Course Matrix and Syllabus (Semesters III and IV)

Five Year Integrated B.Sc.(Hons.)-M.Sc. Program in Chemistry

(under CBCS, *w.e.f.* Academic Session 2021-2022)

Offered By

Department of Chemistry and Chemical Sciences

CENTRAL UNIVERSITY OF JAMMU
Rahya-Suchani (Bagla), District-Samba
Jammu-181143, (J&K) India

Semester – III

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
	Organic Chemistry-II	CC	4	3-1-0
	Physical Chemistry-II	CC	4	3-1-0
	Inorganic Chemistry-III	CC	4	3-1-0
	Organic Chemistry Lab-II	CC	2	0-0-4
	Physical Chemistry Lab-II	CC	2	0-0-4
	Inorganic Chemistry Lab-III	CC	2	0-0-4
	Botany	GE	4	3-1-0
	Botany Lab	GE	2	0-0-4
	Basic Analytical Chemistry	AEEC	2	2-0-0
	Total		26	

Semester – IV

Course Code	Course	Type	Credits	Contact hours per week (L-T-P)
	Organic Chemistry-III	CC	4	3-1-0
	Physical Chemistry-III	CC	4	3-1-0
	Inorganic Chemistry-IV	CC	4	3-1-0
	Organic Chemistry Lab-III	CC	2	0-0-4
	Physical Chemistry Lab-III	CC	2	0-0-4
	Inorganic Chemistry Lab-IV	CC	2	0-0-4
	Zoology	GE	4	3-1-0
	Zoology Lab	GE	2	0-0-4
	Green Methods in Chemistry	AEEC	2	2-0-0
	Total		26	

Examination Pattern

Course	Credit	CIA	MSE	ESE	Max. Marks
Theory	4	25	25	50	100
Theory	2	12.5	12.5	25	50
Practical	2	25	-	25	50

Semester: III
Course Name: Organic Chemistry-II
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Alkanes: Nomenclature, Formation of alkanes, Corey-House reactions, Decarboxylation of carboxylic acids, Wurtz Reaction, Wurtz-Fittig Reaction, Free-radical halogenation of alkanes-Relative reactivity and selectivity.

Cycloalkanes: Nomenclature, Methods of preparation, Types of cycloalkanes and their relative stability, Bayer's strain theory and its limitations, Ring strain in cyclopropane and cyclobutane, Ring inversion of cyclohexane with energy diagrams, Relative stability of chair, boat and twist boat forms.

UNIT – II **12 hours**

Alkenes: Nomenclature of alkenes, Formation of alkenes by elimination reactions: Dehydration, dehydrohalogenation and dehalogenation reactions, Mechanisms of E1, E2, E1cB reactions, Regioselectivity, Saytzeff rule, Hoffmann elimination, Reactions of alkenes: Electrophilic additions and their mechanisms (Markovnikov/Anti-Markovnikov addition), Mechanism of oxymercuration-demercuration, Hydroboration-oxidation, Epoxidation, Ozonolysis, Hydrogenation, *syn*- and *anti*-Hydroxylation, Polymerization.

UNIT – III **12 hours**

Dienes and Cycloalkenes: Nomenclature and classification of dienes: Isolated, conjugated and cumulated dienes, Structure of allenes and butadiene, Methods of formation, Polymerization, 1,2- and 1,4-Addition reactions of conjugated dienes, Diels-Alder reaction, Methods of formation and chemical reactions of cycloalkenes.

Alkynes: Nomenclature, Structure and bonding in alkynes, Methods of formation, Acidity of alkynes, Chemical reactions of alkynes, Mechanism of electrophilic and nucleophilic addition reactions, Hydration to form carbonyl compounds, Hydroboration-oxidation, Metal-ammonia reductions, Oxidation and polymerization.

UNIT – IV **12 hours**

Carbonyl compounds I: Nomenclature, Structure of the carbonyl group, Synthesis of aldehydes and ketones: Oxidation of alcohols, Oppenauer oxidation, Synthesis from acid chlorides, Rosenmund reduction, Friedel-Crafts reaction, Synthesis of aldehydes and ketones using 1,3-dithianes, Synthesis of ketones from nitriles and from carboxylic acids.

