केंद्रीयजनजातीयविश्वविद्यालयआंध्रप्रदेश

CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH

(A CENTRAL UNIVERSITY ESTABLISHED BY AN ACT OF PARLIAMENT)

CURRICULUM & SYLLABUS

Minor in Chemistry for UG programs

(As per National Education Policy 2020)

w.e.f. 2023-24 admitted batch

DEPARTMENT OF CHEMISTRY
SCHOOL OF SCIENCES
CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH
VIZIANAGARAM – 535003, A.P.

DEPARTMENT OF CHEMISTRY

The Department of Chemistry at CTUAP is dedicated to providing students with a comprehensive education in Chemistry, aligned with the National Education Policy (NEP-2020). Our undergraduate and postgraduate Chemistry programs integrate fundamental principles, theories, and practical applications, covering diverse subjects such as Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry, and Chemical Biology. The department focuses on addressing global challenges in Synthetic Organic Chemistry, Renewable Energy, Environmental Sustainability, Nanotechnology, and the welfare of Tribal communities through its research endeavors.

MINOR IN CHEMISTRY

A minor in Chemistry offers students a unique opportunity to expand their academic horizons beyond their major discipline. It provides a comprehensive understanding of chemical principles, which can be applied across various fields, enhancing students' analytical and problem-solving skills. This note explores the benefits of pursuing a minor in Chemistry and its significance in fostering interdisciplinary knowledge.

Complementary Skill Development:

- A minor in Chemistry complements various major disciplines such as Biology, Geology Physics, and Environmental Science.
- It equips students with fundamental knowledge in chemical principles, enhancing their understanding of natural phenomena and technological advancements.
- Chemistry serves as a bridge between different scientific disciplines, enabling students to apply their knowledge in diverse areas.

LIST OF COURSES UNDER MINOR IN CHEMISTRY

(Offered by Dept. of Chemistry)

SEMESTER	LEVEL	COURSE CODE	COURSE	CREDITS	MAX. MARKS
I	100	CHE 101/ CHE 121	Inorganic Chemistry-I	3	100
	100	CHE131	Chemistry-I Practicum	1	50
II	100	CHE 151/ CHE 171	Organic Chemistry-I	3	100
	100	CHE181	Chemistry-II Practicum	1	50
III	100	CHE 201/ CHE 221	Physical Chemistry-I	3	100
	100	CHE231	Chemistry-III Practicum	1	50
IV / V / VI	200	CHE 202/ CHE 222	Inorganic Chemistry-II	3	100
	200	CHE232	Chemistry-IV Practicum	1	50
	200	CHE 251/ CHE 271	Organic Chemistry-II	3	100
	200	CHE281	Chemistry-V Practicum	1	50
	200	CHE 252/ CHE 272	Physical Chemistry-II	3	100
	200	CHE282	Chemistry-VI Practicum	1	50

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE101/ CHE 121	**INORGANIC CHEMISTRY-I**	**3**	**I**

***Course Objectives**: On completion of this course, the students will be able to understand:*
Atomic theory and its evolution • Learning scientific theory of atoms, concept of wave function • Elements in periodic table; physical and chemical characteristics, periodicity • To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models • Hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.

UNIT-I

Atomic structure- Bohr's theory, its limitations, and the atomic spectrum of the hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, the significance of ψ and ψ2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for the hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d, and f orbitals.

UNIT-II

Periodicity of elements - s, p, d, and f-block elements, the long form of the periodic table. A detailed discussion of the following properties of the elements, with reference to s, p, d, and f-block.
(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in the periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies, and factors affecting ionization energy.

UNIT-III

Chemical bonding: Ionic bond: General characteristics, types of ions, size effects, radius ratio rule, and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Born-Haber cycle and its application. Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Molecular Orbital Theory (MOT), molecular orbital diagrams of diatomic and simple polyatomic molecules. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

UNIT-IV

Metallic bonding and Weak chemical forces: Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment).

Recommended Books

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
3. Rodger, G.E. Inorganic and Solid-State Chemistry, Cengage Learning India Edition, 2002.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE131	**CHEMISTRY-I PRACTICUM**	**1**	**I**

(A) **Titrimetric Analysis**

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) **Acid-Base Titrations**

(i) Estimation of carbonate and hydroxide present together in a mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(C) **Oxidation-Reduction Titrimetry**

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

Recommended Books

Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6thEd., Pearson, 2009

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE151/ CHE 171	**ORGANIC CHEMISTRY-I**	**3**	**II**

***Course Objectives**: On completion of this course, the students will be able to understand:*
Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms • Stereochemistry of organic molecules • Aromatic compounds and aromaticity, mechanism of aromatic reactions • Understanding hybridization • Reactivity, stability of organic molecules, structure, stereochemistry • Mechanism of organic reactions.

