Semester – III			
Core VII	**Inorganic Chemistry - III**		
Course Code : 21PCHC31	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Objectives:

- To sketch the various crystal structures of the compounds.
- To explain the various electronic theories involved in conducting and semiconducting materials.
- To discuss the synthesis, properties and structures of inorganic rings, chains, cages and clusters.

Course Outcome:

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	demonstrate about Electrical properties and applications of semiconductors.	1,4	Ap
CO 2	discuss about the High temperature super conductors and their applications in Levitation.	4,7	An
CO 3	compare various techniques involved in single crystal growth.	6,8	An
CO 4	sketch the Crystal structures of some Ionic compounds.	1,2	Cr
CO 5	distinguish between Homocyclic and heterocyclic inorganic ring systems.	1,3	An
CO 6	calculate STYX notation for boranes and carboranes.	4	Ap
CO 7	coin the Isolobal relationships between main group and transition metal fragments.	6,8	Cr
CO 8	calculate the Microstates and Term symbols for Transition metal complex.	4,8	Ev
CO 9	discuss the applications of XPES and UVPES to inorganic spectra.	5,6	An

Semester – III			
Core VII	**Inorganic Chemistry - III**		
Course Code : 21PCHC31	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Unit I Solid state I

Types of close packing – hcp and ccp packing efficiency, radius ratios – Methods of Single crystal growth – Bridgeman, Czochralski, Verneuil, Epitaxial growth of thin layers – Chemical vapour transport – Hydrothermal method –Dislocations in solids – Point defects – Schottky and Frenkel defects – Line defects – Surface Defects – Dislocations – Grain Boundary and Stacking Fault – Crystal structures of common ionic compounds NaCl, Na_2O, Zinc blende, Wurtzite, Nickel arsenide, CsCl, Rutile, CdI_2, $CdCl_2$, and CaF_2, Perovskite, K_2NiF_4, Spinels.

Unit II Solid state II

Electronic structure of solids – Band theory, free electron theory – Insulators and semiconductors and its types. Electrical properties (Thomson effect, Peltier effect, Seeback effect, Hall effect) – Dielectric, Ferroelectric, Piezoelectric and Pyroelectric materials and their relationship and applications. Optical and electronic properties of semiconductors – Photovoltaic effect, Hall effect – p-n junction and n-p-n junction and their applications as Rectifiers and transistors – Solid electrolytes, superconductors, High-temperature superconductors, BCS theory, cooper electrons – Meissner effect and levitation.

Unit III Inorganic chains, rings and cages

Chains – Chain catenation – Heterocatenation – Isopoly and heteropoly anions – Silicate minerals –Classification – Aluminosilicates – Sulphur nitrides – Intercalation compounds.

Rings – Borazines, Phosphazenes, Phosphazene polymers– Homocyclic and heterocyclic inorganic ring systems.

Cages – Synthesis, properties and structure of boranes [styx notation], heteroboranes, metalloboranes and carboranes, metallocarboranes, silicones – Wade's rule.

Unit IV Inorganic clusters

Introduction to clusters – Carbonyl clusters, anionic and hydrido clusters, carbide clusters, sulphur metal clusters – Structure and Bonding of Metal clusters: Dinuclear: Cu(II) carboxylate, Chromium(II) acetate and $[M_2Cl_8]^{4-}$ (M = Mo and Re) – Trinuclear: $[M_3(CO)_{12}]$ (M = Fe, Ru, Os) – Tetranuclear: $[M_4(CO)_{12}]$ (M = Co, Rh, Ir) – Hexanuclear clusters: $[Nb_6Cl_{12}]^{2+}$, $[Os_6(CO)_{18}]^{2-}$ and

$[Mo_6Cl_8]Cl_4$ – Capping rule –Clusters rotation with CO shells – Chevrel phases – Isolobal relationships between main group and transition metal fragments – Zintl ions.

Unit V Spectroscopy II

Electronic spectroscopy – Microstates, Term symbols, selection rules – Orgel and Tanabe-Sugano diagrams – Charge transfer spectra – Electronic spectra for 1st row transition metal complexes – Calculation of Dq, B for octahedral d^2 and d^8 systems ($[V(H_2O)_6]^{3+}$, Ni(II) complexes) – Nephelauxetic ratio – Electronic spectra of lanthanide and actinide.

Photo electron spectroscopy – UVPES - Principle, spin-orbit coupling – XPES – Principle, chemical shift in XPES – Koopman's theorem – Applications of XPES and UVPES to inorganic spectra – Auger electron spectroscopy.

Text Books

1. West A.R. *Solid State Chemistry and its Application*. Asia: John Wiley & Sons. 2007.
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter. *Inorganic Chemistry: Principles of Structure and Reactivity*. Harper Collins College Publishers. 4th Edition 2009.
3. Gopalan R. *Textbook of Inorganic chemistry*. Universities press (India) private limited. 2012.
4. Skoog D.A, West D.M, Holler F.J, Grouch S.R. *Fundamentals of Analytical Chemistry*. Thomson Asia Pvt. Ltd. Eighth Edition, Third Reprint 2005.