UNIT – V **12 hours**

Carbonyl compounds II: Reaction of carbonyl compounds: Nucleophilic addition to carbonyl group, Mechanism of aldol, Benzoin and Knoevenagel condensations, Perkin, Cannizzaro, Claisen-Schmidt, Wittig reactions, Baeyer-Villiger oxidation, Benzil-Benzilic acid and Beckmann rearrangements, MPV, Clemmensen, Wolff-Kishner, $LiAlH_4$ and $NaBH_4$ reductions, Halogenation of enolizable ketones, α-Substitution reactions, Use of acetal as protecting group, Introduction to α,β-unsaturated carbonyl compounds, Michael addition.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. T. W. G. Solomons, *Fundamentals of Organic Chemistry*, John Wilev, 5th Ed., 1998.

4. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
5. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
6. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.
7. M. B. Smith, *March's Advanced Organic Chemistry, Reactions, Mechanisms and Structure*, 7th Ed., 2016.

Semester: III
Course Name: Physical Chemistry-II
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Thermodynamics-III: Third law, Nernst heat theorem, Statement and concept of residual entropy, Evaluation of absolute entropy from heat capacity data, Gibbs and Helmholtz functions, *G* and *A* functions as thermodynamic quantities, *G* and *A* as criteria for thermodynamic equilibrium and spontaneity, Their advantage over entropy change, Variation of *G* and *A* with *P, V* and *T*, Maxwell's relation, Thermodynamic equation of state, Temperature dependence of free energy: Gibbs-Duhem, Gibbs-Margules equation, Clausius-Clapeyron equation and its applications.

UNIT – II **12 hours**

Chemical kinetics-I: Introduction to chemical kinetics, Order and molecularity of chemical reaction, Rate expression for first order, second order and third order reactions, Half life, Methods for determining order of reaction, Opposing reactions, Parallel reactions, Consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) and chain reactions.

UNIT – III **12 hours**

Chemical kinetics-II: Effect of temperature and catalyst on rate of reaction, Arrhenius equation, Concept of activation energy, Simple collision theory based on hard sphere model, Lindemann mechanism, Qualitative treatment of the theory of absolute reaction rates, Expression of rate constant based on equilibrium constant and thermodynamic aspects.

UNIT – IV **12 hours**

Catalysis: Characteristic of catalytic reactions, Homogeneous catalysis, Acid-base catalysis and its kinetics, Enzyme catalysis and its mechanism, Effect of temperature on enzyme catalysis, Heterogeneous catalysis, Surface reactions, Kinetics of surface reactions, Unimolecular surface reactions, Bimolecular surface reactions, Effect of temperature on heterogeneous reactions: Unimolecular and Bimolecular.

UNIT – V **12 hours**

Solid state chemistry: Crystal structures, Close packing, Body centered and primitive structures, Symmetry in crystals, Crystallographic point groups, Space groups, Lattices, One, two- and three-dimensional unit cells, Translational symmetry elements, Miller and Weiss indices, Interplanar spacing, Packing diagrams, Atomic packing fraction, Braggs' law, Structures of important ionic solids: Ionic Radii, Ionic solids with formula MX (CsCl, NaCl, zinc blende and wurtzite structures), MX_2 (fluorite and anti-fluorite structures), Crystal defects.

REFERENCES

1. P. W. Atkins, *The Elements of Physical Chemistry*, Oxford, 11th Ed., 2019.
2. R. P. Rastogi and R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing House Pvt. Ltd., 6th Ed., 2009.
3. K. L. Kapoor, *A Text Book of Physical Chemistry*, McGraw Hill Education (India) Pvt. Ltd., Vol. 3, 5th Ed., 2014.
4. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 48th Ed., 2020.

5. K. J. Laidler, *Chemical Kinetics*, Pearson Education India, 3rd Ed., 2003.
6. P. C. Rakshit, *Physical Chemistry*, Sarat Book House, India, 7th Ed., 2014.
7. A. K. Nag, *Physical Chemistry*, Vol. I and II, McGraw Hill, India, 1st Ed., 2019.

