

COURSE OF STUDIES

FOR POST GRADUATE DEGREE IN CHEMISTRY

(SEMESTER SYSTEM)

FOR THE ACADEMIC SESSION 2023-24

POST GRADUATE DEPARTMENT OF CHEMISTRY



K.K. Behra

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GOVERNMENT AUTONOMOUS COLLEGE ROURKELA

COURSE AT A GLANCE

Subject: M. Sc. in Chemistry Academic Session: 2022-24 Academic Year

FIRST SEMESTER				
Course No	Course Title	Credit	Mark distribution	Mark
AECC - I	ENVIRONMENTAL STUDIES AND DISASTER MANAGEMENT <i>Entrepreneurship Development</i>	02	20+ 20 (Assignment) + 60	100
P-101	INORGANIC CHEMISTRY-I	04	20+80	100
P-102	ORGANIC CHEMISTRY-I	04	20+80	100
P -103	PHYSICAL CHEMISTRY-I	04	20+80	100
P -104	INSTRUMENTAL METHODS OF ANALYSIS	04	20+80	100
P -105	INORGANIC PRACTICAL-I	02	50	50
P -106	ORGANIC PRACTICAL-I	02	50	50
Total		22	500	600
SECOND SEMESTER				
Course No	Course Title	Credit	Mark distribution	Mark
IDC <i>AECC - II</i>	FOR NON-CORE STUDENTS <i>Environmental studies and Disaster management</i>	03 <i>2</i>	20+20 (Assignment) + 60	100
P -201	INORGANIC CHEMISTRY-II	04	20+80	100
P -202	ORGANIC CHEMISTRY-II	04	20+80	100
P -203	PHYSICAL CHEMISTRY-II	04	20+80	100
P -204	ATOMIC & MOLECULAR SPECTROSCOPY	04	20+80	100
P -205	INORGANIC PRACTICAL-II	02	50	50
P -206	ORGANIC PRACTICAL-II	02	50	50
Total		23 <i>22</i>		600
<p><i>In addition to this student(s) has to take one Inter Departmental Course IDC of 3 credit offered by other departments.</i></p>				

THIRD SEMESTER				
Course No	Course Title	Credit	Mark distribution	Mark
AECC - II 100	ENTREPRENEURSHIP DEVELOPMENT	2 3	20+ 20 (Assignment) + 60	100
P -301	INORGANIC CHEMISTRY-III	04	20+80	100
P -302	ORGANIC CHEMISTRY-III	04	20+80	100
P -303	PHYSICAL CHEMISTRY-III	04	20+80	100
P -304	ANALYTICAL TECHNIQUES IN ORGANIC CHEMISTRY	04	20+80	100
P -305	PHYSICAL CHEMISTRY PRACTICAL	02	50	50
P-306	INDUSTRIAL CHEMISTRY PRACTICAL	02	50	50
P-307	MOOCs one paper from Swayam or others	03		
Total		25 26		600
FOURTH SEMESTER				
Course No	Course Title	Credit	Mark distribution	Mark
P -401	MATERIAL & ENERGY BALANCE	04	20+80	100
P -402	INDUSTRIAL POLLUTION & ITS MANAGEMENT	04	20+80	100
P -403	ELECTIVE PAPER <i>Industrial Process</i>	04	20+80	100
P -404	PROJECT	04		100
P -405	ELECTIVE PAPER <i>Medicinal Chemistry</i>	04	20+80	100
Elective Papers (The student has to opt any two papers)				
P -403 A	INDUSTRIAL PROCESSES	04	20+80	100
P -403 B	CHEMISTRY OF NANOMATERIALS	04	20+80	100
P-405 A	MEDICINAL CHEMISTRY	04	20+80	100
P -405 B	SURFACTANTS AND DETERGENTS	04	20+80	100
Total		20	500	500
Total Credit		90		2300

*One Non-credit course will be taken by the students during the 2 year study
NCC/NSS/Sports/Yoga/Gardening/Socially Useful Productive Work (SUPW)*

FIRST SEMESTER

P-101

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 β parameters for the complex with T_1 ground state and A_2 ground state, spectrochemical series and nephelauxetic series, charge transfer spectra. Concept of magnetic properties of metal complexes.