Books for Reference

1. Wells A.F. *Structural Inorganic Chemistry*. Oxford University Press.2012.
2. Azaroff L.V. *Introduction to solids*. Tata McGraw Hill publishing Ltd. 2000.
3. Kittel C. *Introduction to solid state physics*. Wiley Eastern Ltd. 7th Edition 2006.
4. Shriver D.F, Atkins P.W, Langford C.H. *Inorganic chemistry*. ELBS, Oxford University Press. 1994.
5. Gary L. Miessler, Donald A. Tarr. *Inorganic Chemistry*. Pearson Publications. 5th Edition 2014.
6. Albert Cotton F, Geoffrey Wilkinson, Carlos A.Manic, Manfred Bochman. *Advanced Inorganic Chemistry*. Wiley Interscience Publication. 6th edition 1999.
7. Lee J.D. *Concise Inorganic Chemistry*. Blackwell Science Ltd. 5th Edition, Reprint2003.
8. Drago R.S. *Physical Methods in Inorganic Chemistry*. Saunders College Publishing. 2nd Edition 1992.
9. Ebsworth David E.A.V, Rankin Stephen Credock W.H. *Structural Methods in Inorganic Chemistry*. ELBS. 1988.

SEMESTER – III			
Core VIII	**Organic Chemistry - III**		
Course Code : 21PCHC32	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives:

- To study pericyclic reactions and their types with mechanism.
- To understand the stereochemistry of reactants, intermediates and products.
- To study the multi-step synthesis of various natural products.
- To learn the importance of steroids and terpenoids in natural products.

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	familiarize the various types of aromatic substitution reactions.	2	Re
CO 2	compare neighbouring group participation and Ambident nucleophiles in aromatic Electrophilic substitution.	4	Ev
CO 3	discuss the Conformational analysis of cyclic molecules and the factors governing the reactivity of axial and equatorial substituents in cyclohexanes.	5	An
CO 4	discuss optical rotatory dispersion and how it is used for the determination of structure of chiral molecules.	6	Ap
CO 5	study the synthesis and Elucidation of structure of steroids and terpenoids.	6	Re
CO 6	learn the conversion of cholesterol to progesterone, estrogen and testosterone.	8	Un
CO 7	acquire knowledge about the reagents specificity.	4	An
CO 8	know about the NMR spectroscopy.	6	Un
CO 9	distinguish spin-spin coupling and application to organic structure ^{13}C spectroscopy.	2	An

SEMESTER – III			
Core VIII	**Organic Chemistry - III**		
Course Code : 21PCHC32	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Unit I Aromatic Electrophilic and Nucleophilic Substitution Reaction

Aromatic Electrophilic substitution – Arenium ion mechanism – Selected reactions and Reactivity – Nitration – Nitrosation – Sulphonation – Halogenation – Friedel Craft's alkylations and arylations – Vilsmeir Haack reaction – Jacobsen reaction – Houben Hoesch reaction.

Aromatic Nucleophilic Substitution – S_NAr mechanism –S_N1 (Aromatic) mechanism with evidences – Benzyne mechanism – Effect of substrate structure, leaving group, attacking nucleophile and solvent – Selected reactions – Von Richter and Smiles rearrangements.

Problems including the basic concepts of Aromatic Electrophilic and Nucleophilic Substitution Reaction.

Unit II Conformational Analysis

Conformation and reactivity of cyclic and acyclic compounds –Conformations of cyclohexanes – Ring inversion, monosubstituted cyclohexanes– Transition States and Intermediates, Conformational free energy, Determination of conformational energy, disubstituted cyclohexanes (1,2), (1,3) an (1,4) – Conformation of poylsubstituted cyclohexanes – Trimethylcyclohexanes, Tetramethylcyclohexanes and Menthols – Conformational analysis of fused bicyclic systems – Decalin and perhydrophenanthrene – Curtin-Hammett principle.

Unit III Steroids and Terpenoids

Steroids: Occurrence, nomenclature, basic skeleton, isolation, structure determination and synthesis of Bile acids, Cholesterol, Androsterone, Testosterone, Estrone, Progestrone, Non-Steroid Hormones.

Terpenoids: Classification, nomenclature, occurrence, isolation – General methods of structure determination – Isoprene rule – Structure determination, stereochemistry and synthesis of the following representative molecules: Zingiberene, Camphor, Apitic Acid, α- pinene and squalene.