Semester: III
Course Name: Inorganic Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemistry of *s*-block elements: General characteristics and comparative study of *s*-block elements, Position of hydrogen in the periodic table, Spectral lines of hydrogen atoms, Uses of hydrogen, Diagonal relationships, Salient features of hydrides, Solvation, Complexation tendencies and functions in biosystem, Introduction to alkyls and aryls.

Noble gases: Occurrence and uses, Rationalization of inertness of noble gases, Clathrates: preparation and properties of XeF_2, XeF_4 and XeF_6, VB and MO treatment for XeF_2, Molecular shapes of noble gas compounds (VSEPR theory).

UNIT – II **12 hours**

Chemistry of *p*-block elements-I:

Electronic configuration, Atomic and Ionic size, Metallic/non-metallic character, Melting point, Ionization enthalpy, Electron gain enthalpy, Electronegativity, Allotropy of C, P, S, Inert pair effect, Comparative study (including diagonal relationship) and Anomalous behaviour of first member of each group, Compounds with C–N and C–S bonds, Silane reagents, Synthesis, properties and modifications on polysilanes, silicides, silicone polymers, Oxygen compounds of silicon.

UNIT – III **12 hours**

Chemistry of *p*-block elements-II:

Hydrides of groups 13, 14, 15, 16 and 17, Oxides of phosphorus, sulphur and chlorine**,** Oxoacids of phosphorus and chlorine, Peroxoacids of sulphur, halides of silicon and phosphorus, Interhalogen and pseudohalogen compounds.

UNIT – IV **12 hours**

Coordination chemistry-I: Basic terminologies, Ligands and their classification, Chelates and their uses, IUPAC nomenclature, Isomerism (structural, geometrical and optical), Valence VBT of coordination complexes and its limitations, Werner's coordination theory, Effective atomic number, Electroneutrality principle and back bonding, Stereochemistry of complexes with 4- and 6-coordination numbers, Polynuclear complexes, Labile and inert complexes.

UNIT – V **12 hours**

Coordination chemistry-II: Crystal field theory and crystal field stabilization energy (CFSE), Measurement of CFSE in weak and strong field complexes, Factors affecting CFSE, Pairing energy, Hydration energy, Crystal field splitting in octahedral, tetrahedral and square planar complexes, Jahn-Teller effect.

Stability constants-Stepwise and Overall formation constants and relation between them, Difference between thermodynamic and kinetic stability, Determination of stability constants by Job's method, Bjerrum's method and Polarographic method.

REFERENCES

1. J. D. Lee, *Concise Inorganic Chemistry*, Oxford University Press, 2010.
2. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, John Wiley, 1999.
3. J. E. Huhey, Harpes and Row, *Inorganic Chemistry-Principles of structure and reactivity*, 4th Ed., 2006.

4. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver and Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press, 2009.
5. M. Weller, T. Overton, J. Rourke and F. Armstrong, *Inorganic Chemistry*: 7th Ed., Oxford University Press, 2018.
6. N. N. Greenwood and Earnshop, *Chemistry of the Elements*, 2nd Ed., Pergamon, 1997.
7. S. Chandra, *Concise Inorganic Chemistry*, Dreamtech Press, 2020.
8. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing Co, 2020.
9. R. D. Madan, G. D. Tuli and W. U. Malik, *Selected Topics in Inorganic Chemistry*, S. Chand Publisher, 2010.
10. P. L. Soni, *Text Book of Inorganic Chemistry*, S. Chand and Sons, New Delhi, 2013.
11. G. Wulfsberg, *Inorganic Chemistry*, 2nd Ed., Viva Publisher, 2018.