TEXT BOOKS:

1. *Chemical Applications of Group Theory* by F. A. Cotton, Wiley India (P) Ltd., 3rd edn, 2009, New Delhi.
2. *Symmetry and Spectroscopy of Molecules* by K. V. Ready, New Age International Ltd. 2nd edn, 2009, New Delhi.
3. *Symmetry and Group Theory in Chemistry* by R. Ameta, New Age International Ltd., 1st edn, 2013, New Delhi.
4. *Solid State Chemistry* by D. K. Chakravarty, New Age International Limited, 1996, New Delhi.
5. *Advanced Inorganic Chemistry* by F. A. Cotton and G. Wilkinson, Wiley India (P) Ltd., New Delhi, 6th edition, 1999.
6. *Fundamental concepts of Inorganic Chemistry (vol-5, and vol-6)* by Asim K. Das and Mahua Das, CBS publishers and distributors, 2nd Edition, 2019.

REFERENCE BOOK

1. *Inorganic Chemistry* by G. L. Miessler and D. A. Tarr, Pearson Education, 3rd edn, 2004.
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.

P-102

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.

Handwritten signatures and initials: *SB*, *Sachin*, *SK*, *Rohit*, *Sonia*, *MB*.

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

P-103**PHYSICAL CHEMISTRY I****4 credits****UNIT-I****Chemical Kinetics & Fast Reaction**

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**Polymer Chemistry**

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**Adsorption & Catalysis**

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**Phase Rule**

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. *Chemical Kinetics* by K.J. Laidler, Pearson; 3rd edition (1997)
2. *Textbook of Physical Chemistry* by K L Kapoor, McGraw Hill (2014)
3. *Principles of Physical Chemistry* by B.R. Puri, L.R. Sharma, M.S. Pathania, Vishal Publishing Co, 47th Edition (2016)
4. *Polymer Science* by Gowariker, Viswanathan & Sreedhar

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. *Reaction Kinetics* by Pilling & Seakins
4. *Physical Chemistry Through Problems* by Dogra & Dogra

P-104**INSTRUMENTAL METHODS OF ANALYSIS****4 credits****UNIT-I****Atomic Absorption and Flame Emission Spectroscopy**

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**Electroanalytical Method**

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**Thermoanalytical Methods**

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**Chromatography**

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.

P-105**INORGANIC CHEMISTRY PRACTICAL-I****2 credits**

Analysis of an inorganic mixture containing not more than 6 radicals. The mixture will include rare earth like Tungstate, Vanadate, Molybdate and Cerium (IV). Insoluble matters and other interfering radicals will also be included. Organic radicals are excluded.

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

P-106**ORGANIC CHEMISTRY PRACTICAL-I****2 credits**

Add Skoog Book

Isolation and identification of multi-functional compounds in a mixture of two organic compounds.

BOOK:

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

SECOND SEMESTER

P -201

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 in regard to iron-storage and transportation.

Chemistry of porphyrin, iron porphyrins (heme proteins): hemoglobin (Hb), myoglobin (Mb) and their behavior as oxygen carrier, O₂ affinity, cooperativity and Bohr's effect, heme protein as electron carrier with particular reference to cytochrome-c and cytochrome-450, and cytochrome oxidase. Catalases and peroxidases. non-heme oxygen uptake protein (hemerythrin and hemocyanin).

Magnesium porphyrins (Chlorophyll): Photosynthesis, the light and dark reaction (Calvin cycle). Non-heme iron-sulphur protein as electron carrier, rubredoxins and ferredoxins.