Unit IV Reagents in Organic Reactions

Synthetic applications of the following – Crown Ethers, Diazomethane, 2,3-Dichloro-5,6-dicyano-1,4-benzoquinone(DDQ), N,N-Dicyclohexylcarbodiimide (DCC), Di-isobutyl aluminium hydride (DIBAL), 1,3-dithiane, Fenton's reagent, Gilman, Jones reagent, Lithium diisopropylamide (LDA), Osmium tetroxide, Pyridinium chlorochromate (PCC), Phase Transfer Catalysts (PTC), Wilkinson's catalyst, Ziegler-Natta catalyst.

Unit V Pericyclic Reactions

Atomic and molecular orbitals – Woodward-Hoffmann rules – The Mobius and Huckel concept, FMO and correlation diagrams – Electrocyclic reactions – con and dis rotatory motions for 4n and 4n+2 system (butadiene and 1,3,5-hexatriene) – Stereochemical course of electrocyclic reaction in terms of conservation of orbital symmetry – Cycloaddition – Suprafacial and antarafacial additions, [2+2] and [2+4] reactions (ethylene and butadiene) – Sigmatropic rearrangements with examples – C- and H-migration – [1,3], [3,3] & [1,5] shift – Claisen and Cope rearrangements.

Text Books

1. Mukherjee Kapoor Singh. *Mechanism of Organic reactions*. Kolkata: Books and Allied Ltd, 2021.
2. Kalsi P.S. *Organic Reaction & Mechanism*. New Delhi: New Age International Publishers, 4th Edition 2020.
3. Ahluwalia V.K, Parshar R.K. *Organic Reaction Mechanism.* New Delhi: Narosa Publishing House. Fourth Edition2019.
4. Somorendra Nath Sanyal. *Reactions, Rearrangements and Reagents*. Noida: Bharati Bhawan Publishers & Distributors. 2021.
5. Raj K Bansal. *Organic reaction mechanism*. New Delhi: New Age International Publishers.4th Edition 2012.
6. Nasipuri D. *Stereochemistry of Carbon Compounds*. New Delhi: New Age International Publishers.3rdEdition, 2018.

Books for Reference

1. Michael B Smith. *March's Advanced Organic Chemistry: Reactions, Mechanism and Structure*, New York: John-Wiley and Sons, 8thEdition, 2019.
2. Jonathan Clayden.Nick Greeves, Stuart Warren, Wothers. *Organic Chemistry*.New York:Oxford University Press.2nd Edition 2021.
3. Ernest Eliel. *Stereochemistry of Carbon Compounds*.New Delhi: Tata-McGraw Hill Publishing Company.2001.
4. Kalsi P.S. *Stereochemistry: Conformation and Mechanism*.New Delhi: New Age International Publishers.8thEdition 2015.
5. Norman R.O.C, Coxon J.M. *Principles of Organic synthesis*.Switzerland: Spinger and Business Media, LLC.Third edition1994.

Semester – III			
Core IX	**Physical Chemistry - III**		
Course Code : 21PCHC33	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Objectives:

- To achieve base knowledge about the concepts of physical chemistry.
- To solve Debye-Huckel theories for electrolytes.
- To demonstrate the Chemical information from spectroscopy.

Course Outcomes:

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO1	outline the behavior of electrolytes in solutions.	4	An
CO2	Predict the structure of the electrode surface and the applications of electrode process.	7	Cr
CO 3	investigate the corrosion and polarization studies	7	Ev
CO 4	analyse Onsager relations and Electro kinetic effect	1	An
CO 5	Justify electrochemical mechanisms of nervous system	6,7	Ev
CO 6	Categorise the principle and applications of NMR and EPR spectroscopy.	6,8	An
CO 7	differentiate the various types of electronic spectroscopy and draw the structures of various molecules.	4	An
CO 8	judge the structure of molecules by applying various spectroscopic techniques.	5	Ev

Semester – III			
Core IX	**Physical Chemistry - III**		
Course Code : 21PCHC33	**Hrs / Week : 5**	**Hrs / Sem : 75**	**Credits : 4**

Unit I Electrochemistry I

Debye-Huckel theory of inter-ionic attraction–Debye-Huckel Onsager equation and its validity– Debye-Falkenhagen and Wein effects – Activity coefficinets of electerolytes – Debye-Huckel limiting law – Debye-Huckel Bronsted equation – Quantitative and qualitative verification of Debye-Huckel limiting law – Electrode-electrolyte interface – Structure of electrified interface: Helmholtz-Perrin model and Gouy-Chapman Diffuse charge model of the double layer – Electrocapillary phenomenon – Lipmann equation.

Unit II Electrochemistry II

Kinetics of electrode reaction – Polarization and over potential – Butler-Volmer equation for one step and multistep electron transfer reactions – Tafel equation – Significance of I_c and transfer coefficient – Diffusion over potential - Polarizable and non- polarizable electrodes – Ilkovic equation – Derivation of Ilkovic equation from Fick's laws of diffusion – Corrosion – Pourbaix diagrams – Evan's diagram – Bioelectrochemistry – Electrochemical mechanisms of nervous system.