Semester: III
Course Name: Organic Chemistry Lab-II
Course Code: **2 Credits (0-0-4)**

Organic preparations (At least 10 experiments)

1. Acetylation of any two of the following compounds: Aniline, Toluidines, Anisidines, Phenols, β-Naphthol, Salicylic acid by (i) using conventional method and (ii) using green approach.
2. Benzolyation of any two of the following compounds: Aniline, Toluidines, Anisidines, Phenols, β-Naphthol, Resorcinol by Schotten-Baumann reaction.
3. Bromination of acetanilide by conventional method and using green approach (Bromate-bromide method).
4. Bromination of aniline and phenol.
5. Nitration of acetanilide and nitrobenzene by conventional method.
6. Nitration of salicylic acid by green approach (using ceric ammonium nitrate).
7. Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.
8. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
9. Hydrolysis of amides and esters.
10. Semicarbazone of any one of the following compounds: Acetone, Ethyl methyl ketone, Cyclohexanone, Benzaldehyde.
11. Aldol condensation using either conventional or green method.
12. Any other related experiments as desired by the course teacher.

REFERENCES:

1. F. G. Mann and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: III
Course Name: Physical Chemistry Lab-II
Course Code: **2 Credits (0-0-4)**

PART A: Kinetics

1. Study the kinetics of hydrolysis of an ester in presence of HCl as catalyst and determine the energy of activation of the reaction.
2. Determination of the velocity constant of hydrolysis of ethyl acetate by NaOH (saponification of an ester).
3. Determination of the relative strength of two acids say, HCl and H_2SO_4, by studying the hydrolysis of ester.
4. Determination of equilibrium constant of the reaction $KI + I_2 \rightleftharpoons KI_3$ by solubility method.
5. Determination of the kinetics of decomposition of H_2O_2.

PART B: Adsorption

1. Determination of adsorption of acetic acid on charcoal - verification of Freundlich's adsorption isotherm.
2. Determination of the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich adsorption isotherms.

Any other related experiments as desired by the course teacher.

REFERENCES

1. A. K. Nad, A. Ghosha and B. Mahapatra, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012.
2. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 36th Ed., 2015.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: III
Course Name: Inorganic Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

PART A: Volumetric analysis
Complexometric titrations using disodium salt of EDTA

1. Estimation of Mg^{2+}, Zn^{2+}.
2. Estimation of Ca^{2+} by substitution method.

Iodometry and iodimetry redox titration

1. Determination of the strength of copper sulphate solution iodometrically using iodine solution.
2. Determination of strength of arsenous oxide solution iodimetrically using sodium thiosulphate solution.

PART B: Qualitative inorganic analysis

Qualitative semi-micro analysis of mixture containing three anion radicals and three cation radicals:

Analysis of anions: Acetate, Oxalate, fluoride, Chloride, Bromide, Iodide, Nitrate, Carbonate, Sulphide, Sulphite, Sulphate, Borate and Phosphate.

Analysis of cations: NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}, Ca^{2+}, Ba^{2+}, Sr^{2+}, Mg^{2+}.

Any other related experiments as desired by the course teacher.

REFERENCES

1. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, 2nd Ed., S. Chand and Sons, 2012.
2. J. Mendham, *Vogel's Textbook of Quantitative Analysis*, 6th Ed., John Wiley and Sons, 2009.
3. G. Raj, *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, 2013.
4. S. Ratnani, S. Agrawal and S. K. Mishra, *Practical Chemistry*, McGraw Hill, 2020.
5. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: III
Course Name: Basic Analytical Chemistry
Course Code: **2 Credits (2-0-0)**

UNIT – I **10 hours**

Introduction to Analytical Chemistry and its interdisciplinary nature, Concept of sampling, Importance of accuracy, precision and sources of error in analytical measurements, Presentation of experimental data and results, Standard deviations, Standard deviation of calculated results: Sum or difference, Product or quotient, Significant figures, Rounding and expressing results of chemical computations.

UNIT – II **10 hours**

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, Use of indicators.
Analysis of water: Definition of pure water, Sources responsible for contaminating water, Water sampling methods, Water purification methods.
Analysis of food products: Nutritional value of foods, Idea about food processing and food preservations and adulteration.

UNIT – III **10 hours**

Chromatographic techniques: Chromatographic separations: General description and classification of chromatographic methods, Thin layer, Paper and Column chromatographic techniques and their simple applications, Types of adsorbents, R_f-values and their significance, Principle and simple applications of ion exchange separation.

