VIJAYANAGARA SRI KRISHNADEVARAYAUNIVERSITY

JNANASAGARA CAMPUS, BALLARI – 583 105

Department of Studies in Chemistry

SYLLABUS

Master of Science
(I-IV Semester)

With effect from
2024-25

VIJAYANAGARA SRI KRISHNADEVARAYA UNIVERSITY

JNANASAGARA CAMPUS, BALLARI-583105

Department of Studies in Chemistry

Programme: Master of Science (M.Sc.) in Chemistry

Programme Overview:

Duration: 2 Years (4 semesters)

Master of Science (M.Sc.) in Chemistry programme provides fundamental and applied knowledge in Chemistry with hands-on training through laboratory practicals and foster careerin teaching, research or industry.

Program Educational Objectives (PEOs):

- Post graduates will demonstrate capability to understand, analyse, develop, and execute the chemical solutions for the current societal requirements through experimental and experientiallearning.
- Post Graduates exhibit professionalism and organizational goals with commitment to ethics,team work and respect for everyone.
- Students gets motivated for continuous learning and career development.
- Students impart educational skills and the knowledge in Chemistry in academia, research andindustries .

Program Outcomes (POs):

- Discipline knowledge: Capable to apply knowledge of Chemistry and research to understand andsolve the societal requirements.
- Solving of problems: Identify, analyse, interpret and develop solutions for problems related toChemistry in Society.
- Design and Execute chemical systems for different applications

- Apply hands-on training and research knowledge to conduct investigations, interpretation and formulation of solution.
- Application of advanced methodologies in synthesis and analytical techniques for finding solution in various domains.
- Acquire the information on the environmental issues and apply the knowledge to monitor and provide solutions to overcome.
- Able to work individually as well as in teams by institutionalizing the ethical values.
- Motivate for continuous learning and acquire updates in the field.

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Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) for Chemistry

M.Sc. I-SEMESTER

Semester No.	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	Sem. Exam	Total	L	T	P		
FIRST	DSC1	24CHE1C1L	Concepts and Models in Inorganic chemistry	30	70	100	4	-	-	4	3
	DSC2	24CHE1C2L	Theoretical Organic Chemistry	30	70	100	4	-	-	4	3
	DSC3	24CHE1C3L	Kinetics and Electrochemistry	30	70	100	4	-	-	4	3
	DSC4	24CHE1C4L	Analytical methods and treatment of data	30	70	100	4	-	-	4	3
	SEC1	24CHE1S1LT	R and D and Quality control	20	30	50	1	1	-	2	2
	DSC1P1	24CHE1C1P	Inorganic chemistry Quantitative analysis	20	30	50	-	-	4	2	4
	DSC2P2	24CHE1C2P	Organic Chemistry qualitative analysis	20	30	50	-	-	4	2	4
	DSC3P3	24CHE1C3P	Kinetics and Electrochemistry	20	30	50	-		4	2	4
Total Marks for I Semester						**600**				**24**	

M.Sc. II SEMESTER

Semester No.	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	Sem. Exam	Total	L	T	P		
SECOND	DSC5	24CHE2C5L	Chemistry of Coordination compounds	30	70	100	4	-	-	4	3
	DSC6	24CHE2C6L	Reaction mechanisms in organic synthesis and Pericyclic reactions	30	70	100	4	-	-	4	3
	DSC7	24CHE2C7L	Electro, Quantum and Photochemistry	30	70	100	4	-	-	4	3
	DSC8	24CHE2C8L	Spectroscopic and Thermal methods	30	70	100	4	-	-	4	3
	SEC2	24CHE2S2LP	Research Methodology	20	30	50	1	-	2	2	2
	DSC5P4	24CHE2C5P	Preparation and analysis of Coordination compounds	20	30	50	-	-	4	2	4
	DSC6P5	24CHE1C6P	Synthesis of organic compounds	20	30	50	-	-	4	2	4
	DSC7P6	24CHE1C7P	Catalysis and photochemistry Practicals	20	30	50	-	-	4	2	4
Total Marks for II Semester						**600**				**24**	

M.Sc. III-SEMESTER

Semester No.	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	Sem Exam	Total	L	T	P		
THIRD	DSC9	24CHE3C9L	Spectroscopy	30	70	100	4	-	-	4	3
	DSC10	24CHE3C10L	Chemistry of Heterocyclic Compounds	30	70	100	4	-	-	4	3
	DSE1	24CHE3E1AL	A. Polymer Science & Technology	30	70	100	4	-	-	4	3
		24CHE3E1BL	B. Nanomaterials and Applications								
		24CHE3E1CL	C. Applied Physical Chemistry								
	DSE2	24CHE3E2AL	A. Nuclear Chemistry and Materials Science	30	70	100	4	-	-	4	3
		24CHE3E2BL	B. Green Chemistry								
		24CHE3E2CL	C. Industrial Inorganic Chemistry								
	GEC1	24CHE3G1AL	A. Analytical techniques	20	30	50	2	-	-	2	2
		24CHE3G1BL	B. Separation and purification techniques								
		24CHE3G1CL	C. Environmental Chemistry and Waste management								
	SEC3	24CHE3S3P	Semi micro Qualitative Inorganic analysis	20	30	50	4		4	2	4
	DSC9P7	24CHE3C9P	Instrumentation/ Physical Chemistry Practicals	20	30	50	-	-	4	2	4
	DSC10P8	24CHE3C10P	Quantitative analysis of Organic functional groups	20	30	50	-	-	4	2	4
Total Marks for III Semester						**600**				**24**	

M.Sc. IV-SEMESTER

Semester No.	Category	Subject code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of exams (Hrs)
				IA	Sem. Exam	Total	L	T	P		
FOURTH	DSC11	24CHE4C11L	Bioinorganic and Organometallic chemistry	30	70	100	4	-	-	4	3
	DSC12	24CHE4C12L	Thermodynamics	30	70	100	4	-	-	4	3
	DSE3	24CHE4E3AL	A. Modern Organic synthesis	30	70	100	4	-	-	4	3
		24CHE4E3BL	B. Natural products of Biological Importance								
		24CHE4E3CL	C. Bioorganic chemistry								
	DSE4	24CHE4E4AL	A. Advanced Chromatographic and Microscopic techniques	30	70	100	4	-	-	4	3
		24CHE4E4BL	B. Applied Analysis								
		24CHE4E4CL	C. Environmental and Biochemical Analysis								
	GEC2	24CHE4G2AL	A. Chemistry for daily life	20	30	50	2	-	-	2	2
		24CHE4G2BL	B. Water and food quality and laws								
		24CHE4G2CL	C. Agro and Environmental Chemistry								
	DSC11P9	24CHE4C11P	Spectral interpretation of data	20	30	50	-	-	4	2	4
	Project	24CHE4C1R	Project work	30	70	100		-	8	4	4
Total Marks for IV Semester						**600**				**24**	

(I-IV semester)- Total Marks: 2400 and Total credits: 96

DSC – Department Specific Core, DSE – Discipline Specific Elective, SEC – Skill Enhancement Course, GEC – Generic Elective Course, IA – Internal Assessment, SEE – Semester End Examination, L – Lecture, T – Tutorial, P – Practical.

M.Sc. Chemistry First Semester

Course: Concepts and Models in Inorganic Chemistry	Course Code: 24CHE1C1L
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objectives:

1. Acquisition of skills in Inorganic Chemistry.
2. To impart essential theoretical knowledge on atomic structure, periodic properties and chemical bonding.
3. To develop the ability to correlate the chemical and physical properties of elements and their compounds with their positions in the periodic table.
4. Understand the theories in Inorganic Chemistry

Unit-I: Periodic properties and Ionic bond

Review of periodic properties- atomic size, ionization potential, electron affinity and electro negativity.

Ionic Bond, **Covalent Bond and Metallic Bond**

Ionic bond-properties of ionic compounds, ionic radii, factors affecting ionic radii, radius ratio rules, types and structures of simple ionic compounds, lattice energy, Born-Lande equation, Kapustinskii equation, Born-Haber cycle-applications, size effects, polarizing power and polarizability of ions, Fajan's rule, covalent character in ionic compounds, solubility of ionic solids and hydration energy.

VBT approach, VSEPR-shapes of molecules, concepts of resonance and hybridization, Energetics of hybridization, partial ionic character, covalent coordinate and multicentre bonding, M.O theory-LCAO approach, σ, δ and π molecular orbits. M.O treatment of homonuclear and heteronuclear diatomic molecules, Bond order in delocalized π- bonding systems, Ex: CO_3^{2-}, NO_3^- and SO_3. Metallic bonding – electron sea model, VBT.