UNIT-IV

Biomolecular Catalysis

Basic concepts of amino acids, peptides and proteins, structures of proteins, preliminary idea about enzyme, cofactor, co-enzyme, apoenzyme, prosthetic group, metal-activated enzyme and metalloenzyme. biological significance and mechanistic aspects of carboxypeptidase, carbonic anhydrase, blue-oxidases, non-blue oxidases, superoxide dismutase, structure and biological functions of molybdenum nitrogenase.

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.

P-202
UNIT-I

ORGANIC CHEMISTRY II

4 credits

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, Sayetzeff 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

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

P-203

UNIT-I

PHYSICAL CHEMISTRY II

4 credits

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.

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UNIT-II	<i>Classical and Quantum Statistical Mechanics</i> 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	<i>Partition Functions & Statistical Thermodynamic Properties of Solids</i> 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	<i>Computer Application in Chemistry</i> 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:	<ol style="list-style-type: none"> 1. <i>Text Book of Physical Chemistry</i> by K.L. Kapoor 2. <i>Principles of Physical Chemistry</i> by Puri, Sharma & Pathania 3. <i>Chemical Thermodynamics</i> by Rastogi & Mishra 4. <i>Thermodynamics for Chemists</i> by S. Glasstone 5. <i>Molecular Thermodynamics</i> by McQuarrie & Simon 6. <i>Statistical Thermodynamics</i> by M. C. Gupta 7. <i>Computational Chemistry</i> by A.C. Norris 	
REFERENCE BOOKS:	<ol style="list-style-type: none"> 1. <i>Advanced Physical Chemistry</i> by D.N. Bajpai, S. Chand; 2nd edition (1992) 2. <i>Atkins' Physical Chemistry</i> by P. W. Atkins and Julio de Paula, , Oxford; 10th Edition (2014) 3. <i>Physical Chemistry Through Problems</i> by Dogra & Dogra 	
P-204	ATOMIC & MOLECULAR SPECTROSCOPY	4 credits
UNIT-I	<i>Atomic Spectroscopy</i> 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	<i>Vibrational & Rotational Spectroscopy & Raman Spectroscopy</i> Molecular Spectra of Diatomic Gases, Classification of molecules, Rotational Spectra, Vibrational Spectra, Vibrational-Rotational Spectra, P, Q and R Branches.	
UNIT-III	<i>Raman Spectroscopy</i> Theory of Raman spectra, Rotational Raman spectra, Vibrational Raman spectra, Rotational-Vibrational Raman spectra, comparison with IR spectra.	
UNIT-IV	<i>Electron Spin Resonance Spectroscopy</i> Theory, instrumentation, g-values, hyperfine splitting, ESR spectra of systems with more than one unpaired electron, double resonance, ENDOR and ELDOR techniques.	
TEXT BOOKS:	<ol style="list-style-type: none"> 1. <i>Fundamentals of Molecular Spectroscopy</i> by C.N. Banwell 2. <i>Fundamentals of Molecular Spectroscopy</i> by G.M. Barrow 3. <i>Molecular Spectroscopy</i>, P.S. Sindhu 	
REFERENCE BOOKS:	<ol style="list-style-type: none"> 1. <i>Advanced Physical Chemistry</i> by D.N. Bajpai, S. Chand; 2nd edition (1992) 2. <i>Atkins' Physical Chemistry</i> by P. W. Atkins and Julio de Paula, , Oxford; 10th Edition (2014) 3. <i>Physical Chemistry Through Problems</i> by Dogra & Dogra 4. <i>Spectroscopy Vol. I & II</i> by Walker & Straw 	

P-205

INORGANIC CHEMISTRY PRACTICAL-II**2 credits**

- Principle of estimation of the main constituents of Brass and Portland Cement.
 - Estimation of Ca and Mg in a given solution prepared from a sample of cement by EDTA method.
 - Estimation of Cu in a given solution prepared from a sample of Brass.
- Preparation and characterization of the following inorganic compounds:
 - Tetramminecupric sulphate $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
 - Sodium cobaltinitrite, $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$
 - Potassium chromioxalate, $\text{K}_3[\text{Cr}(\text{C}_2\text{O}_4)_3]$.