REFERENCES

1. J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, *Vogel's Quantitative Chemical Analysis*, 6th Ed., Pearson, 2009.
2. H. H. Willard, L. L. Merritt Jr., J. A. Dean and F. A. Settle Jr., *Instrumental Methods of Analysis*, 7th Ed., Wardsworth Publishing Company, 1988.
3. G. D. Christian, *Analytical Chemistry*, 6th Ed., John Wiley & Sons, New York, 2004.
4. D. C. Harris, *Exploring Chemical Analysis*, 9th Ed., New York, W.H. Freeman, 2016.
5. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, 3rd Ed., New Age International Publisher, 2008.
6. D. A. Skoog, F. J. Holler and S. R. Crouch, *Principles of Instrumental Analysis*, 7th Ed., 2006.

Semester: IV
Course Name: Organic Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Alcohols: Monohydric alcohols: Methods of formation, Reduction of aldehydes, ketones, carboxylic acids and esters, Hydrogen bonding, Acidic nature, Reactions of monohydric alcohols: Substitution, Dehydration, Oxidation and Esterification, Methods to distinguish primary, secondary and tertiary alcohols, Dihydric alcohols: Methods of formation, Chemical reactions of vicinal glycols, Oxidative cleavage by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement, Trihydric alcohols: Methods of formation, chemical reactions of glycerol.

UNIT – II **12 hours**

Phenols: Preparation of phenols, Acidity and factors effecting it, Relative acidity of phenol, alcohol and carboxylic acid, Resonance stabilization of phenoxide ion, Reactions of phenols, Electrophilic aromatic substitution, Mechanisms of Fries rearrangement, Claisen rearrangement, Kolbe's–Schmidt reaction, Gattermann synthesis, Hauben-Hoesch, Lederer-Manasse, Reimer-Tiemann reaction, Schotten-Baumann Reaction.

UNIT – III **12 hours**

Ethers: Nomenclature, Methods of formation, Physical properties, Chemical reactions, Cyclic ethers, Introduction to crown ethers, Structure and applications.

Epoxides: Nomenclature and synthesis of epoxides, Acid and base-catalyzed ring opening of epoxides, Regiochemistry of epoxide ring opening, Reactions of epoxides with alcohols, amines, Grignard and organolithium reagents.

UNIT – IV **12 hours**

Alkyl halides: Methods of formation, Mechanisms of nucleophilic substitution reactions of alkyl halides (S_N1, S_N2, S_Ni), Substitution at the allylic and vinylic positions, Mechanisms of elimination reactions of alkyl halides (E1 and E2), Stereochemical aspects of substitution and elimination reactions, Competition between substitution and elimination, Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.

Aryl halides: Preparation of aryl halides, Aromatic nucleophilic substitution, Addition-elimination and the elimination-addition mechanisms.

UNIT – V **12 hours**

Active methylene compounds: Acidity of α-hydrogens, Keto-enol tautomerism, Preparation of ethyl acetoacetate, Alkylation of diethyl malonate and ethyl acetoacetate, Synthetic applications of ethyl acetoacetate: Synthesis of ketones, Carboxylic acids and Ketonic acids, Biginelli reaction, Hantzsch dihydropyridine synthesis, Synthetic applications diethyl malonate: Synthesis of disubstituted acetic acid, α-Substituted succinic acids, Ketones and Ketonic acids.

REFERENCES

1. R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, *Organic Chemistry*, 7th Ed., 2011.
2. A. Bahl and B. S. Bahl, *A Text Book of Organic Chemistry*, 22nd Ed., 2016.
3. T. W. G. Solomons, *Fundamentals of Organic Chemistry*, John Wilev, 5th Ed., 1998.
4. I. L. Finar, *Organic Chemistry*, Vol. I and II, 6th Ed., 2002.

5. L.G. Wade Jr., *Organic Chemistry*, Prentice Hall, 8th Ed., 2016.
6. P. Y. Bruice, *Organic Chemistry*, 8th Ed., 2016.
7. F. A. Carey and R. M. Giuliano, *Organic Chemistry*, *McGraw Hill*, 10th Ed., 2016.
8. M. B. Smith, *March's Advanced Organic Chemistry, Reactions, Mechanisms and Structure*, 7th Ed., 2016.