Coordination numbers, factors affecting coordination numbers, stereochemistry of coordination compounds. Non-stoichiometry, metal-metal bonding and cluster compounds.

[16 hrs]

Unit-II: Chemistry of S and P-Block Elements

Alkali metals, alkaline earth metals and their complexes, crown ethers, oxides of alkali metals. Synthesis, properties and structure of boron hydrides, boranes, borazines, boron-phosphorus and boron-arsenic compounds.Oxides and oxy acids of nitrogen, phosphorus, sulphur and halogens.Interhalogen compounds and noble gas compounds, silicates and zeolites.

[12 hrs]

Unit-III: Chemistry of d and f Block Elements

Chemistry of 3d,4d and 5d elements- trends in properties and spectral and magnetic behavior; stability of oxidation states and Catalytic properties. Chemistry of lanthanides and actinides-trends in physical and chemical properties, lanthanide contraction- causes and consequences.stereochemistry, magnetic and spectral behavior, synthesis and separation of trans-uranium elements, super heavy elements, Applications of Lanthanides. **[12hrs]**

Unit-IV: Acid – Base Chemistry

Introduction different definitions, types of reactions, solvent systems and leveling effect. Generalized acid-base concept-basicity of metal oxides, hydration and hydrolysis. Measurement of acid – base

strengths. Steric affects-back strain, front strain and internal strain. Solution effects with respect to liquid ammonia, anhydrous sulphuric acid, acetic acid and liquid sulphur dioxide, acetic acid, HF, N_2O_4, super acids and molten salts. HSAB-classification & strength of hardness and softness.Irving-William's series.Theoretical basis of hardness and softness.

REFERENCES

1. Inorganic Chemistry by Catherine E. Housecroft& Alan G. Sharpe 2nd Edition (2021)
2. Inorganic Chemistry by James E House (2021).
3. Inorganic Chemistry -5th Edition by Shriver & Atkins(2020).
4. Basic Inorganic Chemistry – 3rd edition, F.A Cotton, G.Wilkinson and P.L.Gaw, John wiley and sons (2002).
5. Inorganic chemistry – James E Huheey, Harper and Row Publishers (2004)
6. Concepts and Models of Inorganic Chemistry – 3rd edition, B.E Douglas, D.H. Mc Daniel and Alexander, Wiley (2001)
7. Inorganic Chemistry – 2nd edition, D.F Shriver, P.W.Atkins and C.H.Langtore Oxford University Press (1994).
8. Chemistry of Elements – N.N. Greenwood and A.Earnshaw, Pergaman (2000).
9. Inorganic Chemistry – 2nd edition, C.E Housecraft and A.G Sharpe, Pearson Education Ltd. (2005).
10. Concise Inorganic Chemistry – J.D. Lee, ELBS 3rd edition (2017).

Course outcomes:

1.	Identify the nature of bonding exists between various elements.
2.	Apply fundamental chemical theories in interpretation of complex systems
3.	Interpret and apply the properties of s, p, d and f block elements for different applications.
4.	Apply the theories of acid base in Chemical reactions

Course: Theoretical Organic Chemistry	Course Code: 24CHE1C2L
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objectives:

1. To understand basic and fundamental theoretical aspects of organic chemistry.
2. To study the nature of bonding and aromaticity in organic compounds.
3. Evaluate the molecular geometry, hybridization and polarity of organic molecules.
4. To acquire the knowledge of substitution reactions occurring in organic molecules.
5. To understand electron delocalization and its effect on stability and reactivity

Unit-I: Nature of bonding in organic compounds and aromaticity

Concepts of bonding, hybridization-geomerty and shape of simple molecules.Delocalized chemical bonding, conjugation, Cross conjugation, resonance hyperconjugation, bonding in fullerenes, Tautomerism.

Aromaticity in the benzenoid and non-benzenoid compounds.Alternant and non-alternant hydrocarbons, *Hückel's* rule.The energy level of π M.O., Annulenes, anti-aromaticity, aromaticity, Homo aromaticity.

Bonds weaker than covalent, addition compound, crown ether complexes, and cryptands, Inclusion compound, cyclodextrins, Catananes& rotaxanes.

Reactive Intermediates

Types of mechanism, methods of determination of reaction mechanism-cross over experiments, product analysis, intermediates, isotopic labelling, stereochemical studies, thermodynamic and kinetic studies.

Reactive intermediates: Generation, stability, and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes, and nitrenes.

[14hrs]

Unit-II: Stereochemistry

Elements of symmetry, concepts of chirality, optical isomerism, projection formulae, *Fisher*, *Sawhorse*, *Newman* and *Flying* wedge formulae and their inter-conversion, optical isomerism due to one or more than one chiral centers. Threo and erythro isomer, enantiomers, diastearic isomers, and epimers.

Optical activity in the absence of chiral carbon – Biphenyls and spiranes,

Optical isomerism of nitrogen compounds, conformational analysis of (cyclic and acyclic systems) – ethane, butane, mono & di-substituted cyclohexanes.

Geometrical isomerism – isomerism in ketoximes, aldoximes and Beckmann rearrangement.

[12hrs]

Unit-III: Aliphatic nucleophilic and electrophilic substitution reactions

Aliphatic Nucleophilic Substitution:

S_N2, S_N1, mixed S_N2 and S_N1 and SET mechanisms. The neighboring group mechanism, neighboring group participation by π and σ bonds.Common carbocation rearrangements.The S_Ni mechanism.Nucleophilic substitution at an allylic, aliphatic, trigonal, and vinylic carbon.Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis, ambident nucleophile, and regioselectivity.

Aliphatic Electrophilic Substitution:

Bimolecular mechanisms-S_E2 and S_E1, electrophilic substitution accompanied by double bond shifts. Effect of substrates and the solvent polarity on the reactivity. **[14hrs]**

Unit-IV: Aromatic nucleophilic and electrophilic substitution reactions.
Aromatic Nucleophilic Substitution:

S_NAr, S_N1, benzyne, and $S_{RN}1$ mechanisms, Reactivity-effect of substrate structure and attacking nucleophile.The VonRichter, Sommelet-Hauser, and smiles rearrangements.

Aromatic Electrophilic Substitution:

The arenium ion mechanism, orientation,and reactivity, energy profile diagrams.The ortho/para ratio, ipso attack, orientation in other ring systems.

Quantitative treatment of reactivity in substrates and electrophiles. *Vilsmeyer* reaction, *Gattermann-Koch* reaction.

Named reactions and rearrangements: Aldol, Perkin, Dickman condensation, Hofmann, Schmidt, Lossen, Curtius rearrangements, Reimer-Tiemann reaction, Wittig reactions and (Mechanism with examples). **[16hrs]**

REFERENCES:

1. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structureby Michael B. Smith , Jerry March 6th edition (2021).
2. Organic Chemistry by Paula Bruice 8th edition (2016).
3. Reaction mechanism in organic chemistry – S.M Mukharji & S.P Singh (1984).
4. Stereochemistry of Organic Compounds, Second Ed., D. Nasipuri, New Age International, (2005).
5. Stereochemistry of Organic Compounds, E. L. Eliel and S. H. Wilen, Wiley India, (2008).
6. Organic Chemistry, J. Clayden, N. Geeves and S. Warren, Oxford University Press, (2012).
7. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman, (1985).
8. Advanced Organic Chemistry: Reactions, Mechanism, and Structure, March, Jerry, 6th edition, John Wiley, (2007).
9. Advanced Organic Chemistry, Carry, F. A.; Sundberg, R.J., 3rd edition, Plenum, (1990).
10. A Guide Book to Mechanism in Organic Chemistry, Sykes, Peter, 6th edition, Longman, (1989).
11. Organic Chemistry ,Morrison, R. T.; Boyd, R. N., 6th edition, Prentice Hall, (1992).
12. Organic Reactions and their Mechanisms,Kalsi, P. S., 2nd edition, New Age International Publishers, (2000).
13. Named reaction in organic chemistry – Surrey 2nd edition(1961).
14. Retrosynthesis to Asymmetric synthesis, Authors: Šunjić, Vitomir, Petrović Peroković, Vesna

Course outcomes:

1.	Acquire the basic and fundamental aspects of organic chemistry reactions.
2.	Interpret the molecular geometry, hybridization and polarity of organic molecules
3.	Recognize the existence of stereoisomerism and conformational analysis
4.	Capable to predict the mechanism of substitution reactions
5.	Apply the knowledge in nomenclature, identification of organic compounds

Course: Kinetics and Electrochemistry	Course Code: 24CHE1C3L
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course objectives:

1. To understand physical phenomenas like Chemical thermodynamics and Chemical kinetics.
2. To study the nature of kinetics of reactions and electrochemical reactions.
3. Evaluate the basics and applications chemical thermodynamics.
4. To acquire the knowledge of catalysis and electrochemistry in solution state.
5. To understand basics of corrosion, corrosion control and its applications,

Unit- I: Chemical Thermodynamics:

A brief resume of laws of thermodynamics, Concepts of entropy and enthalpy, concept of fugacity and free energy, entropy and free energy changes and spontaneity of processes. Variation of free energy with T & P. Maxwell's relations, thermodynamic equations of state, limitations of Van't Hoff's equation, Nernst Heat theorem & its applications.