BOOK:

- Vogel's Qualitative Inorganic Analysis, 7th edition; Revised by G. Svehla.*
- 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*

P-206

ORGANIC CHEMISTRY PRACTICAL-II**2 credits**

- Preparation of benzoin, benzil and benzilic acid from benzaldehyde.
- Preparation from p-idotoluene from p-toluidene.
- Preparation of ethyl acetoacetate from ethyl acetate.
- Estimation of nitrogen by Kjeldahl method.
- Estimation of keto group by gravimetric method.
- Dibenzalacetone from benzaldehyde.
- Cannizaro reaction – 4-chloro benzaldehyde as substrate.
- Grignard reaction – synthesis of triphenyl methanol from benzoic acid.

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

IDC

INTERDISCIPLINARY COURSE ON CHEMISTRY**3 credits**

Biophysics, Nanoscience & Computational design in drugs & functional materials
 → An interdisciplinary

UNIT -I**MOLECULAR BIOPHYSICS**

Basic ideas on structure and conformation of simple molecules, structural features of proteins, nucleic acids, carbohydrates and lipids. Aspects of biomolecular forces, Higher order structural organization of proteins and nucleic acid, Basic thermodynamics, ligand binding and cooperativity in biological systems, kinetics, diffusion and sedimentation.

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.

UNIT III**COMPUTATIONAL DESIGN ON DRUGS AND FUNCTIONAL MATERIALS**

Structure representation: Building of small molecules, co-ordinate system for structure representation, Building of Biopolymers and oligopeptides. Conformational analysis, Molecular docking, Structure and features of conducting and semiconducting organic materials, Machine learning approach as future prospect.

BOOK:

- Principles of Biochemistry : International Edition , David Nelson and Michael Cox, WH Freeman; 7th ed. 2017.
- Biophysical chemistry, Charles R Cantor and Paul R Schimmel, WH Freeman, 1980
- Organic Photovoltaics- materials, device Physics and Manufacturing Technologies , (eds. C. Brabec, V Dyakonov, U Scherf) 2 nd Ed. Wiley-VCH, Germany, 2014.
- Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
- Introduction to Computational Chemistry by Frank Jensen, Wiley Publication.
- Andrew R Leach, Molecular Modeling: Principles and Applications, 2nd Ed., Prentice Hall, 2001

THIRD SEMESTER

P -301
UNIT-I

INORGANIC CHEMISTRY-III**4 credits****Substitution Reactions in Octahedral Complexes**

Nature of substitution reactions, kinetic application of Crystal Field Theory, acid hydrolysis of octahedral Co(III) complexes with reference to effect of charge, chelation, steric crowding & effects of leaving group, base hydrolysis of octahedral Co(III) complexes: Conjugate base mechanism, test of conjugate base mechanism, anation reaction, substitution reaction without cleavage of metal-ligand bond.

UNIT-II

Substitution Reactions in Square Planar Complex and Redox Reactions

Thermodynamic and kinetic stability, trans effect and its synthetic applications, theories of trans effect (polarization & π -bonding theories), factors affecting the rate law and reaction profile (leaving group, steric group, charge, electrophilic catalysis, nucleophile and temperature). Redox reactions: electron tunneling hypothesis, concept of Marcus-Hush theory, atom transfer reactions, one and two electron transfer, complementary and non-complementary reactions, inner sphere and outer sphere reactions, electron transfer through extended bridges, concept of hydrated electron.

UNIT-III

Nuclear Chemistry

Nuclear stability, magic numbers, radioactivity, general characteristics of radioactive decay particles, decay kinetics, nuclear reaction, Bethe's notation, types of nuclear reaction, nuclear cross section, compound nuclear theory, nuclear fission, liquid drop model, shell model, hard core preformation theory, fission fragments and their mass distribution, charge distribution, ionic charge of fission fragments, working principle of nuclear reactor, concept of nuclear fusion, concept of boron-neutron capture therapy.

