medicinal and Pharmaceutical Chemistry Wilson & Giswold

8. Satoskar & Bhandarkar, Text Book of Pharmacology –.

9. B. K. Sharma, Industrial Chemistry Goyal publishing house, Mirut.

10. Riegel's Hand Book of Industral Chemistry, 9th Edition, Jems A. Kent.

11. Industrial Chemistry- E Stoch, Vol- I, Ellis Horwood Ltd. UK.

12. An Introduction to Industrial Organic Chemistry- Wiseman and Peter,

13. Overview of Bulk and Fine Chemicals by Anna Regini Anthony, Walnutpublication.com

14. A Comprehensive Overview of Bulk and Fine Chemicals by 13. Fine Chemicals, The Industry and The Business Second Edition Peter Pollak, PhD Reinach, Switzerland A John Wiley & Sons, Inc., Publication

15. Research and Development in The Chemical and Pharmaceutical Industry By Peter Bamfield, Third Completely Revised And Enlarged Edition, Publication WILEY-VCH Verlag Gmbh & Co. Kgaa, Weinheim 2006

(Sem: - V)

Practicals : Heavy and Fine Chemicals-I

Course/ Paper Title	Heavy and Fine Chemicals-I
Vertical:	Elective
Course Code	RUSCHDSEP502
Type:	Practical
Credit:	2 credits
Hours Allotted:	60 Hours
Marks Allotted:	50 Marks

Course Objectives: **(CLOs)**

CLO1: To develop practical skills in organic synthesis including nitration, methylation, oxidation, and condensation reactions.

CLO2: To Apply quantitative analytical methods such as titrimetric and complexometric analysis for estimation of pharmaceutical and inorganic compounds.

CLO3: To Understand and perform standard laboratory technique thin layer chromatography for separation and identification.

CLO4: To Enhance laboratory competence in handling chemicals, preparing reagents, and interpreting experimental results with accuracy and safety.

Course Outcomes :

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

CO1: Perform synthesis of organic compounds using appropriate reaction techniques.

CO2: Conduct quantitative estimations of pharmaceutical and inorganic substances using titration methods (acid-base, iodometric, complexometric titrations).

CO3: Demonstrate proficiency in laboratory techniques such as TLC for separation and identification.

CO4: Analyze experimental results to determine concentration, purity and composition of given samples.

Preparations (09) :

To prepare the -

1. Benzil from Benzoin.
2. 5-nitrosalycilic acid from salicylic acid.
3. Nerolin from 2-naphthol.
4. Benzal acetophennoe (chalcone) by condensation of benzaldehyde with acetophenone.
5. p-nitrobenzoic acid from p-nitrobenzaldehyde.
6. Caprolactam from cycloheanone oxime.
7. Ferrous sulphate heptahydrate
8. Double salt (Ferric alum).
9. Copper sulphate pentahydrate

Estimations (09) :

To determine the -

1. Phosphoric acid from a given sample using 1-naphtholphthalein and phenolphthalein indicator. (Students to prepare succinic acid solution for standardization of NaOH).
2. Magnesium hydroxide in a commercial sample of milk of magnesia.

To estimate the -

3. Tincture iodine from commercial sample.
4. To estimate the amount of aspirin in given tablet. (Back titration method)
5. Ibuprofen in the given sample (Back titration method)
6. Acid neutralising capacity of an antacid from the given tablet.
7. Chlorine by iodometric method from the given sample. (Bleaching Powder)
8. Zn by complexometric titration from the given tablet
9. Ca by EDTA method (titrimetric) from the given tablet.

Thin layer chromatography-

1. To Identify the drugs by TLC. **(any 02)** (from Tablets Excedrin, Anacin etc separation and identification of **aspirin, acetaminophen, caffeine, ibuprofen etc.)**

Reference Books:

1. Vogel: Text book of Quantitative Analysis including Instrumental Analysis.
2. Vogel: Text book of Quantitative Organic Analysis.
3. Advanced Practical Organic Chemistry 3rd Edition, N.K. Vishnoi, Vikas Publication,
4. Practical Organic Chemistry by Mann and Saunders.
5. Vogel's Textbook of Quantitative Chemical Analysis 5th Edition
6. Vogel's Qualitative Inorganic Analysis 5th Edition

B.Sc. (Sem.- V)

Category: VSC

Chemical Synthesis and Analysis -I

Course/ Paper Title	**Chemical Synthesis and Analysis-I**
Vertical	VSC
Type	Practical
Course Code	RUSCHVSCP501
Semester	5
No. of Credits	2
No. of lecture Hours/week	4 hours practical/week
Hours Allotted	60
Marks Allotted	50 marks

Course Learning Objectives:

CLO1: To give an understanding of principles and techniques involved in the synthesis of coordination compounds.

CLO2: To develop practical skills in the use of complexing agents for quantitative determination of metal ion concentrations by gravimetric and complexometric titrations

Course Outcomes:

CO1: To demonstrate an ability to synthesize different coordination compounds.

CO2: To determine the concentration of metal ions samples by complexometric titrations

CO3: To determine the concentration of metal ions samples by gravimetric estimations

Experiments :

1. Preparation of potassium trioxalato chromate (III) complex
2. Preparation of bis acetylacetonato Copper (II)
3. Preparation of Potassium dioxalatocuprate (II), $K_2[Cu(C_2O_4)_2]$
4. Preparation of tetraamine Copper(II) sulfate
5. Complexometric titration of Lead using Xylenol orange indicator
6. Preparation of tris(thiourea)cuprous(I) sulphate
7. Complexometric titration of Al3+ with Xylenol Orange (Back Titration)
8. Estimate the amount of iron present in the given ferric alum solution by using dichromate solution and dipenyl amine indicator
9. Estimation of Nickel using EDTA (Complexometric)
10. Determination of calcium in presence of Magnesium by EDTA titration using Patton Reader indicator
11. 11.Gravimetric estimation of Zn as $ZnNH_4(PO_4)$
12. 12.Gravimetric estimation of Ba as $BaCrO_4$

REFERENCES

1. Vogel AI, Jeffery GH. Vogel's Textbook of Quantitative Chemical Analysis. Longman Scientific and Technical; 1989.
2. Pass G, Sutcliffe H. Practical Inorganic Chemistry. 1969.
3. Svehla G. Vogel's Qualitative Inorganic Analysis. 1979.
4. Advanced Experiments in Inorganic Chemistry G.N. Mukherjee
5. Inorganic Syntheses. John Wiley & Sons; 2009.
6. Girolami GS, Rauchfuss TB, Angelici RJ. Synthesis and technique in inorganic chemistry: a laboratory manual. Sausalito, Calif.: University Science Books; 1999

B.Sc. (Sem.- V)

Category: VSC Practical

Chemical synthesis and Analysis-II (Organic Chemistry)

Course/ Paper Title	**Chemical synthesis and Analysis-II**
Course offered as	VSC-3
Type	Practical
Course Code	RUSCHVSCP502
Semester	5
No. of Credits	2
No. of lecture Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives:

CLO1: To understand the concept of chemical separation of organic binary Solid-solid mixture.

