

Semester Syllabus for M. Sc. in Applied Chemistryw.e.f. 2026-28 Academic Year

FIRST SEMESTER (DECEMBER 2026)

Course No	Course Title	Credit	Mark
ACH-411	INORGANIC CHEMISTRY-I	04	100
ACH-412	ORGANIC CHEMISTRY-I	04	100
ACH-413	PHYSICAL CHEMISTRY-I	04	100
ACH-414	INSTRUMENTAL METHODS OF ANALYSIS	04	100
ACH-415	INORGANIC CHEMISTRY PRACTICAL	02	100
ACH-416	PHYSICAL CHEMISTRY PRACTICAL	02	100
	*ENVIRONMENTAL STUDIES AND DISASTER MANAGEMENT	02	100
Total		22	700

**The detailed course will be available on the University website.*

SECOND SEMESTER (APRIL 2027)

Course No	Course Title	Credit	Mark
ACH-421	INORGANIC CHEMISTRY-II	04	100
ACH-422	ORGANIC CHEMISTRY-II	04	100
ACH-423	PHYSICAL CHEMISTRY-II	04	100
ACH-424	ATOMIC & MOLECULAR SPECTROSCOPY	04	100
ACH-425	ORGANIC CHEMISTRY PRACTICAL	02	100
ACH-426	ANALYTICAL CHEMISTRY PRACTICAL	02	100
	*INTERDISCIPLINARY COURSE (IDC)	03	100
Total		23	700

**The detailed course will be available on the University website.*

Note: Also, the student has to opt for one MOOC course of 03 credits through the Swayam, NPTEL, etc., platform, which will be reflected in the 4th Semester GRADE SHEET.

THIRD SEMESTER (DECEMBER 2027)

Course No	Course Title	Credit	Mark
ACH-511	INDUSTRIAL POLLUTION & ITS MANAGEMENT	04	100
ACH-512	INDUSTRIAL PROCESSES	04	100
ACH-513	ANALYTICAL TECHNIQUES IN ORGANIC CHEMISTRY	04	100
ACH-514	PROJECT	04	100
ACH-515	INDUSTRIAL CHEMISTRY PRACTICAL	02	100
ACH-516	SEMINAR	02	100
	*ENTREPRENEURSHIP DEVELOPMENT	02	100
Total		22	700

**The detailed course will be available on the University website.*

FOURTH SEMESTER (APRIL-2028)

Course No	Course Title	Credit	Mark
ACH-521	CHEMISTRY OF NANOMATERIAL	04	100
ACH-522	ADVANCED ANALYTICAL CHEMISTRY	04	100
ACH-523	MEDICINAL CHEMISTRY	04	100
ACH-524	SURFACTANTS AND DETERGENTS	04	100
ACH-525	COMPUTATIONAL CHEMISTRY PRACTICAL	02	100
ACH-526	COMPREHENSIVE VIVA	02	100
	MOOC/ALTERNATIVE COURSE	03	100
Total		23	700

In addition to this, the student has to take Yuva Sanskar and give preference for either the NCC or NSS course.

FIRST SEMESTER

ACH-411	INORGANIC CHEMISTRY-I	4 credits
UNIT-I:	Basic Concepts of Symmetry and Group Theory	
	Symmetry operation, symmetry element, classification of symmetry elements, definition of group, subgroup, cyclic groups, molecular point groups, group multiplication table, group generators, symmetry of platonic solids, conjugacy relation and classes, matrix representation of symmetry elements, character of a representation, reducible and irreducible representation, properties of irreducible representation.	
UNIT-II:	Group Theory and Spectroscopy	
	Character table (explanation and significance), construction of character tables for C_{2v} , C_{3v} , C_{4v} , C_{2h} , D_{2d} and D_4 point groups, direct product, standard reduction formula, applications of group theoretical methods for selection rules in: infrared spectroscopy, Raman spectroscopy and electronic spectroscopy.	
UNIT-III:	Theories of Metal-Ligand Bonding	
	Basic concepts of crystal field theory (CFT), molecular orbital theory (MOT): classification of metal valence orbitals into sigma symmetry, ligand group orbitals (LGOs) of sigma symmetry, LGOs of pi symmetry, molecular orbital energy level diagrams for octahedral and tetrahedral complexes, concept of ligand field theory (LFT).	
UNIT-IV:	Term Diagram, Electronic Spectral and Magnetic Properties of Metal Complexes	
	Concept of term symbols, derivation of term symbol for pn and dn configurations, Orgel diagram for dn configurations, Significance of Tanabe-Sugano diagram. Electronic spectra of metal complexes, selection rules, relaxation in selection rules, evaluation of Dq, B and beta(β) parameters for the complex with T1 ground state and A2 ground state, spectrochemical series and nephelauxetic series, charge transfer spectra. Concept of magnetic properties of metal complexes.	
TEXT BOOKS:	1. <i>Chemical Applications of Group Theory</i> by F. A. Cotton, Wiley India (P) Ltd., 3rd edn, 2009, New Delhi. 2. <i>Symmetry and Spectroscopy of Molecules</i> by K. V. Ready, New Age International Ltd. 2nd edn, 2009, New Delhi. 3. <i>Symmetry and Group Theory in Chemistry</i> by R. Ameta, New Age International Ltd., 1st edn, 2013, New Delhi. 4. <i>Solid State Chemistry</i> by D. K. Chakravarty, New Age International Limited, 1996, New Delhi. 5. <i>Advanced Inorganic Chemistry</i> by F. A. Cotton and G. Wilkinson, Wiley India (P) Ltd., New Delhi, 6th edition, 1999. 6. <i>Fundamental concepts of Inorganic Chemistry (vol-5, and vol-6)</i> by Asim K. Das and Mahua Das, CBS publishers and distributors, 2nd Edition, 2019.	
REFERENCE BOOK	1. <i>Inorganic Chemistry</i> by G. L. Miessler and D. A. Tarr, Pearson Education, 3rd edn, 2004. 2. <i>Inorganic Chemistry (Principles of Structure and Reactivity)</i> by James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi Pearson Education, 4th edn, 2006.	
ACH-412	ORGANIC CHEMISTRY-I	4 credits
UNIT-I:	Aromaticity and Electronic Effects	
	Delocalized chemical bonding, Conjugation, Cross conjugation, Electronic effect, Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, Alternant and non-alternant hydrocarbons, Energy levels in odd and even-alternant hydrocarbons, energy levels of π -molecular orbitals, Aromaticity of annulenes and heteroannulenes, Anti-aromaticity, Homo-aromaticity.	
	Classification of reactions and mechanisms, Kinetic and thermodynamic control	