UNIT-IV

Solid State Chemistry

General idea of crystal lattice, unit cell, classification of crystals, crystal planes, Miller indices, Bragg's law and applications, determination of cubic crystal structure from systematic absences in diffraction pattern, perfect and imperfect crystals, point defects, stoichiometry defects, Schottky defects and Frenkel defects, thermodynamics of Schottky and Frenkel defects, bonding in ionic solids, colour centers, non-stoichiometry defects, band structure of solids.

TEXT BOOKS:

1. *Mechanisms of Inorganic Reactions* by F. Basolo and R. G. Pearson.
2. *Inorganic Chemistry* by Asim K Das.
3. *Inorganic Chemistry* by Cotton and Wilkinson (4th Edn).
4. *Essentials of Nuclear Chemistry* by H. J. Arniker
5. *Solid State Chemistry* by D. K. Chakravarty, New Age International Limited, 1996, New Delhi.

REFERENCE BOOKS

1. *Solid State Chemistry and its Applications* by A.R. West, Wiley, 1989, 2nd edition, Singapore.
2. *Principles of the Solid State* by H.V. Keer, Wiley Eastern. Limited, 1993, New Delhi.

P-302
UNIT-I

ORGANIC CHEMISTRY III**4 credits****Organic Redox Reaction**

Oxidation: Oxidation of hydrocarbons, oxidation of alcohols by various reagents, oxidation of carbon-carbon double bonds to diols and epoxides, Chromium (VI), Manganese (VII) oxidants, Oxidation with peracids, with hydrogen peroxide, with singlet oxygen. with iodobenzene diacetate, and thallium (III) nitrate.

Reduction: Catalytic hydrogenation, selectivity of reduction, Reduction by hydride transfer reagents: Aluminium alkoxide, Sodium borohydride (NaBH_4), diisobutylaluminium hydride, Sodium cyanoborohydride, Lithium trialkylborohydride, reduction with hydrazine, reduction with trialkyltinhydride, the Birch reduction, the Wolff-Kishner reduction, the Cannizarro reduction, the Resenmund reduction.

UNIT-II

Pericyclic Reaction and Photochemistry

Pericyclic reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann rules, Correlation diagrams and FMO approach. Electrocyclic reactions - Conrotatory and disrotatory motions, $4n$, $4n+2$ and allyl systems. Cycloaddition reactions - suprafacial and antarafacial additions, $4n$ and $4n+2$ systems, thermal and photochemical processes, 1,3 dipolar cycloadditions and cheletropic

reactions. Sigmatropic rearrangements - [i,j] shifts of C-H and C-C bonds; Sommelet-Hauser, Claisen, thio-Claisen, Cope and aza-Cope rearrangements. Ene reaction. Photochemical processes: Fluorescence, Phosphorescence, excimers and exciplex formation, Photochemical reactions: Cis-Trans Isomerization, photochemical dissociation, Reduction of ketones, Paterno-Buchi reaction, Norrish type I and II reactions, Di- π -methane rearrangement, Photochemistry of arenes, Barton reaction.

UNIT-III**Reagents in Organic Synthesis**

Gilman's reagent, Lithium dimethyl cuprate, Lithium diisopropyl amide, DCC, 1,3-Dithiane, Trimethyl silyl iodide, Tri-n-butyl tin hydride, Osmium tetroxide, Selenium dioxide, Phase transfer catalysis (Crown ether, Merrifield resin, Wilkinson's catalyst), Dichloro dicyano benzoquinone (DDQ).

UNIT-IV**Retrosynthetic Approach**

Synthetic design: Introduction, Retrosynthetic approach, Terminology in Retro synthetic analysis, One group disconnection, (alcohol, carbonyl compound, olefins and acids), Two group disconnections (β -hydroxy compounds, α , β -unsubstituted carbonyl compounds, 1,3-dicarbonyl compounds, 1,5 dicarbonyl compounds), Synthesis of some organic molecules by disconnection approach.