Application of Thermodynamics:

Partial molar quantities, partial molar volume and free energy (chemical potential), their significance and determinations. Gibbs- Duhem and Duham-Margules equations (statement and derivation)

Thermodynamics of Ideal Solutions:

Deductions of Raoult's law for ebullioscopy, cryoscopy and osmotic pressure. Thermodynamic treatment of Le-Chatelier principle.

Thermodynamics of Non-ideal Solutions: Activity, activity coefficient-standard states.

[12hrs]

Unit-II: Chemical Kinetics

Theories of Reaction Rates:

Activated complex theory and its applications in solution reaction. Theory of unimolecular reactions- Lindeman, Hinsel-Wood and RRKM theory

Complex reactions- parallel, consecutive and reversible reactions. Chain reactions (H_2-halogen reactions). Branched chain reactions- general rate expression. Photochemical (H_2-halogen reactions)

Reactions in Solution:

Ionic reactions - salt and solvent effects. Substituent effects on the rates of reactions, linear free energy relationships - Hammett and Taft equations.

[14 hrs]

Unit-III: Catalysis and Surface Reaction

Homogeneous catalysis-equilibrium and steady state treatments, activation energies of catalyzed reactions. Acid-base catalysis, measurements of catalytic activity. Kinetics of enzyme catalyzed reactions-Michaelis- Menten equation. Effect of pH, temperature & inhibitors. Industrial applications of catalysts.

Surface Reaction Kinetics:

A review of adsorption isotherms, Gibb's adsorption isotherm, multilayer adsorption-BET equation (derivation)- application in surface area determination. Harkin-Jura equation (derivation)-application. Heterogeneous catalysis-catalytic activity at surfaces.

[14 hrs]

Unit-IV: Electrochemistry-I and Corrosion Science

Electrochemistry of Solutions:

Ionic atmosphere, physical significance of k (Cuppa), Faraday's laws of electrolysis, Debye-Huckel limiting law, Debye-Huckel equation for appreciable concentration. Huckel and Bronsted equation. Qualitative verification of Debye-Huckel equation, Ostwald's dilution law, Bjerrum theory of ion association- triples ion- conductance minima.

Corrosion Science

Corrosion- Introduction, definition, examples. General mechanism, Factors affecting corrosion reactions. Types of corrosion with examples. Electrochemical theory of corrosion of iron metal, Hydrogen embritlement and passivation of metals

Corrosion control: Metal coatings (Galvanisation and Tinning process), inhibitors. Cathodic Protection, Anodic protection and Electrochemical methods of protection.

Industrial Corrosion: Corrosion in Boiler, Acidic corrosion, Alloying and dealloying. Corrosion in petrochemical industries.

[16hrs]

REFERENCES:

1. The Laws of Thermodynamics Peter Atkins (2010)
2. *Atkins' Physical Chemistry 11th Edition* Peter Atkins, Julio de Paula, James Keeler (2018).
3. PhysicalChemistry,Atkins(ELBS), 5^{th}Ed (1995).
4. PhysicalChemistry-G.M.Barrow,McGrawHill,Int.St.Ed(1988).
5. FundamentalsofPhysicalChemistry-MaronandLando, CollierM acmillan, (1974).
6. ThermodynamicsforChemists-S.Glasstone, East-west,(1973).
7. Themodynamics-RajaramandKuriokose(East-West) (1986).
8. ChemicalKinetics-K.J.Laidler,HarperandRow,(1987).
9. Electrochemistry-Glasstone,AffiliatedtoEast-West, Press,(1942).
10. PrinciplesandApplicationsofElectrochemistry-Crow, Chapmanhall,London, (1988).
11. Engineering Chemistry, P.C. Jain and Monica Jain, Dhanpat Rai Publications, New Delhi (2015).
12. Introduction to Corrosion Science, E. Mc Cafferty, Springer, (2010).

Course outcomes:

1.	Able to analyse Thermodynamics as well as kinetics of reactions.
2.	Evaluate the kinetics of chemical reactions with step wise mechanisms
3.	Apply of thermodynamics to ideal and non ideal solutions
4.	Integrate the knowledge of catalysis, multilayer adsorption and surface reactions
5.	Interpret the electrochemical behaviour in solution state and surface
6.	Analyse and solve the corrosion process

Course: Analytical Methods and Treatment of data	Course Code: 24PHY1C4L
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 30 Marks	**Semester End Examination:** 70 Marks

Course Objectives:

1. To understand the concepts of classical methods of analysis like titirmetry, gravimetry.
2. To gain knowledge of purity and separation techniques
3. To acquire basics of electroanalytical techniques
4. To inculcate the skills for chemical analysis and treatment of data

Unit – I: Errors, Sampling and Separation Techniques

Analytical techniques and methods, method validation, Limitations of analytical methods. Classifications of errors, accuracy, precision, minimization of errors, significant figures and computations, mean, relative and standard deviation, distribution of random errors, relativity of results. Confidence interval, comparison of results, comparison of the means of two samples, Significance tests Q-test, F-test, Paired t-test for the number of replicate determinations, comparison of more than two means (analysis of variance),.Correlation and regression, linear regression, Least square method. Analysis- Calibration, standard addition, internal standardisation, internal normalization, external standardisation. Quality control and quality assurance. Importance of sampling, the basis of sampling, sampling procedure, sampling statistics, sampling and physical state, crushing and grinding, hazards in sampling.

[14 hrs]

Unit – II: Titrimetic analysis:

Acid base titrations:

Principle, role of solvent in acid-base titrations, effect of concentration. Titration curves for strong acid - strong base, weak acid – strong base, weak base –strong acid, Poly protic acids, poly equivalent bases, determination of equivalence point – theory of acid base indicators, colour change range of indicators.Applications for nitrogen, nitrates and carbonates andorganic functional groups like carboxylic acid, sulphonic acid, amine, ester, hydroxyl, carboxyl groups.

Oxidation –Reduction Titrations:

Redox process-balancing redox equations, titration curves .Redox indicators, detection of end point, visual indicators and potentiometric end point detection. Quantitative applications-adjusting the analyte's oxidation state, determination of chemical oxygen demand (COD) in natural and waste waters and other applications. Titrations of mercaptans and ascorbic acid with I_3^- and titration of organic compounds using periodate. Karl Fischer reagent for water determination.

Complexometric Titrations:

Introduction, complexation reaction, titration curves, types of EDTA titrations, titrations of mixtures, selectivity, masking and demasking agents, metal ion indicators, some practical considerations. Applications of EDTA titrations- hardness of water, magnesium and aluminium in antacids, magnesium, manganese and zinc in a mixture.

Precipitation Titrations:

Precipitation reactions, titration curves, factors influencing the sharpness of end points, completeness of the reaction. Chemical indicators - Volhard, Mohr and Fajan's methods. Precipitation titrations involving silver nitrate. Applications.

Organic Reagents in Inorganic Analysis and Chromatography

Organic precipitants, general properties, reagents as precipitants (DMG, 8-hydroxy quinoline, acetyl acetone, etc).

Gravimetric analysis:

Introduction, precipitation methods, the colloidal state. Requirements & conditions of precipitations, co-precipitation, post precipitation, nature of the precipitate, super saturation, precipitation from homogeneous solution and effect of excess of precipitant, temperature, pH and complex formation on completeness of precipitation, washing the precipitate and peptization. Fractional precipitation, organic precipitants, volatilization or evolution methods. Filtration, washing, drying and ignition of precipitates.

[16hrs]

Unit- III: Separation Techniques

Basic separation techniques in analysis, classification

Solvent Extraction:

Principle, distribution law. Choice of solvents for extraction, factors affecting extraction-pH and oxidation state, masking and salting out agents. Techniques-batch, continuous and multiple extractions and synergic extraction. Applications

Paper and thin layer Chromatography:

General principles and mechanism, classification of chromatographic methods-paper, thin layer, column and liquid chromatography. Selection of stationary and mobile phases, preparation of micro and macro plates, development, spray reagents, identification and detection, reproducibility of Rf values, qualitative, quantitative analysis and applications of TLC.