Unit III Irreversible Thermodynamic Processes

Phenomenological laws and Onsager reciprocal relations – Entropy production due to heat flow – Entropy production in chemical reactions – Entropy production and entropy flow in open system – Transformation properties of fluxes and forces – Principle of microscopic reversibility and Onsager reciprocal relations – Verification of Onsager relations – Electro kinetic effect – Thermomolecular pressure difference and Thermomechanical effect. Applications of irreversible thermodynamics to biological and non-linear thermodynamics of Irreversible processes.

Unit IV Nuclear Magnetic Resonance Spectroscopy

Nuclear Magnetic Resonance Spectroscopy – Theory of PMR spectra – Chemical shift – Factors affecting chemical shift – Solvents used in NMR – Solvent shift – Hydrogen bonding – Relaxation times and spin-spin interactions - Theory of Spin-spin splitting – Magnitude of coupling – Coupling constant, J – Factors influencing coupling constant –Calculation of coupling constants– First-order spectra of complex systems – NMR of simple AX and AMX type molecules – Double resonance technique.

Unit V Electronic Spectroscopy and Photoelectron spectroscopy

Electronic spectroscopy – Electronic spectrum of diatomic molecules – Born-Oppenheimer approximation – Sequences and progressions – The Frank-Condon principle – Dissociation energy and dissociation products – The fortrat diagram – Predissociation.

Photoelectron spectroscopy – Principle – XPES, UVPES and Chemical information from photoelectron spectroscopy – Applications of ESCA.

Text books

1. Glasstone S. *An Introduction to Electrochemistry.* New Delhi:East West Press Pvt. Ltd. 1956.

2. Puri, Sharma, Pathania. *Principle of Physical Chemistry.* Vishal Publications. 48th Edition 2020.

3. Gurdeep R. Chatwal, Sham K. Anand. *Spectroscopy.* Himalaya Publishing House. 2009.

Books for Reference

1. Antorpov L. *Theoretical Electrochemistry*. Moscow: Mir Publishers. 2nd Edition 1977.

2. Bockris J O'M, Reddy A K N. *Modern Electrochemistry*. New York: Plenum Press. Vol. 1 & 2, Second Edition 1998.

3. McQurrie D.A, Simon J.D. *Physical Chemistry. A Molecular Approach.* New Delhi: Viva Books Pvt. Ltd.1999.

4. Rajaram J, Kuriakose J C. *Kinetics and Mechanism of Electrochemical Transformations.* New Delhi: Ch-13, Macmillan India Ltd. 1993.

5. Banwell C.N. *Fundamentals of Molecular Spectroscopy.* Noida: McGraw Hill Education.4th Edition 1994.

6. Barrow G M. *Introduction to Molecular Spectroscopy*. New York: McGraw Hill. 1964.

7. Drago R.S. *Physical Methods in Inorganic Chemistry.* New Delhi: East West Press Ltd. 1971.

8. Straughan B.P, Walker S. *Spectroscopy.* New York: London Chapman and Hall, A Halstet Press Book, John Wiley & Sons Ins. Volume 1, 2 & 3.1975.

Semester – IV			
Core X	**Inorganic Chemistry - IV**		
Course Code : 21PCHC41	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives:

- To explain the various photophysical and photochemical processes involved in inorganic compounds.
- To understand the chemistry involved in energy sources of life and functions of enzymes.
- To discuss the theory of various types of nuclear reactions.
- To study in detail NMR, NQR and ESR spectroscopies.

Course Outcome:

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	demonstrate about the energy sources of life using photosynthetic and non-photosynthetic processes	4,5	Ap
CO 2	illustrate the inhibition and poisoning of xanthane oxidase and aldehyde oxidase.	5	Ap
CO 3	explain about the iron transport and storage proteins.	3	Un
CO 4	describe about tracer technique and counter technique in nuclear chemistry.	5,6	An
CO 5	justify substitution reactions in octahedral and square planar complexes	2,6	Ev
CO 6	sketch the electron transfer mechanism for inner and outer sphere complexes.	2	Ap
CO 7	catagorise the principle and applications of NMR, NQR and EPR spectroscopy.	6,8	An
CO 8	demonstrate the structural information from NMR and EPR spectra.	2,3	Ap

Semester – IV			
Core X	**Inorganic Chemistry - IV**		
Course Code : 21PCHC41	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Unit I Bioinorganic chemistry I

Energy sources of life – Non-photosynthetic process – Metalloporphyrins – Cytochromes A,B,C – Dioxygen binding – Interaction between Heme and Dioxygen , Binding of Dioxygen – Myoglobin – Structure and Functions of Hemoglobin – Electron transfer : Rubidoxins and Ferridoxins – Respiration: Blue copper proteins – Photosynthesis: PS-I, PS-II– Photosynthesis with mechanism of Chlorophyll.