reactions, Hammond's postulate, Transition states and intermediates in Potential energy diagrams, The Hammett equation and linear free energy relationship, Substituent and reaction constants, Hard and soft acids and bases. Effect of structure on the strengths of acids and bases.

UNIT-II:**Aliphatic Substitution Reactions**

Nucleophilic substitution – S_N2 , S_N1 and SET mechanisms. Neighboring group participation by σ and π -bonds, anchimeric assistance. Carbocation rearrangements, Nucleophilic substitution at an aliphatic trigonal, allylic and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile, regioselectivity.

Electrophilic substitution reactions – S_E1 , S_E2 and S_Ei mechanisms, Effect of substrate, leaving group and solvent, Reactions (hydrogen exchange, migration of double bonds, keto-enol tautomerism, halogenation, aliphatic diazonium coupling, Stork-enamine reaction).

UNIT-III:**Aromatic Substitution Reactions**

Aromatic electrophilic substitution reactions – The arenium ion mechanism. Orientation and reactivity. Energy profile diagrams. Structure reactivity relationship in mono-substituted benzene, Quantitative treatment of reactivity in substrates and electrophiles. orientation in benzene and higher order rings with one or more than one substituent, Diazonium coupling, Vilsmeier - Haack reaction, Gatterman reaction, Gatterman-Koch reaction, Hoesch reaction Pechmann reaction.

Aromatic Nucleophilic Substitution – ArS_N1 , ArS_N2 , benzyne, Effect of substrates, leaving groups, and attacking nucleophile, Reactions: Nucleophilic displacement in areno-diazonium salts by different nucleophiles, Goldberg reaction, Schiemann reaction, Chichibabin reaction.

Free radical Substitution: Intermediates, Reaction at sp^2 carbon, Reactivity in aliphatic, at bridge head position and in aromatic substrates.

UNIT-IV:**General Stereochemistry**

Chirality, Fischer projection and R and S notations, Threo and erythro nomenclature, E and Z nomenclature, Optical isomerism in biphenyls and allenes, Concept of Prostereoisomerism and Asymmetric synthesis, Conformation of a few acyclic molecules (alkanes, haloalkanes), Conformation of cyclic systems having one and two sp^2 carbon atoms.

TEXT BOOKS:

1. *Organic Chemistry (Second Edition)*, by J. Clayden, N. Greeves, S. Warren.
2. *Organic Reactions and Their Mechanisms* by P S Kalsi, New Age International Private Limited; Fifth edition, 2020
3. *Organic Reaction Mechanisms* by Raj K. Bansal, New Age International Private Limited, 2012
4. *Mechanism and Theory in Organic Chemistry* by Lowry and Richardson (Harper Row Publishers, New York)
5. *A Guidebook to Mechanism in Organic Chemistry* by Peter Sykes
6. Jonathan Clayden, Nick Greeves, and Stuart Warren. "Organic Chemistry," Oxford University Press, 2014.
7. D. Nasipuri, *Stereochemistry of Organic Compounds Principles and Applications*, New Age International Publishers, 3rd Edition, 2011
8. *Stereochemistry: Conformation and Mechanism* by P.S. Kalsi New Age Publishers; Tenth Edition, 2019

REFERENCE BOOKS:

1. *Advanced Organic Chemistry: Reaction Mechanism and Structure* by Jerry March (Wiley Eastern Limited)
2. W. Carruthers, Iain Coldham, *Modern Methods of Organic Synthesis South Asia Edition*, Cambridge University Press, Fourth Edition, 2015.
3. F. A. Carey and R. J. Sundberg, *Advanced Organic Chemistry Part B: Reaction and Synthesis*, Springer, 5th Edition, 2010.
4. *Stereochemistry of Organic Compounds* by Ernest L. Eliel Wiley; 1st Edition, 2008