Ion Exchange Chromatography:

Definitions, requirements for ion exchange resin, principle, basic features of ion exchange reactions, types of ion exchange resins, ion exchange capacity, resin selectivity. Synthesis and factors affecting the selectivity. Process of elution and Applications in preparative, purification and recovery processes.

[12 hrs]

.**Unit –IV: Electroanalytical techniques**

Introduction and requirements

Conductometry:

Theory- Measurement of Conductivity - Basis for Conductometric titrations. Conductometry as an analytical tool.

Potentiometry:

Principles, Reference electrodes, indicator electrodes, selective electrodes, Membrane electrodes. Glass electrodes for the measurement of cations other than hydrogen,pH measurement, measurement of cell emf - potentiometric titrations.Solid state electrodes, liquid membrane electrodes. Ion-selective field effect transistors (ISFETS). Gas sensing electrodes. Chemical and environmental applications. Potentiometric titrations- acid-base, precipitation and redox titrations. Null-point potentiometry.

Voltametry: Polarography - Direct current and AC Polarography - Theory - Dropping Mercury Electrode- Quantitative technique - Measurement of Wave Heights - Pulse Polarography - Rapid Scan Polarography. Applications-electrochemical reversibility and Stripping Voltametry - Cyclic Voltametry-Principles and applications. Modified electrodes. Voltammetry with micro electrodes.

Amperometry : Pricnciples, amperometric titrations with examples. Biamperometry.

Electrogravimetry: Theory, completeness and nature of the deposit, instrumentation, electrolytic separation of metals and applications. **[12 hrs]**

REFERENCES:

1. Analytical Chemistry 2.1David Harvey, DePauw University (2016).
2. Analytical Chemistry by Gary D. Christian,7th Edition , (2014).
3. Fundamentals of Analytical Chemistry D.A Skoog, D.M West, Holler and Crouch, Saunders College Publishing, 8th edition, (2005).
4. Analytical Chemistrym G.D Christian, John Wiley and Sons Inc, 5th edition, (2001)
5. Vogel's Test book of Quantitative Chemical Analysis, J. Mendham, R.C Denny, J.D Barnes and M.J.K Thomas, 6th edition, (2003).
6. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, (2000).
7. Instrumental Methods of Analysis, H.H Willas, L.L Merritt and J.A Deay, 7th edition, (1988).
8. Instrumental Methods of Analysis, W.M Dean and Settle, 7th edition, (1986).

Course outcomes:

1.	Apply basic analytical methods for chemical analysis
2.	Evaluate and treat the analytical data
3.	Apply the separation techniques in separation and purification
4.	Design and interpret the analytical data

Course: R &D and Quality control	Course Code: 24CHE1S1LP
Teaching Hours/Week (L-T-P): 1- 1 - 0	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objectives:

1. Students acquire basic knowledgeable industries and research**.**
2. To understand the functioning of Research and Development and quality control.

Unit-I: Research and Development

Industry: Types of chemistry related industries; Sections and responsibilities

Research & Development:

Importance, Process development & product development, In-house failure and addressing; Design & executions of reactions.

Chemistry software: Chemdraw ; Scifinder

Production: Control & Execution; Testing of In-house failure products.

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[10 hrs]

Unit-II: Quality Control & Quality Assurance

Quality Control:

Functions & Responsibilities , Method development and validation, analytical parameters –LOD, LOQ

Quality Assurance:

Functions & Responsibilities. 6 sigma concept and ISO accreditation. Total Quality Management perspective, methodologies and procedures; Roadmap to TQM, ISO 9000, KAIZEN, Quality Circles, Models for organizational excellence

Application of Software tools and Case Studies.

Intellectual Property rights and Pharmaceuticals

[10 hrs]

Unit-III: Safety practices and Environmental treatment plant

Safety Apparels in Industries: Precautions, Safety Apparels, handling of toxic and explosives, first aid in case of emergency and medications.

Environment treatment plant: Regulatory requirements, control, monitoring and treatment of treatment liquid and solid waste treatment; Recovery, incineration and Toxic metals treatment.

Preparation for the interview:

How to face an interview?.

[8 hrs]

REFERENCES:

1. Research Design: Qualitative, Quantitative and Mixed Methods Approaches by Creswell (2014).
2. Research Methods: A Practical Guide For Students And Researchers 1st Edition.
3. Perfect Quality Assurance & Quality Control Paperback – Import, 19 by Ram Babu Sao November (2016).
4. Essential environment Jay H. Withgott 09 September (2021).

5. How to Write the Perfect Resume: Stand Out, Land Interviews, and Get the Job You Want by Dan Clay.

Course outcomes:

1.	Design new reactions
2.	Analyse and interpret the analytical data
3.	Skills for industries

Course: Inorganic Chemistry Quantitative analysis	Course Code: 24CHE1C1P
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objectives:

1. Hands-on training for quantitative estimation using volumetric and gravimetric analysis.
2. Understand the importance of determination of common metallic traces affecting the biological system.
3. Understand and appreciate common useful methods of detection of traces of elements.

List of Experiments:

1. Determination of iron using $KMnO_4$ (0.02M) and ceric ammonium sulphate (0.02M) as titrants.
2. Determination of calcium using $KMnO_4$ (0.02M) as titrants.
3. Determination of copper volumetrically using KIO_3.
4. Estimation of calcium and magnesium carbonates in dolomite solution using EDTA titration.
5. Estimation of lead using EDTA titration.
6. Gravimetric analysis of sulphate with barium.
7. Gravimetric analysis of iron.
8. Determination of nickel gravimetrically using dimethyl glyoxime.
9. Separation and determination of two metal ions, iron and nickel by volumetric and gravimetric methods.
10. Separation and determination of two metal ions, copper and iron by volumetric and gravimetric methods.
11. Separation and determination of two metal ions, calcium and iron, by volumetric and gravimetric methods.
12. Determination of Aluminium by EDTA method.

REFERENCES

1. A text book of quantitative inorganic analysis- A.I.Vogel, 3rd edition, 5th edition. .
2. Quantitative chemical analysis – Daniel, C.Harris, 7th edition,(2006).

Course Outcomes:

1.	Analyse binary and complex mixtures of metallic ions by volumetric and gravimetric methods
2.	Design procedure for the quantification of inorganic compounds in various samples
3.	Analyze an experimental procedure and suggest improvements.
4.	Interpret the analytical data to comply with regulatory standards

Course: Qualitative Analysis of Organic Binary Mixtures	Course Code: 24CHE1C2P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objectives:

1. Expose to simple synthetic procedures in the laboratory.
2. Correlate theoretical concepts for preparing, purifying, and identifying organic molecules.
3. Comply with safety rules in conducting laboratorial experiments.
4. To identify the components through various steps, derivative preparation, checking the purity of components.

List of Experiments

1. Systematic qualitative analysis and separation of organic binary mixtures (solid + solid) and their identification through various steps, derivative preparation, checking the purity of components by melting point (minimum 10 mixtures).

NOTE: In the examination, a candidate has to separate the binary mixture and analyze one component indicated by the examiner.

REFERENCES

1. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath, 7th Ed., (2011).
2. Qualitative Analysis of Organic Compounds byA.I. Vogel 4thEdition.
3. Vogel's Textbook of Practical Organic Chemistry, Ed. 5, Longman, (1989).
4. Experiments and Techniques in Organic Chemistry, Pasto, Johnson and Miller, Prentice Hall, (1992).
5. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold.
6. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.

Course outcomes:

1.	Analyse and separate complex organic mixtures
2.	Design experimental approach for purification of organic compounds
3.	Develop methodology for synthetic reaction and characterization
4.	Hands on training in determining melting point , boiling point, TLC etc

Course: Kinetics and Electrochemistry Practicals	Course Code: 24CHE1C3P
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 20 Marks	**Semester End Examination:** 30 Marks

Course Objectives:

1. Study Kinetics of chemical reactions
2. To understand varied solvents interaction by phase formation mechanism
3. Analysis of samples using conductometric techniques

List of Experiments

1. Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different temperatures, determination of rate of constants and energy of activation.
2. Study of kinetic reactions between $K_2S_2O_8$ and KI, first order, determination of rate constants at two different temperatures and Energy of activation.
3. Conductometric titration of mixture of HCl and CH_3COOH against NaOH.
4. Conductometric titration of mixture of HCl and CH_3COOH and $CuSO_4$ against NaOH.
5. Conductometry-To determine the degree of hydrolysis and hydrolysis constant of anilinehydrochloride.
6. Conductometric titration of potassium iodide with mercuric perchlorate.
7. Determination of Molecular weight of polymer by viscometer.
8. Phase diagram for Three component liquid system, acetic acid, benzene and water.
9. Kinetics of dissociation of trichloroacetic acid.
10. Determination of rate constant and order of reaction between $K_2S_2O_8$ and KI.
11. Determine the equilibrium constant for the reaction KI + I2 = KI_3 by distribution method.