CLO2: To learn the synthesis of organic compounds.

Course Outcomes:

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

CO1: Identify and separate the organic binary solid-solid mixture.

CO2: Synthesize grams scale organic compound.

List of experiments:

A. Separation of Binary solid-solid mixture- (2.0 gms mixture to be given).

1. Minimum 8 mixtures to be completed by the students.
2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (2-naphthol, 1-naphthol), water insoluble base (nitroanilines), water soluble neutral (thiourea) and water insoluble neutral compounds (anilides, amides, m-DNB, hydrocarbons).
3. After correct determination of chemical type, the separating reagent should be decided by the student for separation.

   Follow separation scheme with the bulk sample of binary mixture.
4. After separation into component A and component B, one component (decided by the examiner) is to be analysed and identified with m.p.

B) Organic Preparation

1) O-Acylation
2) N-Acylation
3) O-Methylation of Naphthol
4) Preparation of benzilic acid from benzil by grinding (solid-state)

Reference Books:

1. Practical Organic Chemistry – A. I. Vogel
2. Practical Organic Chemistry – H. Middleton
3. Practical Organic Chemistry – O. P. Agarwal

Semester: VI

B.Sc. (Sem.- VI)

Category: Major

Title of Paper: Concepts in Advanced Physical Chemistry – II

Course/ Paper Title	Concepts in Advanced Physical Chemistry - II
Vertical	Major
Type	Theory
Course Code	RUSCHMJ601
Semester	6
No. of Credits	2
No. of lecture Hours/week	2 hours practical /week
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: **The course aims to:**

CLO1: Develop understanding of **nuclear chemistry**, including radioactive decay processes, nuclear reactions, fission process, nuclear reactors, and applications of radioisotopes.

CLO2: Introduce fundamental concepts of **quantum chemistry**, including limitations of classical mechanics, wave-particle duality, uncertainty principle, and basic quantum mechanical operators.

CLO3: Explain the mathematical and conceptual framework of **wave mechanics**, including Schrödinger wave equation, wave functions, and operator theory.

CLO4: Provide knowledge of **electrochemistry**, including activity, ionic strength, Debye-Hückel theory, and classification of electrochemical cells.

Course Outcomes: At the end of the course, students will be able to:

CO1: Explain radioactive decay processes, nuclear reactions, working of nuclear reactors, and applications of radioisotopes in chemical studies.

CO2: Apply fundamental principles of quantum theory, including **de-Broglie relation, uncertainty principle**, and explain limitations of classical mechanics.

CO3: Explain Schrödinger wave equation, properties of wave functions, and apply concepts of **operators, eigen values, and eigen functions** in quantum mechanics.

CO4: Apply concepts of activity and activity coefficient and classify electrochemical cells, including concentration cells and liquid junction potential.

Unit I

1.1. Nuclear Chemistry (8 Hours)

- **Introduction:** Radioactive substance, radioactivity, Types of nuclear radiations Basic terms-radioactive constants (decay constant, half-life and average life) and units of radioactivity.
- **Detection and Measurement of Radioactivity:** Detection and measurement of nuclear radiations using G.M. Counter and Scintillation Counter.
- **Radioactive Equilibrium:** Difference between chemical equilibrium and radioactive equilibrium.
- **Application of use of radioisotopes as Tracers:** Chemical reaction mechanism, age determination- dating by C14.
- **Nuclear Transmutation:** Nuclear transmutation (one example for each projectile), artificial radioactivity, Q- value of nuclear reaction, threshold energy. (Numerical expected)
- **Fission Process:** Fissile and fertile material, chain reaction, factor controlling fission process, multiplication factor and critical size or mass of fissionable material
- **Nuclear reactor:** Construction and working of Nuclear Power reactor

1.2. Basic of Quantum Chemistry: (7 Hours)

- **Classical mechanics:** Introduction, limitation of classical mechanics, Black body radiation, photoelectric effect, Compton effect.
- **Quantum mechanics:** Introduction, Planck's theory of quantization, wave particle duality, de-Broglie's equation, Heisenberg's uncertainty principle. State function and its significance (Numerical expected)
- **Progressive and standing waves:** Introduction, Schrodinger's time independent wave equation (No derivation expected), Properties of wave function.
- **Concept of operators:** Definition, addition, subtraction and multiplication of operators, commutative and non-commutative operators, linear operator, Hamiltonian operators, Eigen function, and Eigen value. (Numerical expected)

Unit 2:

2.1. Electrochemistry (7 Hours)

- **Activity and Activity Coefficient:** Lewis concept, ionic strength, mean ionic activity and mean ionic activity coefficient of an electrolyte, expression for activities of electrolytes. Debye Huckel limiting law (No derivation) (Numerical expected)
- **Classifications of cells:** Chemical cells and Concentration cells., Liquid junction potential, Electrode concentration cells, Electrolyte concentration cells with and without transference. (derivation and numerical expected)

2.2. Applied Electrochemistry (3 Hours)

- **Decomposition Potential:** Introduction, experimental determination, Factors affecting it.
- **Over Voltage:** Introduction, Experimental determination, Hydrogen over voltage, Tafel's equation for hydrogen overvoltage. (Numerical expected)

2.3. Resonance Spectroscopy: (5 Hours)

- **NMR -Nuclear Magnetic Resonance Spectroscopy:** Principle, Nuclear spin, magnetic moment, nuclear ' g ' factor, energy levels, Larmor

precession, Relaxation processes in NMR (spin-spin relaxation and spin-lattice relaxation).

- **ESR-Electron Spin Resonance Spectroscopy:** Principle, Fundamental equation, electron g – factor, hyperfine splitting, ESR spectrum of hydrogen and deuterium.

References:

1. K L Kapoor, A Textbook of Physical Chemistry - Dynamics of Chemical Reactions, Statistical Thermodynamics, Macromolecules, and Irreversible Processes by, McGraw Hill Education. Volume 5, 3rd Edition, 2014

2. Walter D. Loveland (Author), David J. Morrissey, Glenn T. Seaborg, Modern Nuclear Chemistry Hardcover, Wiley, 2017

3. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International (P) Ltd., Publishers, 2011.

4. Levine, Physical Chemistry, Tata McGraw Hill Publishing Co.Ltd. 5th Edition, 2002

5. P.W. Atkins, The Elements of Physical Chemistry, Oxford Universtity Press Oxford., 2nd Edition. 1997

6. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, VISHAL PUBLISHING Company, 2008.