Semester: IV
Course Name: Physical Chemistry-III
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemical equilibrium: Dynamic nature of Chemical equilibrium, Attainment and characteristics of chemical equilibrium, Law of mass action and its thermodynamic derivation, Relation between K_p, K_c and K_x, Thermodynamic relations for chemical affinity, Homogeneous equilbria, Temperature dependence of equilibrium constant and integrated form of van't Hoff equation, Pressure dependence of equilibrium constant (K_p, K_c and K_x), Heterogeneous equilibria, Le Chatelier's principle and its thermodynamic treatment.

UNIT – II **12 hours**

Electrochemistry-I: Conductance and ionization: Review of electrolytes, Arrhenius theory of electrolytic dissociation, Conductance and its variation with dilution, Ionic mobility, Kohlrausch law and its applications, Migration of Ions: Transport number and its relation with concentration and ionic mobility, Experimental procedures for measuring transport numbers (Hittorf's rule, Moving boundary method), Abnormal transport numbers, Walden's rule. Conductometric titrations.

UNIT – III **12 hours**

Electrochemistry-II: Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples, Electromotive force (EMF) of a cell and its measurement, Nernst equation, Standard electrode (reduction) potential and its application to different kinds of half-cells, Application of EMF measurements in determining (i) G, H, S and K (equilibrium constants) of a cell reaction using hydrogen, quinone-hydroquinone and glass electrodes, Determination of *p*H using hydrogen and quinone-hydroquinone electrodes, Concentration cell with and without transference, Liquid junction potential, Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

UNIT – IV **12 hours**

Phase equilibrium: Statement and meaning of the terms-phase, component and degree of freedom, Conditions for equilibrium between phases, Thermodynamic derivation of Gibbs Phase Rule, Phase equilibria of one component system: H_2O, CO_2 and S systems, Phase equilibria of two component systems: Simple eutectic systems, Compound formation with congruent and incongruent m.pt, Three component systems: triangular plots, H_2O-$CHCl_3$-CH_3COOH system, Nernst distribution law: its derivation and applications.

UNIT – V **12 hours**

Ionic equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, Ionization of weak acids and bases, *p*H scale, common ion effect, Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and *p*H for different salts. Buffer solutions, Solubility and solubility product of sparingly soluble salts, applications of solubility product principle, Qualitative treatment of acid–base titration curves (calculation of *p*H at various stages), Theory of acid–base indicators, selection of indicators and their limitations.

REFERENCES

1. P. W. Atkins, *The Elements of Physical Chemistry*, Oxford, 11th Ed., 2019.
2. R. P. Rastogi and R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing House

Pvt. Ltd., 6th Ed., 2009.
3. K. L. Kapoor, *A Text Book of Physical Chemistry*, McGraw Hill Education (India) Pvt. Ltd., Vol. 3, 5th Ed., 2014.
4. B. R. Puri, L. R. Sharma and M. S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co., 48th Ed., 2020.
5. P. C. Rakshit, *Physical Chemistry*, Sarat Book House, India, 7th Ed., 2014.
6. A. K. Nag, *Physical Chemistry*, Vol. I and II, McGraw Hill, India, 1st Ed., 2019.
7. R. P. Sarkar, *General and Inorganic Chemistry,* Vol. I, New Central Book Agency, 3rd Ed., 2011.

Semester: IV
Course Name: Inorganic Chemistry-IV
Course Code: **4 Credits (3-1-0)**

UNIT – I **12 hours**

Chemistry of transition elements-I: General characteristic properties of 3*d*-block elements, Relative stability of their oxidation states with special reference to electronic configuration, Atomic radii and ionic radii, Oxidation state, Colour, Ionization enthalpy, Ability to form complexes, Magnetic properties, Catalytic properties, Binary compounds - Oxides, Halides and sulphides, Coordination number, Geometry and Complex formation.

UNIT – II **12 hours**

Chemistry of transition elements-II: General characteristic properties of 4*d*- and 5*d*-block elements, Comparative treatment with 3*d*-analogues with special reference to electronic configuration, Atomic radii and ionic radii, Colour, Variable valency, Complex formation, Magnetic and catalytic properties, Difference between 3*d*-, 4*d*- and 5*d*-transition series.