ACH-413	PHYSICAL CHEMISTRY-I	4 credits
UNIT-I	<i>Chemical Kinetics & Fast Reaction</i> Theories of reaction rates, Collision theory, Transition state theory, Arrhenius equation and the activated complex theory, Reaction between ions, Salt effect, Steady-State Kinetics, Kinetic and Thermodynamic concept of Reactions, Treatment of unimolecular reaction (Lindeman-Hinshelwood and Rice-Ramspeger-Kassel-Marcus (RRKM) theories), Dynamic chain ($H_2 + Br_2$ reaction, pyrolysis of CH_3CHO , Decomposition of ethane). Study of Fast reactions by relaxation, Stopped flow and Flash photolysis methods.	
UNIT-II	<i>Polymer Chemistry</i> Polymer-definition, Classification of polymer, Polymer structure, Number average and molecular weight average, Step growth & chain growth polymerization, Kinetics of polymerization, Stereochemistry of polymerization.	
UNIT-III	<i>Adsorption & Catalysis</i> Adsorption, types of adsorptions, Gibbs adsorption isotherm, Freundlich's adsorption isotherm, Langmuir's adsorption isotherm and its limitations, BET adsorption isotherm and its applications, Heat of adsorption, estimation of surface areas of solids from solution adsorption studies, Enzyme Catalysis & Heterogeneous Catalysis.	
Unit-IV	<i>Phase Rule</i> Concept of Equilibrium between phases, Derivation of phase rule, Ideal Solution, Lever Rule, Brief concept on one and two component system, Application of phase rule to three component systems of both solids and liquids.	
TEXT BOOKS:	1. <i>Chemical Kinetics</i> by K.J. Laidler, Pearson; 3 rd edition (1997) 2. <i>Textbook of Physical Chemistry</i> by K L Kapoor, McGraw Hill (2014) 3. <i>Principles of Physical Chemistry</i> by B.R. Puri, L.R. Sharma, M.S. Pathania, Vishal Publishing Co, 47th Edition (2016) 4. <i>Polymer Science</i> by Gowariker, Viswanathan & Sreedhar	
REFERENCE BOOKS:	1. <i>Advanced Physical Chemistry</i> by D.N. Bajpai, S. Chand; 2 nd edition (1992) 2. <i>Atkins' Physical Chemistry</i> by P. W. Atkins and Julio de Paula, , Oxford; 10 th Edition (2014) 3. <i>Reaction Kinetics</i> by Pilling & Seakins 4. <i>Physical Chemistry Through Problems</i> by Dogra & Dogra	
ACH -414	INSTRUMENTAL METHODS OF ANALYSIS	4 credits
UNIT-I	<i>Atomic Absorption and Flame Emission Spectroscopy</i> Basic Principle of atomic absorption spectroscopy (AAS), instrumentation, atomization techniques, application of AAS, sensitivity of instruments, strengths and limitations of atomic absorption spectroscopy. Basic principle flame emission spectroscopy (FES), instrumentation, application of FES, limitations in FES.	
UNIT-II	<i>Electroanalytical Method</i> Polarography: principle, instrumentation, Ilkovic equation, Significance of half wave potential, application of polarography. Cyclic voltammetry: principle, instrumentation, and its application, ion selective electrodes.	
UNIT-III	<i>Thermoanalytical Methods</i> Thermogravimetric analysis (TGA): Principle, instrumentation, factors affecting TGA curve, derivative thermogravimetric analysis (DTGA) and application of thermogravimetric analysis, differential thermal Analysis (DTA), instrumentation of DTA and application of DTA, simultaneous study of TGA, DTA with examples. differential scanning calorimetry (DSC) and thermometric titration.	
UNIT-IV	<i>Chromatography</i> Principle and applications of thin layer chromatography (TLC), column chromatography (LC), gas chromatography (GC), high pressure column	

chromatography (HPLC).

**TEXT
BOOKS:**

1. *Analytical Chemistry (Theory and Practice)* by U.N. Dash, Sultan Chand & Sons Pvt. Ltd., New Delhi, 2013.
2. *Basic concept of Analytical Chemistry* by S. M. Khopkar, New Age International (P) Ltd. Publishers, 3rd Edition, 2008.
3. *Instrumental Methods of Chemical Analysis* by Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House, 5th Edition, 2014.

**REFERENCE
BOOKS**

1. *Quantitative Analysis* by Vogel, Pearson Education Ltd., New Delhi, 6th edition, 2009.
2. *Instrumental Method of Analysis* by H. Willard, L. Merritt, J. Dean & F. Settle, CBS publisher and distributors Pvt. Ltd., 7th edition, 2004.

ACH -415

INORGANIC CHEMISTRY PRACTICAL

2 credits

1. Inorganic salt mixture analysis
Inorganic salt mixture analysis containing not more than four radicals. The mixture will include rare earth metal anions like Tungstate, Vanadate and Molybdate. Insoluble matters and other interfering radicals will also be included. Organic radicals are excluded
2. Estimation metal ions via volumetric analysis
 - a) Estimation of Ca and Mg ions in a given a sample of cement by EDTA method.
 - b) Estimation of Cu ion in a given a sample of brass by iodometry method.

BOOKS:

1. *Vogel's Qualitative Inorganic Analysis*, 7th edition; Revised by G. Svehla.
2. *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Revised by G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denny.

Advanced Practical Inorganic Chemistry, 22nd edition; By Gurdeep Raj

ACH -416

PHYSICAL CHEMISTRY PRACTICAL

2 credits

1. Determination of ionization constants of weak acids and verification of Oswald's Dilution law.
2. Conductometric titration of Strong/Weak acid with Stron/Weak base
3. Conductometric titration of a mixture of HCl+CH₃COOH with NaOH
4. Potentiometric titration of strong acid with strong base.
5. Verification of Beer's Lambert Law and unknown concentration determination.
6. Verification of additivity rule spectrophotometrically.
7. Determination of temperature coefficient and energy of activation of hydrolysis of ethyl acetate.
8. To study the complex formation between ammonia and Cu⁺².
9. Determination of unknown dextrose solution by polarimetry
10. Study of inversion of cane sugar in acid medium by polarimetry.

BOOK:

1. *Practical Physical Chemistry* by B. Viswanathan & P. S. Raghavan, Viva Books
2. *Experimental Physical Chemistry* by R.C. Das & B. Behera, McGraw-Hill Education

SECOND SEMESTER

ACH -421

INORGANIC CHEMISTRY-II

4 credits

UNIT-I

Complexes of Carbon Monoxide and its Analogs

Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important synthesis and reactions of metal carbonyls, carbonylate anions and carbonylate hydride, carbonyl halides; preparation, bonding and important reactions of transition metal complexes with isocyanide, cyanide, dinitrogen, carbon disulphide and nitrogen monoxides; chemistry of carbenes and carbynes.