7. J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco, Modern. Electrochemistry Springer, 2nd Edition, 1st Indian reprint, 2006

8. Donald A. McQuarrie, Quantum Chemistry Paperback, Viva Books, 2020

9. Quantum Chemistry by R. K. Prasad, October 1993

SEMESTER VI

Category: Major

Title of Paper: CONCEPTS IN ADVANCED INORGANIC CHEMISTRY-II

Course/ Paper Title	**CONCEPTS IN ADVANCED INORGANIC CHEMISTRY-II**
Vertical	Major
Type	Theory
Course Code	RUSCHMJ602
Semester	6
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objective:

The course aims to develop proficiency in the learner to

CLO1: To apply the crystal field theory and Molecular orbital theory to explain bonding in coordination compounds

CLO2: To elaborate on the stability of complexes and the factors affecting the stability

CLO3: To discuss about the reactivity of complexes and the mechanism of reactions undergone by complexes.

CLO4: To explain the chemistry of organometallic compounds and their role in catalysis

Course outcomes:

After the completion of the course the learner will be able to

CO1: To apply the Crystal field theory and the Molecular orbital theory to explain bonding in coordination compounds

CO2: To discuss thermodynamic stability of complexes and the factors affecting them.

CO3: To write the mechanism of different types of reactions undergone by complexes.

CO4: To discuss the chemistry and applications of organometallic compounds.

Unit I

1.1 Crystal Field Theory (5 lectures)

- Limitations of Valence Bond Theory, Fundamentals of Crystal Field Theory , Crystal field Splitting of *d* orbitals in octahedral, square planar and tetrahedral complexes, Crystal field splitting parameter 10Dq(Δ), factors affecting 10Dq, spectrochemical series. Crystal field stabilisation energy(CFSE), calculation of CFSE for octahedral complexes with d0 to d10 metal ion configurations.

1.2 Molecular Orbital theory applied to Coordination compounds(5 lectures)

- Limitations of CFT: Evidences for covalence in metal complexes with respect to (i) intensities of d-d transitions (ii) ESR spectrum of $[IrCl6]^{2-}$ (iii) Nephelauxetic effect.
- Identification of the central metal orbitals , their symmetry suitable for formation of σ bonds with ligand orbitals and Construction of ligand group orbitals
- Construction of molecular orbitals for ML6 complex. Examples like [FeF6]-4, $[Fe(CN)_6]^{-4}$, $[CoF_6]^{-3}$ $[Co(NH_3)_6]^{+3}$
- Effect of π-bonding on complexes.

1.3 Stability of Metal Complexes (5 lectures)

- Thermodynamic and Kinetic stability of complexes. Stability constants: Stepwise and overall stability constants and their interrelationship.
- Factors affecting thermodynamic stability (Factors related to nature of central metal atom, nature of ligand, chelate effect)

Unit 2:

2.1 Reactivity of Metal Complexes (5 Lectures)

- Comparison between Inorganic and organic reactions, Types of reactions in metal complexes, Study of Inert and labile complexes with respect to $[Ti(H_2O)_6]^{3+}$ and $[Cr(H_2O)_6]^{3+}$complexes, Ligand substitution reactions: Associative and Dissociative mechanisms, Acid hydrolysis, base hydrolysis and anation reactions.

2.2 Organometallic Compounds of main group elements (5 lectures)

- History of **Organometallic Chemistry**
- **General characteristics** of various types of organometallic compounds, viz. ionic, s-bonded and electron deficient compounds.
- **General synthetic methods of organometallic compounds:** (i) Oxidative-addition, (ii)Metal-metal exchange(trans-metalation), (iii) Carbanion-halide exchange, (iv) Metal-hydrogen exchange (metallation) and (v) Methylene-insertion reactions.
- **Some chemical reactions of organometallic compounds**: (i) Reactions with oxygen and halogens, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents
- **Applications**

2.3 Role of Transition metals in catalysis (5 lectures)

Comparison between homogeneous and heterogeneous catalysis

- Basic steps involved in homogeneous catalysis
- Mechanism of Wilkinson's catalyst in hydrogenation of alkenes.
- Polymerisation of Alkenes using Zeigler Natta Catalyst

References:

1. Lawrance GA. Introduction to Coordination Chemistry. John Wiley & Sons; 2013.
2. Gopalan R. Concise Coordination Chemistry. Vikas Publishing House; 2001.
3. Rodgers GE. Introduction to coordination, solid state, and descriptive inorganic chemistry. New York; London: The McGraw-Hill Companies; 1999
4. Sontag C. 101 Group Theory for Chemists. Lulu.com; 2018.
5. Newman DJ, Ng B. Crystal field handbook. Cambridge, Uk; New York: Cambridge University Press; 2000.
6. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985
7. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993
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20 Mehrotra RC. Organometallic Chemistry. New Age International; 2007.

21 Nakazawa H, Koe J. Organometallic Chemistry. Royal Society of Chemistry; 2021

B.Sc. (Sem.- VI)

Category: Major

Title of Paper: Concept in Advanced Organic Chemistry-II

Course/ Paper Title	**Concept in Advanced Organic Chemistry-II**
Course offered as	Major
Type	Theory
Course Code	RUSCHMJ603
Semester	6
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: (List some of the course objectives)

CLO1: To understand and analyse the concept of stereochemical reactions.

CLO2: To know the chemistry of amino acids and nucleic acid.

CLO3: To understand the chemistry of carbohydrates.

CLO4: To know the Infra-red spectroscopy and Proton NMR spectroscopy of organic compounds.

CLO5: To learn the name reactions and polymer chemistry.

CLO6: To understand the process of reagents and catalyst in chemical transformation.

Course Outcomes: (List some of the course outcomes)

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

CO1: To write the stereochemical reactions.

CO2: To Illustrate the chemistry of amino acids and nucleic acid.

CO3: To describe the chemistry of carbohydrates.

CO4: To corelate the structure of organic molecule with the help of IR spectroscopy and Proton NMR spectroscopy.

CO5: To identify the name of the reaction and describe the chemistry of polymers.

CO6: To determine the reagents and catalyst for chemical transformation.

Unit I

1.1 Stereoselectivity and stereospecificity (5L)

- Idea of enantioselectivity (ee) and diastereoselectivity (de), Topicity: enantiotopic and diastereotopic atoms, groups and faces.
- **Stereochemical reactions:**
    1. Substitution reactions: SN^i (reaction of alcohol with thionyl chloride)
    2. Elimination reactions: E^2–Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane.
    3. Addition reactions to olefins:
        a) Bromination (electrophilic anti addition)
        b) Syn hydroxylation with OsO_4 and $KMnO_4$
        c) Anti hydroxylation-Epoxidation

1.2 α-Amino acids and Nucleic acid (5L)

- General Structure, configuration, and classification based on structure and nutrition. Properties: pH dependency of ionic structure, isoelectric point and zwitter ion.
- **Polypeptides and Proteins:**

1. Nature of peptide bond. Nomenclature and representation of polypeptides (di- and tri-peptides) with examples, Merrifield solid phase polypeptide synthesis.
2. **Proteins**: General idea of primary, secondary, tertiary & quaternary structure

- **Nucleic Acids:** Controlled hydrolysis of nucleic acids. sugars and bases in nucleic acids. Structures of nucleosides and nucleotides in DNA and RNA. Structures of nucleic acids (DNA and RNA) including base pairing.