Unit II Bioinorganic chemistry II

Enzymes – Zinc enzymes: Carboxypeptidase A, Carbonic anhydrase, Inhibition and poisoning of enzymes illustrated by Xanthane oxidase, aldehyde oxidase, Copper enzyme: Superoxide dismutase, Toxicity of Metals and the role of Metallothionines – Nitrogen fixation – *Invitro* and *Invivo* conditions. Iron storage and transport proteins: Transferrin, Hemosiderin, Ferritin and Siderophores.

Unit III Nuclear Chemistry

Nuclear Reactions – Types, Q value, Cross Section of reactions – Direct nuclear reaction – transmutation reactions: Stripping and pickup – high energy reactions : neutron evaporation and spallation –Theory of nuclear fission– Nuclear Fusion and stellar energy – The Pinch effect – Generation of electricity from nuclear fusion – Nuclear waste disposal – Artificial Disintegration and its methods – Devices used for radioactive measurements i) Countering Techniques such as G.M Ionization and Proportional counters ii) Tracer techniques (Neutron activation analysis).

Unit IV Reaction mechanismin Coordination Complexes

Labile and inert complexes – Thermodynamic and kinetic stability of complexes – mechanism of substitution reactions of metal complexes – D, Id, A and Ia mechanisms – Substitution reactions in octahedral and square planar complexes, acid-catalyzed reactions, base-catalyzed reactions – Trans effect and its influence, water exchange, anation, isomerization reactions. Redox reactions: Inner and outer sphere electron transfer mechanism – Template reactions.

Unit V Spectroscopy III

NMR –Principle, ^{31}P, ^{19}F and ^{15}N NMR - Applications of spin-spin coupling to structure determination: P_4S_3, BrF_5, Pentacyanohydridorhodate(III) ion, SF_4, TiF_4, H_3PO_3, H_3PO_2 – Comparison between ^1H and ^{15}N- NMR of $^{15}NH_3$ – Comparison between ^1H,^{31}P and ^{19}F- NMR of H_2PF_3 and HPF_2 –Double resonance – NMR of fluxional molecules such as PF_5, $(ή^1\text{-}C_5H_5)_2$ $(ή^5\text{-}C_5H_5)_2Ti$, $(ή^5\text{-}C_5H_5)_2Fe_2(CO)_4$ and PCl_2F_3.

EPR – Principle–Fine structure– Interaction between nuclear spin and electron spin (hyperfine coupling) – Hyperfine splitting of systems withI=1/2, 1 &3/2– Zero field splitting &Kramer's degeneracy – EPR spectrum deduction for $[Co(H_2O)^{2+}]$, $[Cr(H_2O)^{2+}]$ $[(NH_3)_5Co\text{-}O\text{-}O\text{-}Co(CN)_5]^{5+}$, $[(NH_3)_5Co\text{-}O\text{-}O\text{-}Co(NH_3)_5]^{5+}$ – Covalency of M-L bonding in bis(salicylaldimine)copper(II) complex by EPR study – Jahn-Teller distortion in Cu(II) complexes.

Text Books

1. James E. Huheey, Ellen A. Keiter, Richard L. Keiter. *Inorganic Chemistry: Principles of Structure and Reactivity.* Harper Collins College Publishers. 4th Edition 1993.
2. Rohatgi Mukherjee K.K. *Fundamentals of Photochemistry.* New age international limited. 2006.
3. Arnikar H.J. *Essentials of Nuclear Chemistry.* Wiley Eastern Ltd. 4th Edition 2000.

Books for Reference

1. Shriver D.F, Atkins P.W, Langford C.H. *Inorganic chemistry.* ELBS, Oxford University Press. 1994.
2. Gary L. Miessler, Donald A. Tarr. *Inorganic chemistry*. Pearson Publications, Third edition 2014.
3. Catherine Housecroft, Alan G. Sharpe. *Inorganic Chemistry*. Prentice Hall.4th Edition 2012.
4. Albert Cotton F, Geoffrey Wilkinson, Carlos. A. Manic, Manfred Bochman. *Advanced Inorganic Chemistry.* Wiley Interscience Publication. 6th edition 1999.
5. Purcell K.F, Kotz J.C. *Inorganic Chemistry*. WB Saunders Company. 1977.
6. Robert H. Crabtree. *The Organometallic Chemistry of the Transition Metals.* John Wiley & Sons Inc. Publication. 6thEdition 2014.
7. Lee J.D. *Concise Inorganic Chemistry*. Blackwell Science Ltd. 5thEdition, Reprint 2003.
8. Samuel Glasstone. *Source Book of Atomic Energy.* East West Pvt. Ltd. 1969.