REFERENCES

1. Experimental Physical Chemistry: A Laboratory Textbook, A. Halpern & G. McBane III Ed. W. H. Freeman (2006)
2. Practical Physical Chemistry- A.J.Findlay (2007).
3. Experimental Physical Chemistry-F.Daniel et el (2006).
4. Selected Experiments in Physical Chemistry- Latham (1974).
5. Experimental Physical Chemistry- Janes and Parichard 3rd edition (1974).
6. Experimental Physical Chemistry- Shoemaker 5th edition (1989).
7. Experimental Physical Chemistry- Yadav, Goel Publishing House.
8. Experimental Physical Chemistry- Das R.C and Behera B., Tata Mc Graw Hill.

Course outcomes:

1.	Skills in analysis of physical properties of materials and reactions
2.	Analyse and interpretation of physical properties
3.	Designing of methods for ionic substances
4	Evaluate the kinetics of reaction

Semester-II

DSC5: Chemistry of Coordination compounds

Course Title: **Chemistry of Coordination compounds**	Course code: 24CHE2C5L
Total Contact Hours: 56	Course Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 h
Summative Assessment Marks: 70	

Course Outcomes (CO's):

1. To understand the general characteristics of the d and f block elements, organometallic compounds, metal carbonyls and metal clusters, thorough knowledge of the different theories to explain the bonding in coordination compounds.
2. To study the nature of various metal complexes and calculate various parameters.
3. Study the existence of stereoisomerism in transition metal complexes.
4. To study the magnetic and spectral properties of metal complexes.
5. To understand electron delocalization and its effect on stability and reactivity

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

1. The subject is designed to strengthen the basic knowledge in the field of complex chemistry and to impart recent advances in the transition metal complex chemistry.
2. Acquisition of knowledge of Geometry, Magnetic and Spectral Properties of Metal Complexes.
3. Will gain in-depth knowledge of d and f block elements, coordination compounds and organometallic compounds which is essential for future career and competitive exams.

Unit	Description	Hours
1	**Metal-Ligand Bonding** **Review of bonding theories:** **Valence Bond Theory (VBT):** Coordinate covalent bonding in metal complexes, applications of VBT in tetrahedral, Square-planar and Octahedral complexes, Limitations of VBT. **Crystal Field Theory (CFT): S**alient features, crystal field splitting of d orbitals in octahedral, tetrahedral, tetragonal and square planar fields. Magnitude of Δ, factors affecting Δ, crystal field stabilization energy (CFSE),effects of crystal field splitting. Spectrochemicalseries, nephelauxetic series, short comings of CFT, evidences for covalence character, John-Teller distortion in metal complexes. **Molecular Orbital Theory (MOT): T**reatment of co-ordination compounds involving σ and π bondings.	14
2	**Spectral and Magnetic Properties:** Term symbols for d^n ions, spectroscopic ground states, selections rules, nature	14

	of spectral bands-band shapes and bond intensities, band widths, effect of spin orbit coupling, Orgel diagrams, Tanabe-Sugano diagrams, Racah parameters, interpretations of spectra of octahedral, distorted octahedral, tetrahedral and square planar complexes. Calculations of nephelauxetic parameter, Charge transfer bands, Interference of charge transfer bands. **Magnetic Properties of Metal Complexes:** Types of magnetic behavior, classical magnetism, orbit coupling, measurement of magnetic susceptibility-Gouy and Faraday methods, diamagnetic corrections, ferro and anti-ferroand ferri magnetism, spin cross-over systems.	
3	**Geometry and Equilibria of Metal Complexes:** **Geometry**: Stereochemistry, coordination numbers 3 to 8, isomerism in metal complexes, geometrical isomerism, optical isomerism, coordination isomerism, ionization isomerism, linkages isomerism. **Metal-Ligand Equilibria in Solution:** Step-wise and over-all formation constant and their relationships, trends in step-wise constant, kinetic and thermodynamic stability of metal complexes, factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand, chelate and macro cyclic effects and their thermodynamic origin, determination of binary formation constants by pH meter, spectrophotometry, polarography and by ion exchange methods.	14
4	**Electron Transfer Reactions (Redox Reactions):** Inner and outer sphere mechanisms, one electron, two electron, complimentary and non complimentary electron-transfer reactions. **Reaction Mechanisms in Transition metal Complexes:** Energy profile of a reaction, inert and labile complexes. Kinetics of octahedral substitution and Mechanistic aspects, substitution reactions in square planar complexes, trans effect, molecular rearrangements of four and six coordinated complexes	14

References:

1. Shriver and Atkin's Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong, 5th Ed, Oxford University press, (2012).
2. Concise Coordination Chemistry, R Gopalan and V Ramalingam, Vikas Publishing House Pvt Ltd., New Delhi, (2005).
3. Basic Inorganic Chemistry, F.A.Cotton, G.wilkinson and P.L.Gau, Jhon Wiley and sons, Inc, 6th edition, (1999).
4. Inorganic Chemistry,J.E.Huheey, E.A.Keiter and R.L.Keiter, 4thedn,(1993).
5. Chemistry of the Elements, N.N.Greenwood and A.E.Earnshaw, Buttrerworth Heilemann, (1997).
6. Essential Trends in Inorganic Chemistry, D.M.P.Mingos, Oxford univ press,(1998).
7. Chemistry of Complex Equilibria, M.T Beck, Rinhold, London, (1990).
8. Magnetochemestry, R.L.Carlin, Springer VerlagVolume92, Issue3 ,März,(1988). Coordination Chemistry, Fred Basolo and Ronald C. Johnson, Wiley, New York, (1984).

Date Course Coordinator Subject Committee Chairperson

DSC6: Reaction mechanisms in organic synthesis and Pericyclic reactions

Course Title: **Reaction mechanisms in organic synthesis and Pericyclic reactions**	Course code: 24CHE2C6L
Total Contact Hours: 56	Course Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 h
Summative Assessment Marks: 70	

Course Outcomes (CO's):

1. To instruct students on the fundamental concepts of organic chemistry as well as their applications.
2. To understand the heterocyclic compounds and natural compounds which comprise the major part of organic chemistry.
3. To gain the useful knowledge on various reaction mechanism and structural activity of organic compounds.
4. To acquire advance knowledge of carbon-carbon and carbon-hetero atomic bonds.
5. To study the various useful organic reagents used in pharmaceutical industries for synthesis of drugs.
6. To acquint with principles of pericyclic reactions and their progress forward or backwards.
7. Cycloaddition reactions and Sigmatropic reactions and rules governing them.

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

1. Get familiarize with heterocyclic compounds, natural products and reagents in organic synthesis. Heterocyclic compounds play an important role in pharmaceuticals.
2. Interpret the concept of reaction mechanism in the transformation from reactant to product.
3. Interpret the mechanistic and stereochemical aspects of carbon-carbon bonds and carbon-hetero atomic bonds.
4. Able to use various reagents in organic synthesis and functional group transformation.
5. Capable to design pericyclic reaction and carry out these types of reaction.