1.3 Carbohydrates (5L)

- **Introduction:** Classification, reducing and non-reducing sugars, DL notation.
- **Structures of monosaccharides:**

1. Fischer projection (4-6 carbon monosaccharides) and Haworth formula (furanose and pyranose forms of pentoses and hexoses).
2. Interconversion: open chain and Haworth forms of monosaccharides with 5 and 6 carbons.
3. Chair conformation with stereochemistry of D-glucose, Stability of chair form of D-glucose.

- **Stereoisomers of D-glucose:** Enantiomer, diastereomers, anomers, epimers.
- **Mutarotation in D-glucose with mechanism**
- **Chain lengthening & shortening reactions:** Modified Kiliani-Fischer synthesis (D-arabinose to D-glucose and D- mannose), Wohl Degradation method (D-glucose to D-arabinose).
- **Reactions of D-glucose and D-fructose:**

(a) Osazone formation (b) reduction: H_2/Ni, $NaBH_4$
(c) methylation (d) oxidation

Unit 2: (15L)

2.1 Spectroscopy II (6L)

- **IR spectroscopy:** Basic Theory, Nature of IR spectrum, selection rule, finger print region.
- **^{1}H-NMR spectroscopy:** Basic theory of ^{1}H-NMR, nature of ^{1}H-NMR spectrum, chemical shift (δ unit), standard for ^{1}H-NMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, C≡C, C=O and benzene ring). Spin- spin coupling and coupling constant. application of deuterium exchange technique. application of H1-NMR in structure determination.
- **Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to IR and ^{1}H-NMR:**

(1) alkanes (2) alkenes (3) alkynes (4) haloalkanes (5) alcohols
(6) carbonyl compounds (7) ethers (8) amines
(broad regions characteristic of different groups are expected).

- Problems of structure elucidation of simple organic compounds using individual or combined use of UV-Vis, IR, Mass and ^{1}H-NMR spectroscopic technique are expected. (Index of hydrogen deficiency should be the first step in solving the problems).

2.2 Mechanism of the following rearrangements with examples and stereochemistry wherever applicable. (2L)

- **Migration to the electron deficient carbon:** Pinacol-pinacolone rearrangement.
- **Migration to the electron deficient nitrogen:** Beckmann rearrangement.
- **Migration involving a carbanion:** Favorskii rearrangement.
- **Name reactions:** Michael addition, Wittig reaction.

2.3 Polymers: (5L)

- **Introduction**: Terms monomer, polymer, homopolymer, copolymer, thermo plastics and thermosets.
- **Addition polymers**: Polyethylene, polypropylene, teflon, polystyrene, PVC and uses.
- **Condensation polymers**: Polyesters, polyamides, polyurethanes, polycarbonates, phenol formaldehyde resins and uses.
- **Stereochemistry of polymers**: Tacticity, mechanism of stereochemical control of polymerization using Ziegler Natta catalysts
- **Natural and synthetic rubbers**: Polymerisation of isoprene: 1,2 and 1,4 addition (cis and trans), Styrene butadiene copolymer.
- **Additives to polymers**: Plasticizers, stabilizers, and fillers.
- **Biodegradable polymers**: Classification and uses. polylactic acid structure, properties and use for packaging and medical purposes.
- (Note: Identification of monomer in a given polymer & structure of polymer for a given monomer is expected. condition for polymerization is not expected)

2.4 Catalysts and Reagents (2L)

- **Study of catalysts and reagents** with respect to functional group transformations and selectivity (no mechanism)
- **Catalysts: Catalysts for hydrogenation**: Raney Nickel, Pt and PtO_2 (C=C, CN, NO_2, aromatic ring), Pd/C: C=C, COCl→CHO (Rosenmund), Lindlar catalyst: alkynes

- **Reagents:** SeO_2 (Oxidation of CH_2 alpha to CO), mCPBA (epoxidation of C=C), NBS (allylic and benzylic bromination)

Reference Books:

1. Stereochemistry of Carbon Compounds, E. L. Eliel, Tata McGraw Hill.
2. Stereochemistry Conformation and Mechanism (Eleventh Edition), P.
3. S. Kalsi, New Age International. Stereochemistry of Organic Compounds: Principles and Applications (Fourth Edition), D. Nasipuri, New Age International.
4. A guidebook to mechanism in Organic Chemistry (Sixth edition), Peter Sykes, Pearson education, New Delhi
5. Organic Reaction Mechanism (Fourth edition), V. K. Ahluwalia, R. K. Parashar, Narosa Publication.
6. Organic Reactions and their mechanisms (Third revised edition), P.S. Kalsi, New Age International Publishers.
7. Organic Chemistry (Fourth edition), G. Marc Loudon, Oxford University press.
8. Introduction to Organic Chemistry (Fourth edition), Andrew Streitwieser, Jr. Clayton H. Heathcock, Macmillan publishing, New York.
9. Organic Chemistry (Sixth edition), Morrison and Boyd, Pearson Education.
10. Introduction to Organic Chemistry, John Mc Murry, Cengage Publisher.
11. Organic Chemistry, Volume- 1 & 2 (Fifth and sixth edition), I. L. Finar, Pearson Education.
12. Absorption Spectroscopy of Organic Molecules, V. M. Parikh, Addison Wesley Publishing Company.
13. Polymer Chemistry, M. G. Arora, K. Singh, Anmol Publications Pvt. Ltd.
14. Polymer Science, V. K. Ahluwalia and A. Mishra, Ane books.
15. Polymer Chemistry An Introduction, v.12, (Third edition), R. B. Seymour, C.E. Carraher, Marcel Dekker.

B.Sc. (Sem.- VI)

Category: Major Theory

Title of Paper: Advanced Drugs and Dyes

Course/ Paper Title	**Advanced Drugs and Dyes**
Course offered as	Major
Type	Theory
Course Code	RUSCHMJ604
Semester	6
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: (List some of the course objectives)

CLO1: To understand the Drug metabolism and concept of drug development.

CLO2: To know the regulatory aspects and medicinal chemistry of nanoparticles.

CLO3: To understand the theory and synthesis of colorants.

CLO4: To learn the non-textile applications Dyes.

Course Outcomes: (List some of the course outcomes)

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

CO1: To correlate the drug metabolism and incorporate the concept in drug development.

CO2: To illustrate the regulatory aspects and medicinal chemistry of nanoparticles.

CO3: Correlate the theory of chemical structure, synthesis and colour development.

CO4: Classify the dyes based on application.

Unit I

1.1 Drug metabolism: (2L)

- Introduction, Absorption, Distribution, Bio- transformation, Excretion Different types of chemical transformation of drugs with specific examples.