UNIT-II

Metal Cluster and Polyacids

Concept of metal cluster, bonding in metal clusters, metal carbonyl type clusters, anionic and hydride clusters, method of synthesis, super large cluster, electron counting in medium size cluster (Wade's rule, capping rule), isolobal relationship, clusters of Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt metals and their synthesis and reactions, Catalysis by metal cluster. Polyacids: definition, classification, polymerization of chromate, isopoly acids and anions, synthesis of isopoly acids, structures of isopolymolybdates, isopolytungstates and isopolyvanadates, heteropoly acids of W and Mo. Applications of isopoly and heteropoly compounds.

UNIT-III

Biomolecular Storage and Transportation of ions

Lipids, lipid bilayer, biological membranes, Ramachandran's plot, biologically important metal ions (Na, K, Mg, Ca, Cu, Fe, Zn, Co and Mo) and their functions, passive and active transport processes, Na^+/K^+ pump, calcium pump, ionophores, storage and transport of iron, copper and zinc, siderophores, ferritin and transferrin regarding iron-storage and transportation.

Chemistry of porphyrin, iron porphyrins (heme proteins): hemoglobin (Hb), myoglobin (Mb), and their behavior as oxygen carriers, O_2 affinity, cooperativity, and Bohr's effect, non-heme oxygen uptake protein (hemerythrin and hemocyanin). Magnesium porphyrins (Chlorophyll): Photosynthesis, the light and dark reactions (Calvin cycle). Non-heme iron-sulphur proteins as electron carriers: rubredoxins and ferredoxins.

UNIT-IV

Biomolecular Catalysis

Basic concepts of amino acids, peptides, and proteins; protein structures; preliminary ideas about enzymes, cofactors, coenzymes, apoenzymes, prosthetic groups, metal-activated enzymes, and metalloenzymes. biological significance and mechanistic aspects of carboxypeptidase, carbonic anhydrase, blue-oxidases, non-blue oxidases, superoxide dismutase, structure and biological functions of molybdenum nitrogenase. Heme protein as an electron carrier with particular reference to cytochrome c, cytochrome P-450, and cytochrome c oxidase.

TEXT BOOKS:

1. *Advance Inorganic Chemistry* by F.A. Cotton, G. Wilkinson & C. Murillo, Wiley Publication, 6th edition, 1999.
2. *Inorganic Chemistry (Principles of Structure and Reactivity)* by James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, Pearson Education, 4th edn, 2006.
3. *Modern Aspect of Inorganic Chemistry* by Emelius and Sharpe, Routledge & Kegan Paul PLC, England, 4th revised edition, 1978.
4. *Bio-Inorganic Chemistry* by Asim K Das.
5. *Bio-Inorganic Chemistry* by E. Ochia.
6. *Bioorganic, BioInorganic and Supramolecular Chemistry* by P. S. Kalsi and J. P. Kalsi.
7. *Inorganic Chemistry (4th Edn)* by Huheey, Keiter, Keiter and Medhi.
8. *Bioinorganic and Suparmolecular Chemistry* by A. Bhagi and G. R. Chatwal..

REFERENCE BOOKS

1. *Inorganic Chemistry* by G. L. Miessler and D. A. Tarr, Pearson Education, 3rd edn, 2008.
2. *Comprehensive Coordination Chemistry*, by Wilkinson, Gillarsand, Pergamon Press, 1989.

ACH-422

ORGANIC CHEMISTRY-II**4 credits****UNIT-I****Addition Reactions**

Addition to C=C multiple bonds – Electrophilic, Nucleophilic and Free radical. Reactions: Hydroboration, Michael reaction, Sharpless Asymmetric epoxidation.

Addition to carbon-heteroatom multiple bonds: Mechanism and reactivity, Reactions: LiAlH_4 reduction of carbonyl compounds, acids, esters, nitriles, addition of Grignard reagents to carbonyl compounds, Reformatsky reaction, Aldol condensation, Knoevenagel condensation, Perkin reaction, Mannich reaction, Wittig reaction, Stobbe reactions, Tollens reaction, Benzoin condensation.

UNIT-II**Elimination Reactions**

E_1 , E_2 , E_1CB and E_2CB mechanisms, Orientation, Effect of substrate, base, leaving group and medium, Orientation of double bond, Saytzeff and Hoffman rules, Pyrolytic elimination reaction, Oxidative elimination (oxidation of alcohol by chromium, Moffatt oxidation). Reactions: Cleavage of quaternary ammonium hydroxides, Chugaev reaction, Shapiro reaction.

UNIT-III**Mechanistic Considerations**

Nature of migration, migratory aptitude, memory effects. Rearrangements: Wagner-Meerwein, Favorskii, Fries, Carbene intermediate, Arndt-Eistert synthesis, Neber, Nitrene intermediates (Beckmann, Hofmann, Schmidt, Lossen, Curtius), Baeyer-Villiger, Shapiro reaction, Von-Richter, Sommelet-Hauser rearrangement.

UNIT-IV**Dynamic Stereochemistry**

Conformation and reactivity, Selection of substrates, Quantitative correlation between conformation and reactivity, (Weinstein-Eliel equations and Curtin-Hammett principles), Conformational effects on stability and reactivity in acyclic compounds (ionic elimination, intramolecular rearrangements) and in cyclic systems, (Nucleophilic substitution reaction at ring carbon, Formation and Cleavage of epoxide rings, Addition reactions to double bonds, Elimination reactions). Stereospecific and stereoselective reactions.