SEMESTER – IV			
Core XI	**Organic Chemistry - IV**		
Course Code : 21PCHC42	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives:

- To understand the stereochemistry of reactants, intermediates and products.
- To understand the stereo-chemical aspects and its applications in organic synthesis.
- To learn the advanced spectroscopic techniques for analysis of organic compound.

Course Outcomes

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	to describe various reactions involved in addition to C=C bonds	2	Ap
CO 2	to demonstrate/apply the concepts involved in elimination reaction	2	Ap
CO 3	study about the outline of retrosynthetic analysis with some examples	7	An
CO 4	appraise the different retrosynthetic compounds	5	Ev
CO 5	to learn the concept of cycloaddition, electrocyclic and sigmatropic reaction mechanism	6	Cr
CO 6	explain the nomenclature, reactivity and spectral properties of heterocyclic compounds	3	Un
CO 7	demonstrate the synthesis and reactivity of heterocyclic compounds	2	Ap
CO 8	outline salient features of fragmentation pattern of organic compounds	8	Ev

SEMESTER – IV			
Core XI	**Organic Chemistry - IV**		
Course Code : 21PCHC42	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Unit I Addition and Elimination Reaction

Addition reaction –Addition to C=C bonds – Electrophilic, nucleophilic and free-radical additions - Additions to conjugated systems – Carbene addition to double bonds – Hydration of olefins.Reactions – Birch reduction – Hydroboration – Michael reaction – Diels-Alder reactions - Mannich reaction – Meerwein-Pondorf reduction – Reformatsky, Claisen, Stobbe, Darsen, Wittig, Thorpe and Benzoin condensations.

Elimination reactions – E1, E2 and E1CB mechanisms – Orientations – Hofmann and Saytzeff rules – Mechanism and orientation in pyrolytic elimination –Chugaev reaction – Cope elimination – Dehydration of alcohols – Dehydrohalogenation – Elimination versus substitution.

Unit II Retrosynthetic Analysis

Synthon – Synthetic equivalent – Functional group interconversions – Use of protecting groups for alcohols, amines, acids, carbonyl compounds – Use of activating and blocking groups – Robinson annulation reaction – Carbon skeletal complexity – Role of key intermediates in organic synthesis –Reterosynthetic analysis of the following compounds – Twistane, cis-Jasmone, Baclofan, Brufen, Trihexylphenydyl, Bisabolene, α-onocerin, isonootkatone, cascarillic acid, camphor.

Unit III Heterocycles and Nucleic acids

Heterocycles: Nomenclature, reactivity, aromaticity, spectral properties– Synthesis and electrophilic and nucleophilic substitution reactions of Indole, Oxazole, Thiazole, Pyrimidine, Pyrazine– Fused ring heterocycles.

Nucleic acids: Nucleic acids and nucleotides – Structure of nucleic acids – Base pairing in DNA – The Watson-Crick model– Nucleic acid and heredity – Replication of DNA– Structure and synthesis of RNA – Transcription– RNA and protein biosynthesis – Translation – DNA sequencing – DNA synthesis.

Unit IV NMR and C^{13} Spectroscopy

PMR spectroscopy – Basic principle – Number of signals – Chemical shift Chemical shift parameters and Internal Standards – Factors influencing chemical shift – Spin–spin coupling in AX, ABX, AMX type molecules – Coupling Constant – Geminal, vicinal and long range coupling – Nuclear Overhauser Effect (NOE) – FT-NMR – C^{13} NMR – 2D NMR – 2D-pulse sequences COSY – NOESY – INEPT and DEPT.

Unit V Mass Spectroscopy

Mass spectrometry – Basic principles–Instrumentation–Techniques of Ion production – EI, CI, FD, FAB, ESI-MS, MALDI-MS–Base peak – Molecular ion and parent ion– Metastable ion – Isotope ion – Daughter ion –Factors affecting fragmentation and governing reaction pathway– Factors governing reaction pathway–Nitrogen rule –Fragmentation pattern of various classes of organic compounds – Hydrocarbons, alcohols, amines, aldehyde, ketone, ether, ester, acids, phenols, amides – Mc-Lafferty rearrangement.

Combined Spectroscopy problems for UV, IR, NMR, C^{13} and Mass Spectroscopy

Text Books

1. Ahluwalia V.K, Parshar R.K. *Organic Reaction Mechanism.* New Delhi: Narosa Publishing House. Fourth Edition 2019.
2. Mukherjee Kapoor Singh. *Mechanism of Organic reactions*. Kolkata: Books and Allied Ltd. 2021.
3. Kalsi P.S. *Organic Reaction & Mechanism*. New Delhi: New Age International Publishers.4th Edition 2020.
4. Raj K Bansal. *Organic reaction mechanism*. New Delhi: New Age International Publishers, 4th Edition 2012.
5. Gurdeep Chatwal. *Organic Chemistry of Natural Products Vol II.* Bombay: HimalayaPublishing House, 2011.
6. Agarwal O.P. *Natural Products Volume I & II*. Meerat: Krishna Prakashan Media (P) Ltd. 2017.
7. Sharma Y.R. *Elementary Organic spectroscopy*. New Delhi: S. Chand & Company. 5th Edition 2013.
8. Jag Mohan. *Organic spectroscopy Principles and Applications*. New Delhi: Narosa Publishing House. Second Edition 2011.