1.2 Modern Drug Development: (6L)

- **Discovery of a Lead compound:** Screening, drug metabolism studies and clinical observation, Lipinski's rule of 5
- Introduction to ***clinical trials; Role of food and drug administration*** (FDA).
- **Medicinal properties** of compounds from Natural Sources: Anti-infective and anticancer properties of Turmeric.
- **Development of drug**: The Pharmacophore identification, modification of structure or functional group, Structure activity relationship (Sulphonamides).
- **Structure modification** to increase potency: Homologation, Chain branching and Extension of the structure. Computer assisted drug design (CADD).
- **Synthesis of d-Amphetamine and Dapson (DDS)**

1.3 Biopharmaceuticals: - (2L)

- Vaccines e.g. Covishield and Covaxin; monoclonal antibodies; recombinant DNA drugs (introductory level).

1.4 Drug Safety & Regulatory Aspects: - (2L)

- Adverse Drug Reactions (ADR); pharmacovigilance; intellectual property rights (IPR) in pharmaceuticals.

1.5 Nano particles in Medicinal Chemistry: (3L)

A) Introduction; Carbon nano particles (structures) and Carbon nano tubes:

- Functionalization for Pharmaceutical applications
- Targeted drug delivery systems.

- In vaccine (Foot and mouth disease)
- Use in Bio-physical treatment.

B) **Gold nano particles** in treatment of: Cancer; Parkinsonism; Alzheimer.

C) **Silver nano particles:** Antimicrobial activity.

Unit 2: (15L)

2.1 Colour and Chemical Constitution of Dyes (4L)

(i) Armstrong theory (quinonoid theory) and its limitations.

(ii) Witt's Theory: Chromophore, Auxochrome, Bathochromic & Hypsochromic Shift, Hypochromic & Hyperchromic effect

(iii) Valence Bond theory, comparative study and relation of colour in the following classes of compounds/dyes: Benzene, Nitrobenzene, Nitroanilines, Nitrophenols, Benzoquinones, Triphenyl methane, Anthraquinones.

(iv) Molecular Orbital Theory. With reference to Ethylene; 1, 3- butadiene & β-carotene.

2.2 Unit Processes (2L)

- Explanation of Sulphonation, Nitration, Halogenation, Diazotisation.

2.3 Synthesis of Dyes (4L)

i) Synthesis Orange IV ii) Industrial preparation of indigo,

iii) Preparation of eosin, iv) Synthesis of Bismarck brown &

v) Synthesis of Indanthrene blue

2.4 Non textile uses of Dyes: (2L)

- **Dyes used in food and cosmetics:**
  a) Properties of dyes used in food and cosmetics
  b) Introduction to FDA and FSSAI
- Commonly used food colours and their limits
- **Miscellaneous use dyes:** Hair dyes, Laser dyes, Paper and leather dyes, Security inks

2.5 Pigments and Optical Brighteners: (3L)

- Introduction, Definition of pigments with examples, Properties of pigments, Difference between dyes and pigments, Definition of Lakes and Toners, Requirement of Pigments, Types of Pigments.
- General idea and important characteristics of optical brighteners.

References:

1. V. K. Ahluwalia and Madhu Chopra; Medicinal chemistry; Ane Books Pvt. Ltd, 2008
2. S. S. Kadam, K. R. Mahadik, K. G. Bothara; Principle of medicinal chemistry. Vol 1, 2023
3. Johnson and Li; The Art of Drug synthesis. Wiley, 2007.
4. Richard B Silvermann; The organic chemistry of drug design & drug action. 2nd ed.; Academic Press. 2012.
5. Lednicer and Mitsher; The Organic Chemistry of Drug Synthesis; Wiley publication, 2007
6. Sodhi. G. S.; Fundamental concepts of Environmental Chemistry; Alpha Science International, 2009.
7. Shrikrishna D. Tupare; Dyes: Overview; Lulu publications, 2021
8. Planning Commission, Niti Aayog, FSSAI and FDA websites
9. Sharma S.K.; Green Chemistry for Dyes Removal from Waste Water- Research Trends and Applications, Ed. Wiley, 2015
10. Khopkar S.M.; Environmental Pollution- Monitoring and Control, New Age International (P) Ltd, New Delhi, 1982

B.Sc.(Sem.- VI)

Category: Practical

Experimental techniques in Physical Chemistry - II

Course/ Paper Title	**Experimental techniques in Physical Chemistry - II**
Vertical	Major
Type	Practical
Course Code	RUSCHMJP601
Semester	6
No. of Credits	2
No. of lecture Hours/week	4 hours
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives: **The course aims to:**

CLO1: Develop experimental understanding of **physico-chemical methods** such as adsorption and viscosity for determination of molecular properties.

CLO2: Provide practical knowledge of **instrumental analytical techniques** such as colorimetry and pH-metry for quantitative determination of chemical substances.

Course Outcomes: **At the end of the course, students will be able to:**

CO1: Determine molecular properties such as **adsorption constants and molecular radius** using physico-chemical experimental methods.

CO2: Apply **colorimetric and pH-metric techniques** for quantitative determination of analytes.

Experiments

Non- Instrumental Experiments:

1) Phase equilibria: To study phase diagram of three component system water-chloroform/ toluene- acetic acid by weight method.

2) To determine the radius of Glycerol molecule by viscosity measurement.

3) To determine the partition coefficient of benzoic acid in benzene & water. Only two bottles

4) To investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich & Langmuir isotherms.

5) Determination of molecular weight of solute by the method of elevation in boiling point.

Instrumental Experiments:

1) To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.

2) To estimate strength of HNO_3 & H_2SO_4 in the mixture of both acids conductometrically.

3) To find out the strength of borax solution by titrating it against HCl pH-metrically.

4) To estimate Fe^{+3} ions by thiocayanate method colorimetrically ..

5) To determine the transport number of Ag^+ and NO_3^- ions in $AgNO_3$ potentiometrically.

6) To determine the basicity of an acid such as citric acid conductometrically.

7) To find out the strength of borax solution by titrating it against HCl pH metrically.

Reference Books:

1. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2006

2. J. N. Gurtu and R Kapoor, Advanced Experimental Chemistry., S.Chand and Co. Vol-I, 1980

3. V. D. Athawale, Experimental Physical Chemistry, New Age International (P) Limited, 2001

B.Sc. (Sem.- VI)

Category: DSE (Theory)

Title of Paper: Concepts in Advanced Analytical Techniques II

Course/ Paper Title	**Concepts in Advanced Analytical Techniques II**
Course offered as	Major
Type	Theory
Course Code	RUSCHDSE601
Semester	6
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50 marks

Course Objectives: (List some of the course objectives)

CLO1: Understand principles, instrumentation, and terminology of electroanalytical methods such as polarography and amperometric titrations.

CLO2: Learn the fundamentals, instrumentation, and application of thermal methods like TGA and DTA.

CLO3: Develop knowledge of qualitative and quantitative analysis and practical applications of separation methods.

Course Outcomes:

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

CO1: Explain principles, working, and terminology of electroanalytical methods such as polarography and amperometric titrations.

CO2: Explain principles, instrumentation, and operation of GC, HPLC, and ion exchange chromatography.