TEXT**BOOKS:**

1. *Organic Chemistry (Second Edition)*, by J. Clayden, N. Greeves, S. Warren.
2. *Organic Reactions and Their Mechanisms* by P S Kalsi, New Age International Private Limited; Fifth edition, 2020
3. *Organic Reaction Mechanisms* by Raj K. Bansal, New Age International Private Limited, 2012
4. *Mechanism and Theory in Organic Chemistry* by Lowry and Richardson (Harper Row Publishers, New York)
5. *A Guidebook to Mechanism in Organic Chemistry* by Peter Sykes
6. Jonathan Clayden, Nick Greeves, and Stuart Warren. "Organic Chemistry," Oxford University Press, 2014.
7. D. Nasipuri, *Stereochemistry of Organic Compounds Principles and Applications*, New Age International Publishers, 3rd Edition, 2011
8. *Stereochemistry: Conformation and Mechanism* by P.S. Kalsi New Age Publishers; Tenth Edition, 2019

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1. *Advanced Organic Chemistry: Reaction Mechanism and Structure* by Jerry March (Wiley Eastern Limited)
2. W. Carruthers, Iain Coldham, *Modern Methods of Organic Synthesis South Asia Edition*, Cambridge University Press, Fourth Edition, 2015.
3. F. A. Carey and R. J. Sundberg, *Advanced Organic Chemistry Part B: Reaction and Synthesis*, Springer, 5th Edition, 2010.
4. *Stereochemistry of Organic Compounds* by Ernest L. Eliel Wiley; 1st Edition, 2008

ACH-423

PHYSICAL CHEMISTRY-II**4 credits****UNIT-I*****Classical Thermodynamics***

Brief resume of the concepts of laws of thermodynamics, Free energy, chemical potential and entropy, Third law of thermodynamics and determination of entropy, Entropy and probability, Boltzmann-Planck equation, Partial molar properties (partial free energy, molar volume and molar heat content), Their significance and determination. Concept of fugacity and its determination.

UNIT-II***Classical and Quantum Statistical Mechanics***

Concept of probability, Stirling approximations, Most probable distribution, System, Phase Space, μ -Space, γ -Space, Liouville's Theorem, Statistical Equilibrium, Brief Concepts on Ensembles, Canonical, Grand Canonical and Micro-canonical ensembles.

Bose-Einstein statistics, Fermi-Dirac statistics and Maxwell-Boltzmann statistics

UNIT-III***Partition Functions & Statistical Thermodynamic Properties of Solids***

Significance of partition function, Calculation of thermodynamic properties and equilibrium constant in terms of partition functions, Evaluation of translational, vibrational and rotational partition function for monoatomic and polyatomic ideal gases, electronic partition function.

Some thermal characteristics of crystalline solids, Classical treatment of solids, Einstein Model, Debye Modification, Limitation and modification of Debye theory.

UNIT-IV***Computer Application in Chemistry***

Basic structure of a computer: The CPU, the I/O devices, the internal memory, commonly used secondary storage media. Data representation: Overview of binary, octal and hexadecimal number system. The software: Concept of low level and high-level languages, Compiler interpreter, editor, operating system concepts, salient features of Windows and LINUX operating systems. Algorithm, Flowchart, Decision-table, elements of high-level programming languages. Application of numerical methods to chemical problems.

TEXT BOOKS:

1. *Text Book of Physical Chemistry* by K.L. Kapoor
2. *Principles of Physical Chemistry* by Puri, Sharma & Pathania
3. *Chemical Thermodynamics* by Rastogi & Mishra
4. *Thermodynamics for Chemists* by S. Glasstone
5. *Molecular Thermodynamics* by McQuarrie & Simon
6. *Statistical Thermodynamics* by M. C. Gupta
7. *Computational Chemistry* by A.C. Norris

REFERENCE BOOKS:

1. *Advanced Physical Chemistry* by D.N. Bajpai, S. Chand; 2nd edition (1992)
2. *Atkins' Physical Chemistry* by P. W. Atkins and Julio de Paula, , Oxford; 10th Edition (2014)
3. *Physical Chemistry Through Problems* by Dogra & Dogra

ACH-424

ATOMIC & MOLECULAR SPECTROSCOPY**4 credits****UNIT-I*****Atomic Spectroscopy***

The electromagnetic spectrum, A general discussion on various molecular excitation processes, Spectra of hydrogen and hydrogen like atoms, alkali metals spectra, L-S coupling, Term symbols, Space quantisation, Zeeman effect, Stark effect, Paschen-Back effect.

UNIT-II***Vibrational & Rotational Spectroscopy & Raman Spectroscopy***

Molecular Spectra of Diatomic Gases, Classification of molecules, Rotational Spectra, Vibrational Spectra, Vibrational-Rotational Spectra, P, Q and R Branches. Theory of Raman spectra, Rotational Raman spectra, Vibrational Raman spectra, Rotational-Vibrational Raman spectra, comparison with IR spectra.

UNIT-III *Electron Spin Resonance Spectroscopy*

Theory, instrumentation, g-values, hyperfine splitting, ESR spectra of systems with more than one unpaired electron, double resonance, ENDOR and ELDOR techniques.

UNIT-IV *Photoelectron Spectroscopy*

Principles of Photoelectron spectroscopy, Sources of monochromatic ionizing radiation, Ionization processes and Koopmans' theorem, Photoelectron spectra and their interpretation, Ultraviolet photoelectron spectra of atoms and molecules, Auger electron spectroscopy.

- TEXT BOOKS:**
1. *Fundamentals of Molecular Spectroscopy* by C.N. Banwell
 2. *Fundamentals of Molecular Spectroscopy* by G.M. Barrow
 3. *Molecular Spectroscopy*, P.S. Sindhu

- REFERENCE BOOKS:**
1. *Advanced Physical Chemistry* by D.N. Bajpai, S. Chand; 2nd edition (1992)
 2. *Atkins' Physical Chemistry* by P. W. Atkins and Julio de Paula, , Oxford; 10th Edition (2014)
 3. *Physical Chemistry Through Problems* by Dogra & Dogra
 4. *Spectroscopy Vol. I & II* by Walker & Straw

ACH-425 ORGANIC CHEMISTRY PRACTICAL 2 credits

1. Isolation and identification of multi-functional compounds in a mixture of two organic compounds.
2. Preparation of;
 - a) Benzoin, benzil and benzillic acid from benzaldehyde.
 - b) p-idotoluene from p-toluidene.
 - c) Ethyl acetoacetate from ethyl acetate.
3. Estimation of;
 - a) Nitrogen by Kjeldahl method.
 - b) keto group by gravimetric method.