Unit	Description	Hours
1	**Reaction mechanism and structure reactivity** **Reaction mechanism**: Types of mechanism, types of reactions, thermodynamics and kinetic requirement. Kinetic and thermodynamics control, *Hammond's* postulate, *Curtin-Hammett* Principle, Potential energy diagrams, transition states and intermediates, method of determining mechanisms, isotope effects. **Free radical reactions**: Types of free radical reactions, free radical substitution mechanism at an aromatic substrate, neighboring group assistance. Reactivity for aliphatic and aromatic substrates at a bridge-head. Reactivity of the attacking radicals. The effect of solvents on reactivity. Coupling of alkynes and arylation of aromatic compounds by diazonium	12

	salts. *Sandmeyer* reaction. Free Radical Rearrangement. *Hunsdiecker* reaction. **Elimination reactions:** The E2, E1, and E1cB mechanisms and their spectrum. Orientation of the double bond. Reactivity effects of substrate structure, attacking the base, the leaving group, and the medium.	
2	**Reactivity of carbon-hetero multiple bonds** Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters, and nitriles. Addition of *Grignard* reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. *Wittig* reaction.Mechanism of condensation reactions involving enolates-Aldol, *Knoevenagel*, *Claisen*, *Mannich*, Benzoin, *Perkin*, and *Stobbe*reactions.Hydrolysis of esters and amides, ammonolysis of esters. **Reactivity of carbon-carbon multiple bonds:** Mechanistic and stereochemical aspects of addition reaction involving electrophiles, nucleophiles, and free radicals. Regio, and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring.Hydrogenation of double and triple bonds, hydrogenation of aromatic ring. Hydroboration.Michael reaction.Sharpless asymmetric epoxidation.	14
3	**Pericyclic reactions** Definition, classifications of Pericyclic reactions. Molecular orbital symmetry, Frontier orbital of ethylene, 1,3 butadiene, 1.3.5-Hexa triene, and allyl systems. Woodward and Hoffmann correlation diagram. FMO & PMO approach, electrogatic reactions-conrotator, and disrotatory motions, 4n, 4n+2, and allyl systems. Cycloaddition – antrafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes. 1, 3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements, superfacial and antrafacial shifts of H., shifts involving carbon moieties, 3, 3-and 5, 5 – sigmatropic rearrangements, Claisen, Cope, and Azo cope rearrangements.	16
4	**Reagents in Organic Synthesis** Use of following reagents in organic synthesis and functional group transformation **1.** Dicyclohexylcarbodiimide (DCC) **2.** Woodward and Prevost hydroxylation **3.** 2,3-Dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) **4.** Phase transfer catalysis **5.** Crown ethers **6.** Dess–Martin periodinane (DMP) **7.** Merrifield resin **8.** Peterson's synthesis **9.** Wilkinson's catalyst **10.** Gilman's reagent **11.** Ziegler–Natta catalyst .	14

References:

1. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 7th Edition, Michael B. Smith, WILEY, (2013).
2. Advanced Organic Chemistry PART A and PART B., F. A. Carey and R. J. Sundburg, Springer (2007).
3. Organic Chemistry, J. Clayden, N. Geeves and S. Warren, Oxford University Press, (2012).
4. Organic Chemistry, Morrison, Boyd and Bhattcharjee, &th Edition, Pearson, (2010).
5. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman, (1985).
6. Pericyclic Reactions, S. M. Mukherji, Macmillan, India, (1980).
7. Reaction Mechanism in Organic Chemistry, S. M. Mukherji and S. P. Singh, Macmillan., (1984).
8. Advanced Organic Chemistry: Reaction Mechanism, R Bruckner, Harcourt (India) Pvt. Ltd., (2001).
9. Reactions Mechanism in Chemistry, Vol. I, II, III, Mukherji, S.M.; Singh, S.P. Macmillan, (1985).
10. Stereochemistry of Organic Compounds, Nasipuri, D. 2nd edition New Age International Publishers, (1994).
11. Stereochemistry of Organic Compounds, Kalsi, P.S. 2 edition, New Age International,
12. Stereochemistry: Conformation and Mechanism, Kalsi, P.S., 2nd edition, Wiley Eastern Limited, (1993).
13. Textbook of Organic Chemistry-R.J.Moorism and Boyd 7^{th} edition.
14. Textbook of Advanced Organic Chemistry-Arun Bhal,(2010).

Date Course Coordinator Subject Committee Chairperson

DSC7: Electro, Quantum and Photochemistry

Course Title: **Electro,Quantum and Photochemistry**	Course code: **24CHE2C7L**
Total Contact Hours: 56	Course Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 h
Summative Assessment Marks: 70	

Course Outcomes (CO's):

1. To Understand the theoretical and basic aspects of basics and applied electrochemistry
2. To acquire knowledge of quantum chemistry.
3. To learn the concept of photochemistry

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

1. Acquire fundamental and basic knowledge of electrochemistry and apply for electrochemical systems
2. Able to understand the photochemistry principles and reactions
3. Able to apply quantum chemistry approaches in different reactions.

Unit	Description	Hours
1	**Photochemistry:** Introduction to photochemistry, photochemical laws, Absorption and emission, Jablonski diagram, Singlet and triplet states, Origin of energy difference between singlet and triplet states, selection rules for electronic transition. Laws of photochemistry, Franck-Condon principle, fluorescence, phosphorescence, Factors affecting Fluorescence and Phosphorescence, Life time of an excited state. Stark-Einstein law of photochemical equivalence, Photosynthesis, quantum yield and its determination, factors affecting quantum yield, Excimer and exciplex, Quenching. Term symbols and its significance, Photochemical reactions, Photo oxidation and photo reduction, Effect of light intensity on the rate of photochemical reactions.	14
2	**Irreversible Electrode Process:** Introduction, reversible and irreversible electrodes, Ohmic overvoltage, concentration overvoltage, activation overvoltage. Hydrogen over voltage and oxygen over voltage. Effect of temperature, current density and pH on over voltage. Experimental determination of over voltage. Equations for concentration over potential, diffusion current, stationary current, ionic product of water, Solubility product.Polarography-half wave potential, application in qualitative and quantitative analysis. Energy barrier and electrode kinetics, Buttler-Volmer equation, Tafel equation.	12

3	**Quantum Mechanics:** Wave-particle duality of material particles, de Broglie equation, Heisenberg uncertainty principle. Concept of operators (operator – operand), algebra of operators, commutative and non commutative operators, linear operators, Laplacian operator, Hamiltonian operator, Eigen value, Eigen function, Hermitian operator. Postulates of quantum mechanics, Schrodinger wave equation for particles. Applications of Schrodinger equation for particle in one and three dimentional box. Application of Schrodinger equation to rigid rotator and harmonic oscillator. Perturbation theory, method-first order and second order correction, application to He – atom (first order correction only)-calculation of first ionization, potential and binding energy. Variation theorem statement and derivation.	14
4	**Electrochemistry and Applied Photochemistry** Debye-Huckel theory of strong electrolytes, Debye Huckel – Onsager equation, Debye – Huckel limiting equation for activity coefficients. Debye-Falkenhagen effect, Electrical double layer and its thermodynamics. A brief survey of Helmholtz – Perrin, Gouy – Champman and Stern electrical double layer, liquid junction potential and its determination. Molar ionic conductance and Stokes's law. **Electrochemical energy sources** – Batteries, characteristics, classification-primary, secondary. Fuel cells: working principle (H_2-O_2, CH_3OH-O_2), Applications **Applied Photochemistry** Photosensitization, photochemical kinetics of: decomposition of CH_3CHO, formation of HCl. Photochemical reactions and its types, Photochemical formation of smog, Stern-Volmer equation (derivation). Photodegradation: photocatalyst-ZnO, TiO_2, principle, application of ZnO/TiO_2. Actinometry-uranyloxalate and potassium ferrioxalate actinometres. Flash Photolysis and its applications, Quantum efficiency. Photochemistry of carbonyl compounds .	16

References:

1. Atkins' Physical Chemistry, Peter Atkins and Julio Paula, Oxford University Press; 10th Ed,(2014).
2. Physical Chemistry- A molecular approach, Donald Mcquarie and John Simon, Viva, 1st Ed, (2010).
3. Physical Chemistry, Ira N Levine, Tata Mcgraw-Hill Education; 6 Ed. (2011).
4. Elements of physical chemistry–Lewis and Glasstone.
5. Physicalchemistry–P.W.Atkins, ELBS,fourth edition (1990).
6. Introductiontoelectrochemistry-S.Glastone.
7. Modernelectrochemistry, Vol I&II, J.O.M.Bockris and A.K.N.Reddy, (1970).
8. Quantum Chemistry, Ira N Levine, Pearson Education, 7th Ed. (2013).

9. Introductory Quantum Chemistry, A. K. Chandra, Tata McGraw-Hill (1998).
10. Quantum Chemistry, R. K. Prasad, New Age International (2001).
11. Quantum Chemistry, Ira N Levine, Pearson Education, 7th Ed. (2013).
12. Fundamentals of Photochemistry ,K. K. Rohatgi and K. K. Mukherjee;, 3rd ed. New Age International (P) Ltd, (2014).
13. Modern Molecular Photochemistry of Organic Molecules ,N. J. Turro, V. Ramamurthy and J. C. Scaiano, 1st ed. University Science, Books, CA, (2010).
14. Photochemical Synthesis, Ninomiya, T. Naito, 1st ed. Academic Press, New York, (1989).