CO3: Apply and compare separation techniques in real-world applications like purification and analysis of mixtures.

Unit I

Electroanalytical methods of analysis [8L]

1.1 Polarography (6L)

- Basic Principle of DC Polarography
- Terms involved in polarography: Residual current, Diffusion current, limiting current, Half-Wave Potential, Drop time
- Role of supporting electrolyte, maxima suppressor and depolarizer in polarographic analysis.
- Dropping Mercury Electrode (DME): Construction, Working, Advantages and Limitations.
- Qualitative and quantitative aspects in polarography
- Terms involved in Ilkovic equation (Numericals expected

1.2 Amperometric titrations (2L)

- Principle of amperometric titrations
- Rotating platinum electrode: Construction and advantages
- Titration curves

  i) Titrant is reducible

  ii) Titrand is reducible

  iii) Product is reducible

1.3 Thermal Methods of Analysis [7 L]

A) Thermogravimetric analysis (TGA)

- Introduction to thermal method and its classification
- Instrumentation and Working (TGA): Block diagram of thermobalance
- Factors affecting thermogram and its significance
- Applications: Determination of drying and ignition temperature range based on thermogram of $CaC_2O_4.H_2O$

B) Differential Thermal Analysis (DTA)

- Principle, Instrumentation, and Reference materials used
- Differential thermogram (DTA curve) $CaC_2O_4 .H_2O$ and $CuSO_4.5H_2O$
- Comparison between TGA and DTA

Unit 2: Separation Methods (15L)

2.1 Gas Chromatography [6]

- Introduction, Principle, Theory and terms involved
- Instrumentation: Block diagram and components, types of columns, stationary phases in GSC and GLC, Detectors: TCD, FID, ECD
- Qualitative, Quantitative analysis and applications

2.2 High Performance Liquid chromatography (HPLC) [5]

- Introduction and Principle
- Instrumentation- components with their significance: Solvent Reservoir, Degassing system, Pump, Precolumn, Sample injection system, HPLC Columns, Detectors (UV – Visible detector, Refractive index detector)
- Qualitative and Quantitative Applications of HPLC

2.3 Ion Exchange Chromatography [4]

- Introduction and Principle.
- Types of Ion Exchangers, Ideal properties of resin
- Ion Exchange equilibria and mechanism, selectivity coefficient and separation factor Factors affecting separation of ions
- Ion exchange capacity and its determination for cation and anion exchangers. Applications of Ion Exchange Chromatography with reference to Preparation of demineralised water, Separation of amino acids.

B.Sc. (Sem.- VI)

Category: DSE Practicals

Course/ Paper Title	Experimental Techniques in Chemical Analysis - II
Course offered as	DSE
Type	Practicals
Course Code	RUSCHDSEP601
Semester	6
No. of Credits	2
No. of lecture Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives:

CLO1: To develop practical skills in advanced analytical techniques such as spectrophotometry, flame photometry and potentiometry

CLO2: To understand principles of separation methods including solvent extraction and ion exchange.

CLO3: To learn quantitative analysis of environmental, pharmaceutical, and industrial samples.

CLO4: To enhance skills in data analysis, graph plotting, and interpretation of analytical results.

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

CO1: Perform accurate quantitative analysis using advanced instrumental techniques of colorimetry, potentiometry and flame photometry.

CO2: Perform accurate quantitative analysis of samples using classical techniques.

CO3: Apply separation and analytical methods for sample matrices.

CO4: Determine pKa of indicator.

List of experiments

1. Estimation of Chromium in water sample spectrophotometrically using diphenylcarbazide.
2. Determination of Maleic acid pH-metrically.
3. Separation and Complexometric estimation of Magnesium from a mixture of iron and Magnesium (Solvent Extraction Method)
4. Determination of chemical oxygen demand of water sample.
5. Estimation of Calcium and Magnesium complexometrically from Dolomite ore.
6. Determination of the saponification number of oil.
7. Colorimetric determination of Phosphate as Ammonium phosphomolybdate.
8. Potentiometric titration of a standard solution of KCl against $AgNO_3$.
9. Estimation of Aspirin Drug in tablets using pH meter.
10. Determination of percent purity of common salt using cation exchanger.
11. Colorimetric estimation of nickel using dimethyl glyoxime reagent.
12. Percent purity of zinc oxide by complexometric titration.

Reference Books:

1. Fundamentals of Analytical Chemistry – Douglas A. Skoog et al.
2. Principles of Instrumental Analysis – Douglas A. Skoog et al.
3. Instrumental Methods of Chemical Analysis – Gurdeep R. Chatwal & Sham Anand
4. Analytical Chemistry – Gary D. Christian
5. Quantitative Chemical Analysis – Daniel C. Harris
6. Basic Concepts of Analytical Chemistry – S. M. Khopkar
7. Chromatography Concepts and Contrasts – James M. Miller
8. Thermal Analysis Fundamentals and Applications – Michael E. Brown
9. Vogel's Textbook of Quantitative Chemical Analysis – Arthur I. Vogel et al.

B.Sc. (Sem.- VI)

Title of Paper: Heavy and Fine Chemicals-II

Heading	Particulars
Vertical:	Elective 2
Type:	Theory
Course Code	RUSCHDSE602
Credit:	2 credits (1 credit = 15 Hours for Theory in a semester)
Hours Allotted:	30 Hours
Marks Allotted:	50 Marks

Course Objectives:

CLO1: To Develop fundamental understanding of industrial chemical processes, equipment (reactors, vessels) and materials such as glass and composites used in chemical industries.

CLO2: To Explain manufacturing processes of key bulk and fine chemicals (e.g., sulphuric acid, ammonia, sodium hydroxide, $KMnO_4$) along with their industrial applications.

CLO3: To Understand the role of small-scale industries (SSI), R&D, technology transfer and intellectual property in chemical industry development.

CLO4: To Analyze industrial products such as oils, detergents, dyes and energy systems (boilers, refrigeration) with respect to production methods and applications.

Course Outcomes :(**Course Learning Outcomes)**

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

CO1: Classify and describe industrial vessels, reactors, glass types and composite materials used in chemical industries.

CO2: Explain and illustrate manufacturing processes of major industrial chemicals and fine chemicals with process conditions and applications.

CO3: Analyze the role of SSI, R&D, technology transfer, energy systems, and IPR in chemical industry operations.

CO4: Apply knowledge of zeolites, ion-exchange resins, oils, detergents, and dyes in industrial and environmental contexts.

Unit 1:

1.1 Introduction to industrial vessels:

- Classification of chemical reactors, pressure vessels for internal or external pressure, maintenance, storage vessels for liquids and gases.

1.2 Glass:

- Composition, types and applications (soda-lime, borosilicate, optical); float glass process.

1.3 Manufacturing process and applications:

- **Sulphuric acid** - Contact Process: raw materials, roasting, double absorption,V_2O_5 catalyst, pollution control, oleum; applications (fertilizers, batteries, pickling, explosives).
- **Ammonia** - Haber Process, applications of ammonia.
- **Sodium Hydroxide**- Chlor-Alkali Process: brine electrolysis, diaphragm/mercury/membrane cell comparison; co-production of Cl_2; caustic soda grades.