TEXT BOOKS:

1. *Reactions, Rearrangements and Reagents* by S.N. Sanyal, Bharati Bhawan Publishers & Distributors; Fourth edition, 2019
2. *Organic Reaction Mechanisms* by Raj K. Bansal, New Age International Private Limited, 2012
3. *Synthetic Approaches in Organic Chemistry*, R.K. Bansal, Narosa Publishing House, India, 1996
4. Jonathan Clayden, Nick Greeves, and Stuart Warren. "Organic Chemistry," Oxford University Press, 2014.
5. *Organic Reactions and Orbital Symmetry* by Gilchrist and Storr, Cambridge University Press; 2nd Edition 1979
6. *Mechanism and Theory in Organic Chemistry* by Lowry and Richardson (Harper Row Publishers, New York)
7. *Photochemistry and Pericyclic Reactions* by Jagdamba Singh and Jaya Singh, New Age; 3rd Edition, 2012
8. Stuart Warren and Paul Wyatt, *Organic synthesis, the disconnection approach*, 2nd edition, Wiley, 2012.

REFERENCE BOOKS

1. W. Carruthers, Iain Coltham, *Modern Methods of Organic Synthesis South Asia Edition*, Cambridge University Press, Fourth Edition, 2015.
2. F. A. Carey and R. J. Sundberg, *Advanced Organic Chemistry Part B: Reaction and Synthesis*, Springer, 5th Edition, 2010.
3. J. March and M. B. Smith, *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 6th Edition, Wiley, 2013.
4. I. L. Finar, *Organic Chemistry Vol. I & Vol. II*, Longman (Cambridge), 2011.

P-303**PHYSICAL CHEMISTRY III****4 credits****UNIT-I****Exact Quantum Mechanical Results**

The Schrodinger equation and the postulates of quantum mechanics, Elementary application of the Schrodinger equation, Particle in a box, Harmonic oscillators, Rigid rotator and hydrogen atom.

UNIT-II**Approximate Methods & Angular Momentum**

The variation theorem, Time independent perturbation of non-degenerate systems, Application of Variation Method and Perturbation Theory to the He atom.

Ordinary angular momentum, generalized angular momentum, Eigen functions for angular momentum, Addition of angular momentum.

UNIT-III**Chemical Bonding in Diatomics**

Born-Oppenheimer Approximation, Molecular Orbital Theory and its Applications, Valence Bond Theory and its Applications, LCAO-MO Theory.

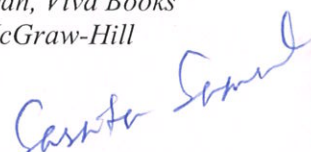
UNIT-IV**Orbital Approximation Methods**

Huckel theory of conjugated systems (Ethylene, Allyl systems, butadiene, cyclopropenyl, cyclobutadiene, bicyclobutadiene, H_3^+ , H_3 and H_3^-), Calculation of bond order, charge density, free valence index, Application of group theory for the simplification of MO determinants of 1,4- butadiene and naphthalene.