Books for Reference

1. Finar I.L. *Organic Chemistry, Volume I.* India: Pearson Education India. 6th Edition, 2002.
2. Finar I.L.*Organic Chemistry, Volume II.* India: Pearson Education India. 5th Edition, 2002.
3. Warren Stuart. *Designing Organic Synthesis: A Programmed Synthon approach.* New York: John Wiley & Sons, 2013.
4. Jonathan Clayden, Nick Greeves, Stuart Warren. *Wothers Organic Chemistry*, New York: Oxford University Press, 2nd Edition 2021.
5. Norman R.O.C, Coxon J.M. *Principles of Organic synthesis*. Switzerland: Spinger and Business Media, LLC.3rd Edition 1994.

Semester – IV			
Core XII	**Physical Chemistry - IV**		
Course Code : 21PCHC43	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives:

- To understand the theories and applications of chemical kinetics.
- To elucidate the structure of chemical compounds by electron spin resonance spectroscopy.
- To gain knowledge about the principles of radiation chemistry and phase equilibrium.

Course Outcomes:

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	detect the use of chemical kinetics in understanding the reaction mechanisms.	2	Ev
CO 2	apply the theories and concepts of chemical kinetics for homogeneous and heterogeneous catalysed reactions.	4	Ap
CO 3	sketch the phase diagram for one, two and three component systems	5	An
CO 4	apply the concepts of statistical thermodynamics for the study of equilibrium reactions and reaction rates.	4	Ap
CO 5	formulate dosimetry and dosimeters in radiation chemistry	6	Cr
CO 6	interpret electron spin resonance and Mössbauer spectroscopies.	3	Ev
CO 7	examine the spin labeling studies of biomolecules using ESR spectroscopy.	7	An
CO 8	judge the structure of molecules by applying various spectroscopic techniques.	5	Ev

Semester – IV			
Core XII	**Physical Chemistry - IV**		
Course Code : 21PCHC43	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Unit I Chemical Kinetics

Theories of reaction rates – Arrhenius theory – Hard-sphere collision theory of gas phase reactions – Potential energy surfaces – Activated complex theory for ideal gas reactions (formation in terms of partition functions) – Relation between activated complex theory and hard sphere collision theory – Thermodynamic formulation – Activated complex theory (Enthalpies and entropies of activation) – Unimolecular reactions – Lindemann, Hinshelwood, RRK, RRKM and Slater theories – Kinetic isotopic effect.

Unit II Chemical and Phase Equlibria

Chemical equilibrium – Definition, Nature and characteristics – Law of mass action – De Donder's treatment of chemical equilibria – Thermodynamic relations for chemical affinity – Homogeneous equilibria – Heterogeneous equilibria – Linear free energy relationship (Hammett equation).

Phase rule – Conditions for equilibrium between phases – Gibbs phase rule – Derivation – One component system – Liquid Helium system – Two component system – Sodium sulphate-Water system–Three component system – Acetic acid-Chloroform-Water system.

Unit III Statistical Thermodynamics

Aim of statistical thermodynamics – Ensembles (Canonical, microcanonical and grand canonical ensembles) – Microstates and macrostates – Stirling's approximation – Maxwell-Boltzmann distribution law –Types of statistics – Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics – Comparison of B.E. and F.D. statistics with Boltzmann statistics –Partition function – Molecular, Translational, Rotational, Vibrational, Electronic and Nuclear partition functions – Thermodynamic properties E, H, S, A, G, Cv and Cp in terms of partition function – Thermodynamic properties of ideal monoatomic gas –Calculation of entropy of monatomic gases (Sackur-Tetrode equation) – Debye theory of heat capacity of solids – Statistical thermodynamics of Ortho and Para Hydrogen.

Unit IV Radiation Chemistry

Introduction – Differences between radiation chemistry and photochemistry – Sources of High energy radiation – Interaction with matter: Primary effects due to charged particles, Radiation Tracks Spurs and δ-rays – Interaction of γ-radiation with matter: Photoelectric effect, Compton Scattering and Pair Production – Units for measuring radiation absorption – Radiation Dosimetry – Units of radiation energy – Chemical Dosimetry – Radiolysis of water: Mean LET in water radiolysis, Ionic Products, Free radical products and Hydrated electrons – Applications of radiation chemistry.