Date Course Coordinator Subject Committee Chairperson

DSC8: Spectroscopic and Thermal methods

Course Title: **Spectroscopic and Thermal methods**	Course code: **24CHE2C8L**
Total Contact Hours: 56	Course Credits: 04
Formative Assessment Marks: 30	Duration of ESA/Exam: 3 h
Summative Assessment Marks: 70	

Course Outcomes (CO's):

1. To Understand the theoretical and basic aspects of symmetry and group theory related to spectroscopy
2. To study interaction of electromagnetic radiation with matter.
3. To apply spectroscopic techniques for quantitative analysis
4. To acquire knowledge on thermal methods of analysis

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

1. Apply fundamental and basic knowledge of spectroscopy in the characterization and interpretation of structure.
2. Able to apply the techniques in academic, industrial and research

Unit	Description	Hours
1	**Group Theory and Symmetry:** Symmetry elements & Symmetry operations, groups, subgroups, cyclic groups, conjugate relationships, classes, molecular point groups, Hermann-Maugin symbols for point groups. Schoenflies notations, matrix representations of symmetry operation, matrix representations of groups. Reducible and Irreducible representations, characters of representations. The great orthogonality theorem, character tables (Cs, Ci, C2, C2v, C2h and C3v) and Multiplication tables (C_{2v}, C_{2h}, C_{3v})– their construction. Mullikan symbols, molecular models. Determination of vibration modes, hybridization, molecular orbitals on the basis of group theory.	12
2	**Electromagnetic radiation and quantitative aspects:** Characterization, quantization of energy levels, regions of electromagnetic radiation, spectrum – interaction electromagnetic radiation with matter – representation of spectra, intensity and width of spectral lines. Quantitative aspects of absorption – Beer- Lambert's law, Terminology associated with absorption measurements. Theory of molecular absorption.Vibration- rotation fine structure of electronic spectra. Criteria for spectrophotometric determinations with examples (Fe, Mo and Ni). Limitations of the law. **UV-Visible Spectroscopy:** Types of absorption bands, modes of electronic transitions, simple chromophoric –auxochrome theory. Solvent effect and choice of solvent. Prediction of λ-max value by using Wood-Ward and Fieser rules for conjugated diens, trienes and cyclic α, β unsaturated aldehydes and ketones, benzene and substituted benzene rings. Instrumentation (single beam and	14

	double beam spectrophotometers). Quantitative and Qualitative applications of UV-Visible spectroscopy in structural and molecular weight determination, Determination of stoichiometry and stability of the complexes, Analysis of binary mixtures(Cr and Mn), measurements of dissociation constants of acids and bases. Photometric titrations and kinetic studies. Method of colour measurement for of NH_3, Cr, Cu, Fe, Mn.	
3	**Inorganic spectral Methods:** **Flame Photometry and Atomic Absorption Spectrometry:** Principles and Theory - Instrumentation - Flames - Burners - Nonflame Techniques - Spectral and Chemical Interferences - Experimental Aspects. Total consumption and premix burners, role of temperature on absorption, emission and fluorescence. Comparative study of the basic components and difference in the instrumental design for atomic absorption and flame photometry. Analytical applications of AAS- determination of mercury. **Atomic Emission Spectrometry and Inductively Coupled Plasma:** Principles and Instrumentation - Excitation source, Limitations of AES, interferences. Effect of organic solvents. Principles of Plasma Spectroscopy - Excitation Source in ICP -Applications. **Nephelometry and Turbidometry:** Tyndall, Rayleigh and Raman Scattering - Principles, Instrumentation and Applications. Light scattering in nephelometry and turbidimetry.Choice between nephelometry and turbidimetry, tubidimetry and colorimetry, nephelometry and fluoromtry. Theory effects of concentration, particle size and wavelength on scattering. Applications: Determination of $SO4_{2-}$., Turbidimetric titrations.	12
4	**Thermal Methods of Analysi-II** **Thermal Methods of Analysi-I** **Thermo Gravimetric Analysis:** Introduction, thermogravimetric analysis(TGA) – types of thermo gravimetric analysis, principles, Automatic thermogravimetric analysis, instrumentation, types of recording thermobalances, sample holders, factors affecting the results – heating rate, furnace instrument control/data handling. Applications- purity and thermal stability, evaluation of correct drying temperature, analysis of complex mixture and determination of kinetic parameters of thermal degradation **Differential Thermal Analysis (DTA):** Theory , variables affecting the DTA, general principles, instrumentation, applications – analysis of the physical mixtures and thermal behavior study, determination of decomposition point. Simultaneous DTA-TGA curves, factors affecting results, and applications. **Differential Scanning Calorimetry (DSC):** Basic principle, differences between DTA and DSC, instrumentation – power compensated DSC, heat flux DSC, applications – studies of thermal transistors and isothermal crystallization, pharmaceutical industry for testing the purity of the samples.	14

	Thermometric titrimetry (Acid-Base, precipitation, Complexation, redox and non- aqueous titrations) and direct injection enthalpimetry-principle, instrumentation, applications.	

References:

1. Atomic and Molecular Spectroscopy: Basic Concepts and Applications, Rita Kakkar, Cambridge University Press, (2015).
2. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York, (2005).
3. Analytical Chemistry, G.D. Christian, 5th ed, John Wiley & Sons, Inc, India (2001).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, prentice Hall, Inc. New Delhi, (1993).
5. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint. Pearson Education Pvt. Ltd., New Delhi, (2003).
6. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, (1990).
7. Principles and Practicals of Analytical Chemistry, F. W. Fifield and Kealey, 3rd edition, Blackwell Sci., Ltd. Maiden, USA, (2000).
8. Modern Analytical Chemistry, David Harvey, McGraw Hill, New Delhi, (2000).
9. Introduction to Instrumental Analysis, Robert. D. Braun, Pharm. Med. Prem. India, (1987).
10. Instrumental Method of Analysis, W. M. Dean and Settle, 7th edition, CBS Publishers, New Delhi,(1986).
11. Instant Notes of Analytical Chemistry, Kealey and Haines, Viva books Pvt. Ltd., (2002).
12. Basic Concepts of Analytical Chemistry, S.M.Khopkar, New Age Intrenational 3rd edition, (2008).
13. Chemical Applications of Group Theory, F. A. Cotton, John Willey & Sons, 3rd Ed. (2008).
14. Symmetry and Spectroscopy of Molecules, K. Veerareddy, Revised II Ed., New age international, 2020.

Date Course Coordinator Subject Committee Chairperson

SEC 2: Research Methodology

Course Title: **Research Methodology**	Course code: 24CHE2S2LP
Total Contact Hours: 28 (01 L-0-2P)	Course Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 1h
Summative Assessment Marks: 30	

Course Outcomes (COs):

1. To Understand the importance and requirement of research
2. To do literature survey and data collection

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

1. Capable to cultivate research knowledge skills
2. Apply the knowledge and data collection methods in experiments and research work

SEC 2: Research Methodology

Unit	Description	Hours
1	**Introduction to Research** Nature and importance of research- Aims, Objectives and Principles: Fundamental research vs. applied research with examples: Qualitative vs Quantitative research: Theoretical research vs. experimental research with examples: Selection of a research problem and Sources of literature – Journals, Conferences, Books. Types of sources: Literature Survey engines- Scopus, web of Science, Google Scholar, PubMed, NCBI, Scihub, etc. Science citation index: Citations, h-index, i10 index, impact factor.	8
2	**Methods of Data Collection** Data Collection Methods- Framing a hypothesis, designing controlled experiments, choosing the sample-size, sampling bias, importance of independent replicates, conducting an experiment, maintaining a lab-notebook to record observations: Identifying experimental errors. Case-studies on well-designed experiments vs. poorly designed experiments. Correlations vs. Causation .Good laboratory Practices. Safety practices in laboratories; Introduction to Chemdraw, Chemsketch and other basic softwares.	8
3	**Data analysis (Practical)** **Data Presentation and Writing:** Technical presentation, technical writing, Formatting citations ; MS Excel for plotting the data (pie chart, plots, bar charts) **Analysis using software tools:** Descriptive Statistics: Mean, standard deviation, variance, plotting data and	12

	understanding error-bars. Curve Fitting: Correlation and Regression. Distributions: Normal Distribution, Gaussian distribution, skewed distributions.	

References (indicative)

1. C.R. Kothari, Research Methodology: Methods and Techniques, II Ed. New Age International Publishers, (2009).
2. Shanthibhushan Mishra, Shashi Alok, Handbook of Research Methodology, I Ed, 2017, Educreation Publishers.
3. Basic Statistical Tools in Research and Data Analysis (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/).
4. Introduction to statistical methods with MATLAB (MATLAB and Simulink Training (mathworks.com).