Lanthanoids and Actinoids: Electronic configuration, Oxidation states, Colour, Spectral and magnetic properties, Lanthanide contraction, Separation of lanthanides and actinides.

UNIT – III **12 hours**

Hard-Soft Acids and Bases: Arrhenius, Bronsted-Lowry, Lewis theories, Lux-Flood, Usanovich, Hard and soft acids and bases (HSAB), Classification of acids and bases as hard and soft, Pearson's HSAB concept, Acid-base strength in relation to hardness and softness, Symbiosis, Theoretical basis of hardness and softness, Relationship between electronegativity and hardness/softness.

UNIT – IV **12 hours**

Chemistry of non-aqueous solvents: Physical properties of solvent, Solvent systems (classification), Reactions in non-aqueous solvents with reference to liquid NH_3, H_2SO_4, liquid HF, liquid SO_2 and PCl_5, Supercritical fluids: Properties of supercritical fluids and their uses as solvents, Solution of metals, Complex formation, Low temperature molten salts, Super-acids.

UNIT – V **12 hours**

Nuclear chemistry and radioactivity-I: Fundamental particles of nucleus, Basics of different nuclear models (shell model, liquid drop model, fermi gas model, and collective model), Isotone, isotope, isobar and isomer, Nuclear reactions, Types of nuclear reactions, Chemical effects of nuclear transformations, Nuclear fission and fusion, Fission products and fission yields, Nuclear reactors: Classification of reactors, Reactor power, Nuclear waste management.

REFERENCES

1. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, John Wiley, 1999.
2. J. D. Lee, *Concise Inorganic Chemistry*, Oxford University Press, 2010.
3. N. N. Greenwood and Earnshop, *Chemistry of the Elements*, 2nd Ed., Pergamon, 1997.
4. S. Chandra, *Concise Inorganic Chemistry*, Dreamtech Press, 2020.
5. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Ed., Vishal Publishing Co, 2020.

6. R. D. Madan, G. D. Tuli and W. U. Malik, *Selected Topics in Inorganic Chemistry*, S. Chand Publisher, 2010.
7. H. J. Arnikar, *Essentials of Nuclear Chemistry*, 4th Ed., Wiley Eastern, 1987.
8. G. Friedlander, T. W. Kennedy, E. S. Macias and J. M. Miller, *Introduction of Nuclear and Radiochemistry*, 3rd Ed., John Wiley, 1981.
9. W. D. Loveland, D. J. Morrissey and G. T. Seaborg, *Modern Nuclear Chemistry*., Wiley–Blackwell, 2005.
10. M. Sharon and M. Sharon, *Nuclear Chemistry*, 2nd Ed., Ane Books, 2018.
11. G. L. Miessler and A. Donald, *Inorganic Chemistry*, 3rd Ed., Pearson, 2009.

Semester: IV
Course Name: Organic Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

Qualitative analysis of organic compounds (At least 10 compounds)
Identification of organic compounds (aromatic/aliphatic, saturated/unsaturated, elements present, functional groups present etc.) via systematic analysis: Phenols, Carboxylic acids, Aldehydes, Ketones, Carbohydrates, Amines, Esters, Amides etc.

REFERENCES:

1. F. G. Mann and B. C. Saunders, *Practical Organic Chemistry*, Pearson Education, 2009.
2. B. S. Furniss, A. J. Hannaford, P. W. G, Smith and A. R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson, 2012.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: IV
Course Name: Physical Chemistry Lab-III
Course Code: **2 Credits (0-0-4)**

PART A: Electrochemistry

1. Determination of the molar conductivity of weak monobasic acid over a given range of concentration.
2. Determination of the ionization constant of a weak acid conductometrically.
3. Potentiometric titration of an acid with a base.
4. Determination of the pK_a value of the given organic acid by p*H* measurement.
5. Determination of the saponification of ethyl acetate conductometrically.
6. Determination of the strength of the given acid condutometrically and pH-metrically using standard alkali solution: (i) Strong acid - Strong base, (ii) Weak acid - Strong base.