1.4 Zeolites, Clays and Ion-exchange resins:

- Structures, properties, industrial applications (water softening, catalysis, pharma purification). Nano-zeolites: improved catalytic properties, enhanced drug loading capacity.

1.5 Industrial preparation of Inorganic Fine chemicals:

- $KMnO_4$
- $FeSO_4.7H_2O$

1.6 Composite materials:

1.6.1 Introduction, Constitution, Classification and applications of the following-

a. Particle Reinforced composites, Fiber reinforced composites GFRP/CFRP, Structural Composites or Layered composites,

b. Nano composites: polymer-clay (montmorillonite), carbon nanotube reinforced polymers - properties and applications.

Unit 2:

2.1. Small scale industries, R & D and technology transfer:

2.1.1 Introduction- Industry Structure.

2.1.2 Need and scope of small-scale industry, SSI rules, and regulations.

2.1.3 R and D, technology transfer, Role of R and D, Functional structure of R and D unit, Research strategies and manufacturing interface, University-Industry interface,

2.1.4 IPR- Patents, Trade Mark.

2.2. General idea of the following: -

- Energy sources and boilers in Industries:
- Refrigeration: System, media used for cold transfer (i.e. brine and other)
- Different Sources of Energy: Generation, Treatment of boiler feed water, Properties of steam, steam table Boilers

2.3 Oils and Fats:

- Introduction, Classification, Properties of oils and fats.
- Extraction of oils from oil seeds, hydraulic pressing and solvent extraction, extraction of animal fats.
- Hardening of oils.

2.4. Detergents:

- Introduction, Classification- cationic, anionic, nonionic, amphoteric.
- Manufacture of DDBS, Industrial applications, Biodegradability issue, Bio-based surfactants

2.5 Introduction to dyes and dye intermediates:

- Definition, types of dyes, properties.
- Synthesis and uses of the following dye intermediates and dyes: i) Nitro derivatives of benzene and naphthalene ii) Indigo iii) Congo red

Reference Books:

1. C. D. Dryden: Outlines of Chemical Technology, edited & revised by M. Gopala Rao & Marshall Sittig East West Press, New Delhi.2008.
2. Faith Keyes and Clerk's Industrial Chemicals, 4th Edn., Wiley Inter-science 1975.
3. Foust A. S. et-al.: Principles of Unit Operations John Wiley & Sons.
4. Macabe W.L., Smith J. C. and Harriott. P. Unit Operations of Chemical Engineering (7th edition) (McGraw Hill Chemical Engineering series).
5. P. H. Groggins: Unit Processes in Organic Synthesis, McGraw Hill.
6. Kirk & Othmer: Encyclopeadia of Chemical Technology, John Wiley and sons.
7. Büchner, Schliebs, Winter, translated by David R. Terrell, Industrial Inorganic Chemistry VCH/Wiley publisher, New York., 2nd edition, 2000
8. K. Welssermel, H. J. Arpe, Industrial Organic Chemistry, VCH Publishers, New York.
9. B. Pearson- Speciality Chemical Innovations in Industrial Synthesis.
10. Edited by K. Venkatraman, The Chemistry of Synthetic Dyes – Academic press Inc. London.
11. B. K. Sharma, Industrial Chemistry Goyal publishing house, Mirut.
12. Riegel's Hand Book of Industrial Chemistry, 9th Edition, Jems A. Kent.
13. E Stoch, Industrial Chemistry Vol- I, Ellis Horwood Ltd. UK.
14. Wiseman and Peter, An Introduction to Industrial Organic Chemistry,: Wiley Interscience, New York,1972.
15. Fine Chemicals, The Industry and The Business Second Edition Peter Pollak, PhD Reinach, Switzerland A John Wiley & Sons, Inc., Publication
16. Research and Development in The Chemical and Pharmaceutical Industry By Peter Bamfield, Third Completely Revised And Enlarged Edition, Publication WILEY-VCH Verlag Gmbh & Co. Kgaa, Weinheim 2006.
17. A Comprehensive Overview of Bulk and Fine Chemicals by 13. Fine Chemicals, The Industry and The Business Second Edition Peter Pollak, PhD Reinach, Switzerland A John Wiley & Sons, Inc., Publication
18. Research and Development in The Chemical and Pharmaceutical Industry By Peter Bamfield, Third Completely Revised And Enlarged Edition, Publication WILEY-VCH Verlag Gmbh & Co. Kgaa, Weinheim 2006

(Sem: - VI)

Practicals : Heavy and Fine Chemicals-II

Heading	Particulars
Vertical:	Elective 4
Course Code	RUSCHDSEP602
Type:	Practical
Credit:	2 credits
Hours Allotted:	60 Hours
Marks Allotted:	50 Marks

Course Objectives: **Course Objectives (COs)**

CLO1: To develop practical skills in the synthesis of organic and inorganic compounds through standard laboratory procedures.

CLO2: To enable students to perform quantitative chemical estimations using titrimetric and analytical methods.

CLO3: To familiarize students with separation and purification technique paper chromatography.

CLO 4: To enhance understanding of reactions, functional group transformations, and analytical interpretation in laboratory practices.

Course Outcomes :(**Course Learning Outcomes)**

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

CO1: Perform synthesis of organic and inorganic compounds following standard laboratory protocols.

CO2: Analyse chemical samples using titrimetric methods such as EDTA, $KMnO_4$, and other estimation techniques.

CO3: Apply separation and identification technique paper chromatography.

CO4: Interpret experimental results and evaluate the accuracy and reliability of laboratory data.

(Sem: - VI)

Practicals : Heavy and Fine Chemicals-II

Preparations (9)
To prepare the following 1) Sulphanilic acid from aniline. 2) Orange II from sulphanilic acid. 3) Malachite Green from benzaldehyde and N,N-dimethylaniline 4) Phthalimide from Phthalic anhydride. 5) Anthranilic acid from phthaliamide 6) Ammonium ferric sulfate 7) Preparation of Alum 8) Pigment-Prussian blue 9) Pigment-Chrome Yellow
Estimations (9)
To determine the- 1. Saponification value of a given sample 2. % Free Fatty Acids of a given sample 3. Iodine Value of a given sample **To estimate the-** 4. Formaldehyde by oxidation using iodine and alkali. 5. Glycine by non-aqueous titration. 6. Aniline by bromination. 7. Acetamide by hydrolysis. 8. Fe(II) by $KMnO_4$ method (titrimetric) 9. Cu by EDTA method (titrimetric)
Paper chromatography (02)
To separate the components of mixture of indicators/pigments by paper chromatography. (e.g. mixture of Dyes alizarin red + methyl orange, methyl red + methylene blue, Methyl orange +Phenolphthalein etc.) (**any 02**)

Reference Books:

1) A. I. Vogel: Text book of Quantitative Analysis including Instrumental Analysis.
2) A. I. Vogel: Text book of Quantitative Organic Analysis.
3) N.K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Edition, Vikas Publication,
4) Practical Organic Chemistry by Mann and Saunders.
5) Vogel's Textbook of Quantitative Chemical Analysis 5th Edition
6) Vogel's Qualitative Inorganic Analysis 5th Edition

Sem VI

Category : VSC

Chemical Synthesis and Analysis -III

Course/ Paper Title	Chemical Synthesis and Analysis-III
Vertical	VSC
Type	Practical
Course Code	RUSCHVSCP601
Semester	6
No. of Credits	2
No. of lecture Hours/week	4 hours practical/week
Hours Allotted	60
Marks Allotted	50 marks

Course Learning Objectives:

CLO1: The Principles and techniques of preparation of different complexes.