BOOK: *Advanced Practical Organic Chemistry, 3/e* by N K Vishnoi

ACH-426 ANALYTICAL CHEMISTRY PRACTICAL 2 credits

1. Determine the pK value of an acid-base indicator.
2. To estimate metal ions by spectrophotometric titration.
3. To determine the pH of a given solution by spectrophotometrically.
4. Adsorption of CH₃COOH on activated charcoal and verification of Freundlich's & Langumir's adsorption isotherm.
5. Simultaneous estimation of Mn and Cr in a solution of KMnO₄ and K₂Cr₂O₇.
6. Determination of hydrolysis constant of aniline hydrochloride.
7. Determination of ionisation constants of multibasic acid potentiometrically.
8. Determination of association constants of CH₃COOH by distribution method between water and toluene.
9. To study the rate of acid catalysed iodination of acetone in presence of excess acid and acetone.
10. To study the stability constant of a metal complex.
11. Estimation of Fe ion in a solution of Mhor's salt.

- BOOK:**
1. *Practical Physical Chemistry* by B. Viswanathan & P. S. Raghavan, Viva Books
 2. *Experimental Physical Chemistry* by R.C. Das & B. Behera, McGraw-Hill Education

THIRD SEMESTER

ACH -511	INDUSTRIAL POLLUTION & ITS MANAGEMENT	4 Credits
UNIT-I	<i>Basics of Industrial Pollution</i> Concept and definition of Industrial pollution, Environment and its classification, Factors influencing environment, Components of Environment; Bio-geochemical cycles; Hydrological cycle, Gaseous cycles (Oxygen cycle, CO₂ cycle, Nitrogen cycle), Sedimentary cycles (Sulfur cycle, Phosphorous cycle); Effects of Industries on the environment; Environmental degradation.	
UNIT-II	<i>Industrial Air Pollution</i> History of major industrial air pollution episodes. Types and classification of Industrial air pollutants. Characterization of gaseous effluents of major industries (thermal power plant, steel, cement, aluminum, paper, fertilizer) and their health effects. Permissible limit and ambient air quality, Methods for control of gaseous air pollutants (Combustion, Absorption and Adsorption). Methods for control of particulate air pollutants (Mechanical device, Filtration, Dry scrubber, Electrostatic precipitator).	
UNIT-III	<i>Industrial Water Pollution</i> History of major industrial water pollution episodes, Classification and types of Industrial water pollutants, Characterization of some liquid effluents of major polluting industries (Paper Mills, Sugar industry, Iron and steel and Textile) and their health effects, Water quality standard : Drinking water quality standard, Irrigation water standard and effluent standard, methods of treatment of industrial waste water: Preliminary treatment, primary treatment (Sedimentation, equalization and neutralization etc.), secondary treatment (Activated sludge technique and Trickling filter) tertiary treatment methods for waste water treatment (Evaporation, Ion exchange, Adsorption, Electrodialysis, Electrolytic recovery, reverse osmosis).	
UNIT-IV	<i>Industrial Solid Wastes</i> Classifications and types of Industrial solid wastes, Generation, disposal and management of industrial solid wastes with special reference to fly ash, red mud, heavy metals (Mercury, Lead, Arsenic, Cadmium), other organic solid wastes and radio-active wastes. Industrial sources of noise, Loudness on Decibel scale, noise levels in decibel scale, effect of noise on human health, prevention and control of industrial noise pollution.	
TEXT BOOKS:	<i>Industrial Pollution and Management by Arvind Kumar, APH Publishing Corporation, New Delhi.</i> <i>Industrial Pollution and its Management by P.C. Trivedi, Avishkar Publishers & Distributors, Jaipur</i> <i>Pollution Control in Process Industries by S.P. Mahajan, Tata McGraw Hill Publishing Company, New Delhi</i> <i>Environmental Engineering by G Kiely, Tata McGraw Hill Publishing, Company, New Delhi.</i>	
REFERENCE BOOKS	<i>Environmental Pollution and Control, 4th ed. by J. Jeffrey Peirce, P. Aarne Vesilind, Ruth F. Weiner, Elsevier Publication</i>	
ACH-512	INDUSTRIAL PROCESSES	4 credits
UNIT-I	<i>Petroleum and Coal Based Chemicals</i> Composition of petroleum, cracking processes, Commercial production of ethylene, acetylene, polymerization mechanisms, Addition, condensation, step growth, chain growth, method of polymerization, Distillation of coal.	