- TEXT BOOKS:**
1. *Introductory Quantum Chemistry*, A.K. Chandra
 2. *Fundamentals of Quantum Chemistry*, R.K. Prasad
 3. *Notes on Molecular Orbital Calculations* by J.D. Roberts
- REFERENCE BOOKS:**
1. *Quantum Mechanics, Volume 2: Angular Momentum, Spin, and Approximation Methods*, 2nd Edition, Claude Cohen-Tannoudji, Bernard Diu, Franck Laloë; Wiley-VCH, 2019
 2. *The Chemical Bond: Fundamental Aspects of Chemical Bonding*, Eds. Gernot Frenking, Sason Shaik; Wiley-VCH, 2014
- P-304**
- 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. *Introduction to Spectroscopy* 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, *Spectrometric identification of Organic Compounds*, John Wiley & Sons, Inc, 2010
 3. D. Nasipuri, *Stereochemistry of Organic Compounds Principles and Applications*, New Age International Publishers, 3rd Edition, 2011
 4. *Spectroscopic Identification of Organic Compounds: Silverstein & Bassler*, Wiley; 8th edition, 2014
- REFERENCE BOOKS**
1. *Spectroscopy of Organic Compounds*, by P S Kalsi, New Age International, 2007
 2. *Basic ^1H - and ^{13}C NMR spectroscopy*, by M. Balci, Elsevier, 2005
- P-305**
- PHYSICAL CHEMISTRY PRACTICAL** **2 credits**
1. Determination of ionization constants of weak acids and verification of Oswald's Dilution law.
 2. Conductometric titration of a mixture of $\text{HCl} + \text{CH}_3\text{COOH}$ with NaOH
 3. Base hydrolysis of ethylacetate conductometrically.
 4. Potentiometric titration of strong acid with strong base.
 5. Verification of Beer's Lambert Law and unknown concentration determination.
 6. Simultaneous estimation of Mn and Cr in a solution of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$.
 7. To estimate metal ions by spectrophotometric titration.
 8. Determine the pK value of an acid-base indicator.
 9. Determination of rate constant of acid hydrolysis of ethyl acetate.
 10. Determination of unknown dextrose solution by polarimetry
 11. Study of inversion of cane sugar in acid medium by polarimetry.
 12. Adsorption of CH_3COOH on activated charcoal and verification of Freundlich's & Langumir's adsorption isotherm.
 13. Determination of association constants of CH_3COOH by distribution method between water and toluene.
 14. To study the rate of acid catalysed iodination of acetone in presence of excess acid and acetone.
 15. Determination of ionisation constants of multibasic acid using a pH meter.
- Books:**
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







P-306

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.

**TEXT
BOOK:**

**FOURTH SEMESTER
(Core Courses)**

P -401	MATERIAL & ENERGY BALANCE	4 credits
UNIT-I:	<i>Material Balances Without Chemical Reactions</i>	
	Process Flow-Sheet, Material Balances, Recycling Operations, Material Balances of Unsteady State Operations.	
UNIT-II:	<i>Material Balances Involving Chemical Reactions</i>	
	Definition of Terms, Electrochemical Reactions, Recycling, Parallel and Bypassing Operations, Metallurgical Applications	
UNIT-III:	<i>Energy Balances</i>	
	Energy and Thermo-Chemistry, Energy Balances, Heat Capacity, Heat Capacity of Gases at Constant Pressure, Sensible Heat Changes in Liquids, Heat Capacity of Gaseous Mixtures, Latent Heats, Enthalpy Changes During Phase Transfers Accompanied by Sensible Heat Changes, Enthalpy Changes Accompanying Chemical Reactions, Effect of Temperature on Heat of Formation, Heat of Reaction, Adiabatic Reactions, Thermochemistry of Mixing Process, Dissolution of Solids, Liquid-Liquid Mixtures	
UNIT-IV:	<i>Stoichiometry and Unit Operations</i>	
	Distillation, Absorption and Stripping, Extraction and Leaching, Crystallisation, Psychrometry, Drying, Evaporation, Less Conventional Operation	
TEXT BOOKS:	<ol style="list-style-type: none"> 1. G.V. Reklaitis, <i>Introduction to Material and Energy Balances, 1st Edition, John Wiley & Sons, 1983.</i> 2. V.V. Veverka and F. Madron, <i>Material and Energy Balancing in the Process Industries: From Microscopic Balances to Large Plants, 1st Edition, Elsevier, 1997.</i> 3. B.I. Bhatt and S.B. Thakore, <i>Stoichiometry, 5th Edition, Tata McGraw Hill, 2010.</i> 	
REFERENCE BOOKS	<ol style="list-style-type: none"> 1. A.E. Morris, G. Geiger, and H.A. Fine, <i>Handbook on Material and Energy Balance Calculations in Material Processing, 3rd Edition, John Wiley & Sons, 2011.</i> 2. C. Oloman, <i>Material and Energy Balances for Engineers and Environmentalists, 3rd Edition, Imperial College Press, 2009.</i> 	
P-402	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, CO ₂ 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***Industrial Solid Wastes***

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

1. *Industrial Pollution and Management* by Arvind Kumar, APH Publishing Corporation, New Delhi.
2. *Industrial Pollution and its Management* by P.C. Trivedi, Avishkar Publishers & Distributors, Jaipur
3. *Pollution Control in Process Industries* by S.P. Mahajan, Tata McGraw Hill Publishing Company, New Delhi
4. *Environmental Engineering* by G Kiely, Tata McGraw Hill Publishing, Company, New Delhi.