PART B: Phase equilibrium

1. Determination of the distribution coefficient (partition coefficient) of benzoic acid between benzene and water at room temperature.
2. Determination of the distribution coefficient (partition coefficient) of iodine between two immiscible solvents (H_2O-C_6H_6; H_2O-CCl_4).

PART C: Solubility

1. Determination the influence of the ionic strength on the solubility of $CaSO_4$ and hence determination of its thermodynamic solubility product and mean ionic activity.

Any other related experiment as desired by the course teacher.

REFERENCES

1. A. K. Nad, Ghoshal and B. Mahapatra, *An Advanced Course in Practical Chemistry,* New Central Book Agency Pvt. Ltd., 3rd Ed., 2012.
2. J. B. Yadav, *Advanced Practical Physical chemistry*, Goel Publishing, 36th Ed., 2015.
3. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: IV
Course Name: Inorganic Chemistry Lab-IV
Course Code: **2 Credits (0-0-4)**

PART A: Qualitative inorganic analysis

Qualitative semi-micro analysis of mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO^{2-} and NO^{3-}, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO^{3-} and Br^-, NO^{3-} and I^-.

PART B: Inorganic preparations

1. Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
2. Sodium trioxalato ferrate (III), $Na_3[Fe(C_2O_4)_3]$.
3. Nickel dimethyl glyoxime Ni-DMG complex, $[Ni(DMG)_2]$.
4. Copper tetraammine complex, $[(Cu(NH_3)_4]SO_4$.

PART C: Separation and quantitative estimation of metal ions

1. Estimation of nickel(II) using dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN.
3. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
4. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Any other related experiment as desired by the course teacher.

REFERENCES

1. V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, *Basic Principles of Practical Chemistry*, 2nd Ed., S. Chand and Sons, 2012.
2. J. Mendham, *Vogel's Textbook of Quantitative Analysis*, 6th Ed., John Wiley and Sons, 2009.
3. A. I. Vogel, *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Ed., John Wiley and Sons, 1989.
4. S. Ratnani, S. Agrawal and S. K. Mishra, *Practical Chemistry*, McGraw Hill, 2020.
5. In-house laboratory manual with experimental procedures and relevant information (Department of Chemistry and Chemical Sciences, Central University of Jammu).

Semester: IV
Course Name: Green Methods in Chemistry
Course Code: **2 Credits (2-0-0)**

UNIT – I **12 hours**

Introduction to green chemistry: Definitions of Green Chemistry, Introduction of twelve principles of Green Chemistry with examples, Atom and step economy, Reducing toxicity, Green solvents, Green Chemistry and catalysis, Alternative sources of energy, Green energy and sustainability, Introduction to multicomponent reactions and Domino reactions, Hantzsch synthesis, Ugi reaction.

UNIT – II **18 hours**

Green synthesis: Comparative study of conventional and green protocols of Wittig reaction, and Baeyer-Villiger oxidation, Green synthesis of ibuprofen.

Real world cases in Green Chemistry: Environmentally safe antifoulant, Surfactants for carbon dioxide-replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments, CO_2 as an environmentally friendly blowing agent for the polystyrene foam sheet, Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments, Green synthesis of a compostable and widely applicable plastic (poly-lactic acid) made from corn, Development of a fully recyclable carpet: Cradle-to-cradle carpeting.

REFERENCES

1. P. Tundo, A. Perosa and F. Zucchini, *Methods and Reagents for Green Chemistry*, Wiley, New Jersey, 2007.
2. A. S. Matlack, *Introduction to Green Chemistry*, Marcel Dekker, Inc., New York, 2001.
3. V. K. Ahluwalia, *Green Chemistry: Environmentally benign reaction*, Boca Raton, FL: CRC, Taylor & Francis, 2008.
4. P. T. Anastas and R. H. Crabtree, *Handbook of Green Chemistry, Green Catalysis, Homogeneous Catalysis*, Wiley, 2014.
5. P. T. Anastas and J. K. Warner, *Oxford Green Chemistry-Theory and Practical*, University Press, 1998.
6. R. K. Sharma, I. T. Sidhwani and M. K. Chaudhari, *Green Chemistry Experiments: A monograph*, I. K. International Publishing House Pvt Ltd. New Delhi, Bangalore. 2013.