UNIT-II	<i>Oil Based Industries & Surface-Active Agents</i> Oils and fats: Solvent extraction of oils, hydrogenation of oil, use of oil in the manufacturing of soap, paints and varnishes. Classification of surface-active agents and manufacturing of detergents used for cleansing purpose.
UNIT-III	<i>Fermentation Industries</i> A general discussion on fermentation conditions, manufacturing of penicillin, Alcoholic beverages, ethanol from molasses and starchy material
UNIT-IV	<i>Pesticides and Pharmaceutical Industries</i> DDT manufacture, BHC manufacture, 2,4-D manufacture, parathion manufacture, pharmaceutical industry
TEXT BOOKS:	1. <i>Outlines of Chemical Technology</i> by M. Gopala Rao and Marshall Sittig, Affiliated East-West Press Pvt. Ltd. 2. <i>Industrial Chemistry</i> by B. K. Sharma
ACH-513	Analytical Techniques in Organic Chemistry 4 credits
UNIT-I	Nuclear Magnetic Resonance Magnetic properties of nuclei, Theory of magnetic nuclear resonance with special reference to proton, Instrumentation, Chemical shift, Simple spin-spin interaction, Shielding effects, Diamagnetic anisotropy, NOE, ^{13}C , ^{15}N , ^{19}F , ^{31}P NMR (preliminary idea).
UNIT-II	Mass Spectrometry Introduction, Mass spectrum, Determination of molecular formulae, molecular ions, Parent peak, Base peak, Use of molecular fragmentation, McLafferty rearrangement, Mass spectra of some classes of compounds (hydrocarbons, alcohols, phenols, ketones, aldehydes, acids and esters)
UNIT-III	Spectroscopic Identification of Organic Compounds Problems involving identification of organic compounds using UV, IR, NMR and Mass spectroscopy.
UNIT-IV	Optical Rotatory Dispersion and Circular Dichroism Plane polarized and circularly polarized lights, Circular birefringence and circular dichroism, ORD, Cotton effect, Rotatory Dispersion of ketones, the Octant rule, Axial haloketone rule.
TEXT BOOKS:	1. <i>Introduction to Spectroscopy</i> by Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan, Cengage Learning India Private Limited; 2015 2. R.M. Silverstein, G. C. Bassler, T. C. Morrill, <i>Spectrometric identification of Organic Compounds</i> , John Wiley & Sons, Inc, 2010 3. D. Nasipuri, <i>Stereochemistry of Organic Compounds Principles and Applications</i> , New Age International Publishers, 3rd Edition, 2011 4. <i>Spectroscopic Identification of Organic Compounds: Silverstein & Bassler</i> , Wiley; 8th edition, 2014
REFERENCE BOOKS	1. <i>Spectroscopy of Organic Compounds</i> , by P S Kalsi, New Age International, 2007 2. <i>Basic ^1H- and ^{13}C NMR spectroscopy</i> , by M. Balci, Elsevier, 2005
ACH-514	PROJECT 4 credits Each student shall carry out project work in industries/institutions. The findings of the project work should be submitted in the form of a dissertation for evaluation by a Board of Examiners.
ACH-515	INDUSTRIAL CHEMISTRY PRACTICAL 2 credits 1. Determination of percentage of purity of commercially available different N, P and K fertilizer. 2. Water analysis: (a) Residual chlorine in town supply water (b) Ammonia content of sewage water 3. Determination of acid value, saponification value and iodine value of different

oils

4. Preparation of indigo from anthranilic acid.
5. Preparation of cinnamic acid from benzaldehyde.
6. Preparation of flavone from o-hydroxy acetophenone.
7. Estimation of sulfur in isothiuronium chloride prepared from thiourea.
8. Separation of components from a mixture by TLC and column chromatography.

Books

From various sources books and journals

ACH-516

SEMINAR

2 credits

Each student has to present a seminar on published paper in the last two years.

FOURTH SEMESTER

ACH -521	CHEMISTRY OF NANO MATERIALS	4 credits
UNIT-I:	Semiconductors and Devices Conducting and semiconducting organic materials. Synthesis and characterizations of organic semiconductors, Conducting and semiconducting materials and insulator, Band gap engineering. Doping of semiconductors. Application of carbon-based materials. Electronic devices and coating.	
UNIT-II:	Nanomaterials for Energy Conversion and Storage Materials Nanomaterials for Solar Energy Conversion Systems. Principles of photovoltaic energy conversion (PV), Structural characteristics and concepts. Types of photovoltaic Cells, Physical concept of photovoltaic cells, Organic solar cells, Dye-Sensitized Solar Cells, Organic-Inorganic Hybrid solar cells. Device fabrication techniques and characterizations, Applications of nanomaterials in in agriculture, food, textile, cosmetics. Current status and future trends.	
UNIT-III:	Nanostructured Materials Intermolecular forces during the formation of nanostructured materials, Structure and features of conducting and ferroelectric materials, structure and features of ferroelectric materials, dielectric properties, piezo and inverse piezoelectric effects, ceramic materials, organic/inorganic hybrid materials and their fabrications and applications.	
UNIT-IV:	Polymers and their Applications Stress-strain behavior, High temperature resistant organic/inorganic polymers, effect of chain flexibility and other steric factors, entropy and heat of fusion, glass transition temperature, relationship between T _m and T _g . Effect of molecular weight on polymer properties and their applications. Synthetic procedure commercial polymers (polycarbonate, polyurethane, polymethylmethacrylate, polyethyleneterphthalate, Nylon, polystyrene), Fire retarding and biomedical polymers	
TEXT BOOKS:	1. <i>Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies</i>, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014. 2. <i>Solar cells: Operating principles, technology and system applications</i> by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981. 3. <i>Semiconductor for solar cells</i>, H J Moller, Artech House Inc, MA, USA, 1993. 4. <i>Recent Literatures and Reviews</i>	
REFERENCE BOOKS	1. <i>Solis state electronic device</i>, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.	

ACH-522	ADVANCED ANALYTICAL CHEMISTRY	4 credits
UNIT-I:	Reliability of Analytical Data Errors in chemical analysis, classification of errors, significant figures, precision and accuracy, methods of expressing accuracy, absolute error and relative error, methods of expressing precision, average deviation, standard deviation, confidence limits, median value, range, coefficient of variation. Sampling in analysis definition: Theory of sampling, technique of sampling, statistical criteria of good sampling and required size, stratified sampling, transition and storage samples.	
UNIT-II:	Ultraviolet and Visible Spectrophotometry Introduction, nature of absorbing species, visual colorimetry, photo-electric cell and filters, Photoelectric filter photometry, errors in photoelectric photometry, Spectrophotometry, working of spectrophotometer, simultaneous spectrophotometry, differential spectrophotometry, reflectance spectrophotometry,	

photometric titrations, composition of coloured complex Sandell's sensitivity, relative concentration and Ringbon's plot.