REFERENCE BOOKS

1. *Environmental Pollution and Control, 4th ed.* by J. Jeffrey Peirce, P. Aarne Vesilind, Ruth F. Weiner, Elsevier Publication

P-405**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.

Elective Papers*(The student has to opt any two papers)***P-403A****INDUSTRIAL PROCESSES****4 credits****UNIT-I*****Petroleum and Coal Based Chemicals***

Composition of petroleum, cracking processes, Commercial production of ethylene, acetylene, polymerization mechanisms, Addition, condensation, step growth, chain growth, method of polymerization, Distillation of coal.[10]

UNIT-II***Oil Based Industries & Surface-Active Agents***

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***Fermentation Industries***

A general discussion on fermentation conditions, manufacturing of penicillin, Alcoholic beverages, ethanol from molasses and starchy material

UNIT-IV***Pesticides and Pharmaceutical Industries***

DDT manufacture, BHC manufacture, 2,4-D manufacture, parathion manufacture, pharmaceutical industry

TEXT BOOKS:

1. *Outlines of Chemical Technology* by M. Gopala Rao and Marshall Sittig, Affiliated East-West Press Pvt. Ltd.
2. *Industrial Chemistry* by B. K. Sharma

P-403B	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 photovoltaics 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	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 1. <i>Solis state electronic device</i>, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995. 	
P-405A	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	
	<ol style="list-style-type: none"> 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, nisoxetine, bropridine). 	

UNIT-IV	<i>Drug and their Applications</i>	
		Chemotherapy of cancer: vincristine and vinblastine and taxol, drug related hormones insulin, vasopressin and oxitosis, prostaglandin, histamine, antiparkinsonin agents antialzheimer agents, antirheumatics and antigout agents.
TEXT BOOKS:		<ol style="list-style-type: none"> 1. <i>Introduction to the Principles of Drug Design</i> by Smith and Williams. 2. <i>Principle of Biochemistry</i> by A.L. Lehninger, D.L. Nelson & Michael M Cox. 3. <i>Organic Chemistry</i> by J. Clayden, N. Greeves, S Warrens, P. Wothers. 4. <i>An Introduction to Medicinal Chemistry</i>, Dr. Bijoy Kundu, Wiley, First Edition, 2020
REFERENCE BOOKS:		<ol style="list-style-type: none"> 1. <i>Medicinal Chemistry</i> by Alfred Burger. 2. <i>Strategy of Drug Design</i> by Purcell.
P-405 B	SURFACTANTS & DETERGENTS	4 credits
UNIT-I	<i>Structural Aspects of Surfactants</i>	
		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	<i>Application of Surfactant</i>	
		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	<i>Structural Aspects of Detergents</i>	
		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	<i>Application of Detergents</i>	
		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:		<ol style="list-style-type: none"> 1. <i>Industrial Chemistry</i> by B. K. Sharma, 9th Edn. 2. <i>The Manufacture of Soaps other Detergents and Glycerin</i> Edited by Edgar Woollatt. 3. <i>Synthetic Detergent</i> Edited by Milwidsky. 4. <i>Bailey's Industrial Oil and Fat Products Vol-1 (4th Edition)</i> Edited by Daniel Swern. 5. <i>Soaps & Detergent</i> Edited by K.S. Parasuram. 6. <i>Surfactants and Interfacial Phenomenon</i> by M.J. Rosen 7. <i>Catalysis in Micellar and Macromolecular Systems</i> BY E.J. Fendler and J.H. Fendler