DSC5 P4: Preparation and analysis of Coordination compounds

Course Title: **Preparation and analysis of Coordination compounds**	Course code: 21CHE2C5P
Total Contact Hours: 56 (0-0-4P/week)	Course Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 4 h
Summative Assessment Marks: 30	

Course Outcomes (CO's):

1. To provide practical training on preparation of different types of metal complexes.
2. To determine the concentration of metal ion in the solutions in different types of reactions.

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

1. Able to estimate the amount of metal ion in given solutions
2. Gain hands on experience and knowledge about the synthesis of various metal complexes of different shapes.
3. Able to gain knowledge on hybridization and structures of complexes.

SL No	List of experiments	Hours
1	Preparation of Mercury tetrathiocyanatocobaltate(III) and analysis of cobalt.	
2	Preparation og Chloropentammine cobalt (III) chloride and analysis of Cobalt and chloride	
3	Preparation of Nickel (II) salicylaldoxime and analysis of nickel.	
4	Preparation of Copper (II) acetyl acetone and analysis of copper.	
5	Preparation of Tris thiourea copper (I) sulphate complex and analysis of copper.	
6	Preparation of Hexammine cobalt (III) chloride and analysis of cobalt.	
7	Preparation of Potassium bisoxalato cuprate (II) dehydrate and analysis of copper.	
8	Preparation of Potassium trisoxalatoferrate (III) and analysis of iron.	
9	Preparation of Nickel (II) Schiff's base complex and analysis of nickel	

References:

1. Vogel's Qualitative analysis, G Svehla and Sivasankar, Pearson press, 7th Ed 2012
2. Quantitative chemical analysis – Daniel, C.Harris, 7th edition (2006).
3. Vogel's Textbook of Quantitative Chemical analysis, Mendham, Denney, Barnes, Thomas, Sivasankar, 6th Ed, Pearson publishers, 2009
4. A text book of quantitative inorganic analysis- A.I.Vogel, 3rd edition, 1966.
5. Vogel's text book of quantitative chemical analysis – J.Basset, R.C.Denney, G. H. Jeffere and J. Mendhom, 5th edition, 1989.
6. Vogel's Qualitative Inorganic Analysis, revised, G. Svehla, Longman, 7th Ed, 1996.
7. Practical Inorganic Chemistry, Marr and Rocket, 1972.

DSC6 P5: Synthesis of organic compounds

Course Title: **Synthesis of organic compounds**	Course code: 21CHE1C6P
Total Contact Hours: 56 (0-0-4P/week)	Course Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 4 h
Summative Assessment Marks: 30	

Course Outcomes (CO's):

1. Train and expose to simple synthetic procedures in the laboratory.
2. To introduce different experiments to develop the skills and strategic approaches for organic Synthesis.
3. To determine physical constants and purification of synthesized organic compounds by Recrystallization techniques.
4. To demonstrate synthesis and TLC to monitor a reaction.

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

1. Students learn various synthetic methodologies and able to detect the functional group by preparation of a suitable derivative.
2. Developed skills provide confidence of handling simple laboratory synthetic experiments in research and industries.
3. Develop hands on expertise to design and conduct the experiments independently

SL No	List of experiments	Hours
1	To determine corrected melting points of an unknown organic compound (calibration of thermometer).	
2	Preparation of Adipic acid from cyclohexanol (oxidation).	
3	Reimer Tiemann reaction (preparation of Salicylaldehyde β-hydroxynaphthaldehyde)	
4	Preparation of acetanilide from Acetophenone.(Beckmann Rearrangement)	
5	Preparation of 7-hydroxy-4-methyl coumarin(Pechmann reaction) from resorcinol	
6	Preparation of benzyl alcohol and benzoic acid (*Cannizzaro's* reaction).	
7	N- Bromo succinimide (Bromination).	
8	Dibenzal acetone from benzaldehyde (*Claisen-Schmidt* reaction).	
9	Cinnamic acid from benzaldehyde (*Knoevenaegal* reaction).	
10	Preparation of Acetanilide, bromoacetanilide, bromoaniline.	
11	Diphenylmethane from benzylchloride (*FriedelCraft's* reaction).	
12	Preparation of Benzanilide (*Schotten-Baumann* reaction).	
13	O-Benzoylbenzoic acid (*Friedel Craft's* reaction).	
14	Preparation of indigo from Anthranilic acid.	

References:

1. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath, 7th Ed., 2011.
2. Comprehensive practical organic chemistry preparation and quantitative analysis-Ahluwalia.V.K.and Renu Agarwal, University Press, Hyderabad (LCS edition 2000).
3. Comprehensive practical organic chemistry-quantitative analysis-V.K.Ahluwalia and university press-Hyderabad.
4. Advanced practical organic chemistry – N.K.Vishnu, second revised edition, Vikas Publication (2000).
5. Advanced practical organic chemistry – D.P.Agarwal, Goel Publishing house, Meerut (U.P).
6. Quantitative & qualitative organic analysis, A.I.Vogel (CBS Publishers, New Delhi-2002).

DSC7 P6: Electro, photochemistry and Catalysis Practicals

Course Title: **Electro, photochemistry and Catalysis Practicals**	Course code: 21CHE1C7P
Total Contact Hours: 56 (0-0-4P/week)	Course Credits: 02
Formative Assessment Marks: 20	Duration of ESA/Exam: 4 h
Summative Assessment Marks: 30	

Course Outcomes (CO's):

1. To gain hands-on expertise in the study of electrochemical techniques like potentiometry.
2. To obtain skills and conduct the spectroscopic experiments

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

1. Capable to correlate the theoretical approach with practical aspects.
2. Acquire expertise in instrumental techniques for industrial and research career.

SL No	List of experiments	Hours
1	Potentiometric titration of KI vs $KMnO_4$ solution.	
2	Potentiometric titration of Fe(II) vs Ce(IV).	
3	To obtain the absorption spectra of colored complexes, verification of Beer's law	
4	Spectrophotometric titration of $FeSO_4$ against $KMnO_4$.	
5	Adsorption of acetic acid on charcoal	
6	Adsorption of Oxalic acid on activated charcoal	
7	Potentiometric determination of available chlorine in bleaching powder.	
8	Determination of dissociation constant of weak acid by conductance method	
9	Conductometric determination of equivalent weight and K_a for a weak acid.	
10	Estimation of metal ions in solution using spectrophotometer. (Ni, etc)	
11	Determination of distribution coefficient for benzene, benzoic acid and water system.	

References:

1. Experimental Physical Chemistry- Athavale V.D, New Gae International Publishers, 2001.
2. Experiments in Physical Chemistry- Carl W Garland; Joseph W Nibler; David P Shoemaker, Mcgraw Hill, 8th Ed, 2009
3. Findlay's Practical Physical ChemistryB P Levitt, Longman, Green and Co,9th Ed, 1973.
4. Experimental Physical Chemistry-F.Daniel et el., 7th Ed, Mcgraw hill, 1970
5. Selected Experiments in Physical Chemistry- Latham, 1964.
6. Advanced Practical Physical Chemistry- Yadav, Krishna Prakashan Media, 2015.

Date Course Coordinator Subject Committee Chairperson

CBCS Question Paper Pattern for PG Semester End Examination with Effect from the AY 2024-25

Disciplines Specific Core (DSC) and Discipline Specific Elective (DSE)

Paper Code: **Paper Title:**
Time: 3 Hours **Max. Marks: 70**
PART-A
Q1. **Answer any Seven questions** **7x2=14**
(Two questions from each Units, total eight questions)
PART-B
Note: Answer any *Four* of the following questions each question carries equal marks.

Q2.UNIT-I (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks
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Q3. UNIT-II (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks

Q4. UNIT-III (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks

Q5. UNIT-IV (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks

Q6. UNIT-I & II (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks

Q7. UNIT-III & IV (format a+b+c) (5+5+4, OR 4+5+5) 14 Marks

Skill Enhancement Courses (SECs)

Paper Code: **Paper Title:**
Time: 1 Hours **Max. Marks: 30**

There shall be Theory examination of Multiple Choice Based Questions [MCQs] with Question Paper set of A, B, C and D Series at the end of each semester for SECs for the duration of One hour (First Fifteen Minutes for the Preparation of OMR and remaining Forty-Five Minutes for Answering thirty Questions). The Answer Paper is of OMR (Optical Mark Reader) Sheet.

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Question Paper Pattern for Subjects with Tutorial

For the subjects with Tutorial component, there is no Semester-End Examination (SEE) to the component C3. The liberty of assessment of C3 is with the concerned faculty. The faculty must present innovative method of evaluation of component C3 before the respective BoS for approval and the same must be submitted to the Registrar and Registrar(Evaluation) before the commencement of the academic year.

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