UNIT-I

Basics of organic chemistry: Organic compounds: Classification, nomenclature and hybridization. Electronic displacements: Inductive, electromeric, resonance, mesomeric, hyperconjugation effect and their applications; dipole moment, bond fission (homolytic and heterolytic) with suitable examples; curly arrow rules; reactive intermediates–carbocation, carbanion, Free radical and carbene; organic reagents – electrophile and nucleophile; nucleophilicity and basicity. Introduction to types of organic reactions and their mechanism – Addition, elimination and Substitution reactions (only basics)

UNIT-II

Stereochemistry: Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations**.**

UNIT-III

Chemistry of aliphatic hydrocarbons-1 (Carbon-Carbon sigma pi bonds): Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Diels-Alder reaction; Allylic and benzylic bromination and mechanism.

UNIT-IV

Aromatic hydrocarbons: Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Recommended Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
3. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE181	**CHEMISTRY-II PRACTICUM**	**1**	**II**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
   a) Water (b) Alcohol (c) Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

Recommended Books

1. Vogel's textbook of Organic Analysis, Longmann Publishers
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE201/ CHE 221	**PHYSICAL CHEMISTRY-I**	**3**	**III**

***Course objectives**: On completion of this course, the students will be able to understand:*
Physical properties of each state of matter and laws related to describe the states • Understanding Kinetic model of gas and its properties • Behavior of real gases, its deviation from ideal behavior • Liquid state and its physical properties related to temperature and pressure variation • Chemistry of solids and its application in chemistry.

UNIT-I

Gaseous state: Deviations from ideal gas behaviour, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT-II

Liquid state

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

UNIT-III

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, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry

Solubility and solubility product. Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

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

UNIT-IV

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law.

Recommended Books

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009)
5. G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE231	**CHEMISTRY-III PRACTICUM**	**1**	**III**

1. Surface tension measurements.

a. Determine the surface tension by (i) drop number (ii) drop weight method.
b. Study the variation of surface tension of detergent solutions with concentration'

2. Viscosity measurements using Ostwald's viscometer.

Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid
b. Preparation of buffer solutions of different pH (a) Sodium acetate-acetic acid (b) Ammonium chloride-ammonium hydroxide.

Recommended Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co., New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Athawale V. D. and Mathur P. Experimental Physical Chemistry, New Age International, (2001)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE202/ CHE 222	**INROGANIC CHEMISTRY-II**	**3**	**IV / V / VI**

***Course objectives**: After completion of the course, the learner shall be able to understand:*
Structure, bonding of s and p block materials and their oxides/compounds • Chemistry of transition elements • Chemistry of noble gases and their compounds • Understanding chemistry of inorganic polymers, their structures and uses.

UNIT-I

Oxidation-Reduction and general principle of metallurgy:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Carbon reduction method. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Zone refining.

UNIT-II

Chemistry of *s* and *p* Block Elements: Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

UNIT-III

Noble Gases: Occurrence and uses, rationalization of the inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF2), Shapes of noble gas compounds (VSEPR theory).

UNIT-IV

Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and poly sulphates.

Recommended books

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry, 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010
6. Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE232	**CHEMISTRY-IV PRACTICUM**	**1**	**IV / V / VI**

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

Recommended books

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

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE251/ CHE 271	**OGANIC CHEMISTRY-II**	**3**	**IV / V / VI**

Course objectives*: After completion of the course, the learner shall be able to understand:*
Familiarization about classes of organic compounds and their methods of preparation • Basic uses of reaction mechanisms • Name reactions, uses of various reagents and the mechanism of their action • Use of reagents in various organic transformation reactions.

UNIT-I

Chemistry of Halogenated Hydrocarbons: *Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs.
elimination.
Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

UNIT-II

Alcohols, Phenols, Ethers and Epoxides: *Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4

UNIT-III

Carbonyl Compounds: Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, LiAlH4, NaBH4, MPV, PDC and PGC);

UNIT-IV

Carboxylic Acids and their Derivatives:

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

Recommended Books/references:

1. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc (2009).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.
3. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
4. Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India, 2003.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE281	**CHEMISTRY-IV PRACTICUM**	**1**	**IV / V / VI**

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

1 Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.

2 Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistry approach)

ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Nitration: (any one)

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

v. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

vi. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE252/ CHE 272	**PHYSICAL CHEMISTRY-II**	**3**	**IV / V / VI**

***Course objectives**: After completion of the course, the learner shall be able to understand:*
Laws of thermodynamics and concepts • Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.• Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law of thermodynamics • Understanding theories/thermodynamics of dilute solutions Dilute solution and its properties.

UNIT-I

Introduction to thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

UNIT-II

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

UNIT-III

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third law of thermodynamics: Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

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

UNIT-IV

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

Dilute solutions: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended Books/References

1. Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.
3. Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.
4. McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.
5. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001
6. *Commonly Asked Questions in Thermodynamics.* CRC Press, 2011.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE282	**CHEMISTRY-VI PRACTICUM**	**1**	**IV / V / VI**

(A list of suggested experiments are given. However, more experiments can be added based on facilities available in the laboratories).

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$
   (ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH3)n$
3. Study the kinetics of the following reactions.
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry,* Eighth Edition, McGraw-Hill(2003).
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry,* Third Edition, W, H. Freeman (2003).