UNIT-III ***Electron Microscopy***

Introduction to optics, Principles of image formation, Light microscopy techniques, Electron Microscopy (SEM and TEM), Instrumentation of SEM and TEM, Application of SEM and TEM, Limitations of electron microscopy

UNIT-IV ***Analytical Applications of Organized Assemblies***

Basic concepts of organized assemblies, Application of micellar systems for UV-Visible/fluorescence spectroscopic detection of ions, micellar enhanced phosphorescence and fluorescence, micellar systems in liquid-liquid extraction, surfactant aggregates in flame and plasma atomic spectrometry, micellar systems in chromatography, recent developments in micellar chromatography, application of surfactants in gel electrophoresis.

- TEXT BOOKS**
1. *Basic Principle of Analytical Chemistry* by S.M. Khopkar
 2. *A Text Book of Quantitative Inorganic Analysis* by A.I. Vogel.

- REFERENCE BOOKS**
1. *Physical Chemistry of Macromolecules* by C. Tanford

ACH-523 **MEDICINAL CHEMISTRY** **4 credits**

UNIT-I: ***Overview of drug action and Modern Drug Development Process***

Definition of drugs, types of pharmacological action of drugs, classification of drugs based on their origin, Drug action, Factors affects ADMET, Modern Drug Development process, Initial steps in drug discovery process, Screening of model organism, parameters involved in drug design physicochemical ionization, H-bonding, chelation.

UNIT-II: ***Pharmacokinetics and Pharmacodynamics***

Introduction, Kinetics of ADME, Methods of assessing major physicochemical properties of compounds, Biochemistry of enzymes, Allosteric enzymes, Roles of enzymes in metabolism, Receptors, their types, location, isolation, transduction mechanism.

UNIT-III: ***Strategies for Synthesis of Candidate Drug***

1. Target selection
2. Retro synthesis (the disconnection approach consecutive versus conversion synthesis including LHASA, strategic bond approach, strategic bond in ring approach, degradation of techniques in, synthetic design of venalflaxin, doxopicomine, clobutinol, nisooxetine, bropirimine.

UNIT-IV: ***Drug and their Applications***

Chemotherapy of cancer: veincristine and vinblastine and taxol, drug related hormones insulin, vasopressin and oxitosin, prostaglandin, histamine, antiparkinson agents antialzheimer agents, antirheumatics and antigout agents.

- TEXT BOOKS**
1. *Introduction to the Principles of Drug Design* by Smith and Williams.
 2. *Principle of Biochemistry* by A.L. Lehninger, D.L. Nelson & Michael M Cox.
 3. *Organic Chemistry* by J. Clayden, N. Greeves, S Warrens, P. Wothers.
 4. *An Introduction to Medicinal Chemistry*, Dr. Bijoy Kundu, Wiley, First Edition, 2020

- REFERENCE BOOK**
1. *Medicinal Chemistry* by Alfred Burger.
 2. *Strategy of Drug Design* by Purcell.

ACH-524 **SURFACTANTS & DETERGENTS** **4 credits**

UNIT-I ***Structural Aspects of Surfactants***

Surfactants, Classification (Anionic surfactants, Cationic head surfactant, Zwitterionic surfactants, Nonionic surfactant, Biosurfactants, Gemini surfactant, double tailed surfactant, Bolaform), Synthesis of Surfactant, Behaviour of Surfactants in aqueous and nonaqueous solution, Different types of interactions, Surface activity, Surface

tension, Factors for organization of surfactants and types of organized assemblies, Hydrophobic interactions, electrostatic interactions, Critical micellar concentration (CMC), Factors affecting CMC, Methods of CMC determination. Aggregation number, Shape and Size of micelle.

UNIT-II***Application of Surfactant***

Spectroscopic investigation and analytical methods, determination of polarity of micelle, structures of micelle, Determination of aggregation number, Industrial Applications of surfactants, Beneficiation of minerals, micellar catalysis, Drug delivery, Wetting, Dispersion and foaming.

UNIT-III***Structural Aspects of Detergents***

Detergents, Principal groups of synthetic detergents, Anionic detergents, Cationic detergents, Non-ionic detergents, Amphoteric detergents, Industrial methods of preparation of Detergents, Concept of hard and soft water, Removal of hardness of water, Oil and fat, General idea of Suds regulators, builders, additives.

UNIT-IV***Application of Detergents***

Manufacture of Shampoos. theories of glyceride structure, Hydrolysis of glycerides, Use of oil in the manufacturing of soap, Principle of soap cleaning, Analysis of soaps as per BIS standards, use of enzymes in detergents, Catalytic hydrogenation of oil, Recovery of Nickel from hydrogenated oil product.

BOOKS:

1. *Industrial Chemistry* by B. K. Sharma, 9th Edn.
2. *The Manufacture of Soaps other Detergents and Glycerin* Edited by Edgar Woollatt.
3. *Synthetic Detergent* Edited by Milwidsky.
4. *Bailey's Industrial Oil and Fat Products Vol-1 (4th Edition)* Edited by Daniel Swern.
5. *Soaps & Detergent* Edited by K.S. Parasuram.
6. *Surfactants and Interfacial Phenomenon* by M.J. Rosen
7. *Catalysis in Micellar and Macromolecular Systems* BY E.J. Fendler and J.H. Fendler

ACH-525**COMPUTATIONAL CHEMISTRY PRACTICAL****2 credits**

1. Use of Microsoft Excel: Balancing Chemical Equations, Bond Enthalpy of Hydrocarbons, Spectrophotometric Analysis, Curve Fitting.
2. Use of Chemdraw: Design molecular 2-D geometry, Preparation of reaction scheme
3. Execution of the Software to solve problems: Eigenvalues and Eigenvectors, Charge Density, Delocalization energy, Molecular geometry, Vibrational frequencies

ACH -526**COMPREHENSIVE VIVA**

Comprehensive viva-voce examination shall be conducted jointly by the external and internal Examiners. Short questions on the theoretical principles, experimental methodologies and instrumentations etc. of the different experiments included in the entire practical/project syllabus of semesters-I, -II, -III and -IV may be asked.