CLO2: The quantitative methods of analysis of the samples.

CLO3: The Laboratory skills required for experimental work.

Course Outcome:

CO1: Synthesis coordination compounds.

CO2: Analyse samples quantitatively.

CO4: Evaluate results and develop suitable schemes for chemical analysis.

Preparations:

1. Preparation of tetraamine copper sulphate $[Cu(NH_3)_4]SO_4.H_2O$
2. Preparation of tris acetyacetonato Iron (III)
3. Preparation of Copper chloride Dimethylsulfoxide
4. Preparation of Bis (8-hydroxyquinolato) Magnesium (II), $[Mg(OX)_2].2H_2O$
5. Estimation of Manganese by complexometric titration method using EBT indicator
6. Estimation of Co by complexometric titration method using murexide indicator

7. Estimation of Mg content in Epsom salt by complexometric titration using EBT indicator
8. To determine water of crystallization in Mohr's salt by estimation with standardized $KMnO_4$
9. Determination of percentage purity of the given water soluble salt and qualitative detection w.r.t added impurity cation and/or anion.(four) Salts of selected Main group metal ions viz. Mg,Zn, Ba, Sr,Ca . Quantitative analysis by titration method. (complexometric titration of all ions using Eriochrome Black T indicator). Qualitative analysis by wet test method. Impurity : NH_4^+,K^+, Cl^-, NO_3^-, I^-,

References

1. Vogel AI, Jeffery GH. Vogel's Textbook of Quantitative Chemical Analysis. Longman Scientific and Technical; 1989.
2. Pass G, Sutcliffe H. Practical Inorganic Chemistry. 1969.

B.Sc. (Sem.- VI)

Category: VSC Practical

Chemical Synthesis and Analysis – IV

Course/ Paper Title	**Chemical Synthesis and Analysis – IV**
Course offered as	VSC-5
Type	Practical's
Course Code	RUSCHVSCP602
Semester	6
No. of Credits	2
No. of lecture Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50 marks

Course Objectives:

CLO1: To understand the concept of chemical separation of organic binary Solid-Liquid & Liquid-Liquid mixture.

CLO2: To learn the synthesis of organic compounds.

Course Outcomes:

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

CO1: Identify and separate the organic binary solid-liquid and liquid-liquid mixture.

CO2: Synthesize grams scale organic compound.

List of Experiments :

A) Separation of Binary liquid-liquid and liquid- solid mixture.

1. Minimum 8 mixtures to be completed by the students.
2. Components of the liquid-liquid mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, isopropyl alcohol, ethyl alcohol, EMK and non-volatile liquids like chlorobenzene, bromobenzene, aniline, N, N- dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate.
3. Components of the liquid - solid mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, ethyl alcohol, IPA, EMK and solids such as water insoluble acids, phenols, bases, neutral.
4. A sample of the mixture one ml to be given to the student for detection of the physical type of the mixture.
5. After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique.
6. After separation into component A and component B, the compound to be identified can be decided by examiner.

B) Organic Preparation:

1) Orange-II
2) Fluorescence
3) meta-Dinitrobenzene
4) Schiff base

Reference Books:

1. Practical Organic Chemistry – A. I. Vogel
2. Practical Organic Chemistry – H. Middleton
3. Practical Organic Chemistry – O. P. Agarwal

Evaluation Pattern

Internal Continuous Assessment: 40%	**External, Semester End Examination 60%** **Individual Passing in Internal and External Examination**
Continuous Evaluation through: Quizzes, Class Tests, presentation, project, creative writing, assignment (any 2)	

QUESTION PAPER PATTERN

(External)

Time: 1 Hour Marks: 30

N.B.:

1. All Questions are Compulsory.

2. Draw neat and labelled diagrams wherever necessary.

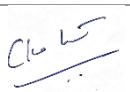
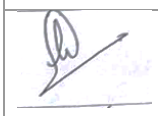
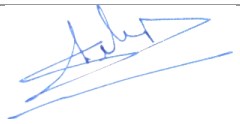
Q. No	Type	Marks	Unit
Q.1	Multiple Choice Question / Fill in the Blanks (Any 5 out of 10) (5 from each Unit)	5	1 & 2
Q.2	Answer in 1–2 Sentences: (Any 5 out of 10) (5 from each Unit)	5	1 & 2
Q.3	Answer any 2 of the following. (Any 2 out of 4)	10	1
Q.4	Answer any 2 of the following. (Any 2 out of 4)	10	2

Evaluation Pattern for

Major/DSE/VSC Practical Course

Duration for End semester examination	External Assessment for Practical	50 Marks
3 hours	Experiment	30
	Viva	10
	Journal	10

Board of studies in Chemistry (2026-2027)

	Category	Name and Designation	Affiliation	Signature
1	Chairperson (Head of Department)	Dr. Aqeela A. S. Qureshi, Associate Professor	Royal College of Arts, Science and Commerce. Mira Road, Thane	
2	Internal BOS Members	Prof.(Dr.) Kalpana Patankar Jain. Principal	Royal College of Arts, Science and Commerce. Mira Road	
		Dr. Chitralekha Kotian Associate Professor		
		Dr. Vibha Bhagat Associate Professor		
		Dr. Gunwanti Negi Assistant Professor		
		Dr. Mustaqeem Mohammed - Assistant Professor		
3	External Subject Expert	Prof. Atul Chaska - Professor	Institute of Chemical Technology, Matunga , Mumbai.	
		Prof. Yogita Shinde - Professor	Department of Chemistry, K.C. College, S.N.C. University , Mumbai	
4	Vice-Chancellor Nominee	Prof. Krishnakant T. Waghmode	Ruparel College of Arts, Science & Commerce, Mumbai	
5	Industry Representativ	Shailesh G. Poojary - Chief Manager, Parle Quality Systems,Parle Products	Parle Products VS Khandekar Marg,Vile Parle East Mumbai-400057	
6	Postgraduate meritorious alumnus	Ms. Pratima Rajesh Yadav PhD. Scholar from ICT, Mumbai.	Institute of Chemical Technology , ,Nathalal Parekh Marg, Matunga, Mumbai – 400019.