Unit V EPR and Mossbauer Spectroscopy

Electron Spin Resonance Spectroscopy – Basic principles – Factors affecting "g" value –Hyperfine splitting –Deuterium, methyl, benzene, naphthalene, anthracene, o-, p- and m-xylene, p-benzosemiquinone radicals – McConnel equation: Calculation of electron density – Fine structure in ESR – Zero field shifting and Kramer`s degeneracy – Double resonance – ELDOR and ENDOR.

Mössbauer spectroscopy – Theory and Principle of Mössbauer spectroscopy – Isomer shift – Quadrupole interactions – Magnetic hyperfine interaction – Doppler shift – Recoil energy – Chemical applications.

Text Books

1. Gupta M.C. *Statistical Thermodynamics*. Wiley Easter Ltd. 1990.
2. Kuriacose, Rajaram. *Kinetics and Mechanism of Chemical Transformation*. Delhi: Macmillan & Co. 1993.
3. Banwell C.N. *Molecular spectroscopy*. New Delhi: TATA McGraw Hill Co. 1997.

Books for Reference

1. Lee J.F, Sears F.W, Turcottee D.L. *Statistical Thermodynamics*. 1972.
2. Donald McQuarrie. *Stastistical Thermodynamics.* New Delhi: Viva Books Private Ltd. Indian Edition 2003.
3. Ferrell L. Hill. *Introduction to Statistical Thermodynamics.* London: Addison-Wesley Publishing Company, INC. 1962.
4. Frost A.A, Pearson R.G. *Kinetics and Mechanism*. Wiley Eastern Pvt. Ltd. 1970.
5. Laidler K.J. *Chemical Kinetics.* New Delhi: TATA McGraw Hill Co. Third edition 1984.
6. SpinksJ.W.T, WoodsR.J. *Introduction to Radiation Chemistry*. John Wiley & Sons. 2nd Edition 1976.
7. Hughes G. *Radiation Chemistry*. Oxford University Press. 1973.
8. Drago R.S. *Physical Methods in Inorganic Chemistry*. New Delhi: East West Press Ltd.1971.
9. Chang R. *Basic Principles of Spectroscopy*. New Jersy: Englewood Cliffs.1978.
10. Straughan B.P, Walker S. *Spectroscopy.* New York: London Chapman and Hall, A Halstet Press Book, John Wiley & Sons Ins. Volume 1, 2, 3. 1975.
11. Barrow G.M. *Introduction to Molecular Spectroscopy*. Tata McGraw Hill Edition. 1993.
12. Gurdeep R Chatwal, Sham K Anand. *Spectroscopy*. Himalaya Publishing House. 2009.
13. Gupta M.C. *Statistical Thermodynamics*. New Delhi: New Age International Pvt. Ltd. 1995.
14. Moore W.J. *Physical Chemistry*. Orient Longman. 5th Edition 1976.
15. Castellan G.W. *Physical Chemistry*. Addison Wesley. 3rd Edition 1983.

Semester – III			
Elective III	**A. Research Methodology**		
Course Code : 21PCHE31	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Objectives:

- To provide resources to the students to stimulate basic research interest and other creative endeavours that promote entrepreneurial culture.
- To explain about various thermal and electrochemical instrumentation techniques.
- To learn about all the hyphenated techniques used for the separation of compounds.
- To interpret the results of analysis with accuracy.

Course Outcome:

CO No.	Upon completion of this course, students will be able to	PSOs addressed	CL
CO 1	select the research topic and able to survey the literature.	3	Ev
CO 2	submit the project proposals to the funding agency.	8	Ap
CO 3	explain about the principle, instrumentation and applications of TGA, DTA and DSC.	3,6	Un
CO 4	compare principle, instrumentation and applications of potentiometry, coulometry and voltammetry.	5	An
CO 5	describe different types of Atomic spectroscopy.	1,5	Un
CO 6	interpret data using TEM, SEM, XRD and EDAX techniques.	5,7	Ev
CO 7	improve the accuracy of data in chemical analysis.	5	Ev
CO 8	defend teaching methods.	6,7	Ev

Semester – III			
Elective III	**A. Research Methodology**		
Course Code : 21PCHE31	**Hrs / Week : 4**	**Hrs / Sem : 60**	**Credits : 4**

Unit I Research methodology

Introduction of research–Selection of a research topic – Surveying the literature– Sources– primary source and secondary source – Identification of research problem – Actual investigation and analysis of experimental results – Reporting the results in the form of communication, paper – Dissertation and thesis writing– Project proposals to funding agency – Impact factor, citations and h-index –Publication and Indexing: Scopus, Web of Science and Google scholar – Concepts of IPR and Plagiarism.

Unit II Thermo and electro analytical methods

Thermoanalytical Methods –Principle, instrumentation and applications of Thermogravimetry (TGA), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC).

Electroanalytical Techniques – Coulometry – Principle, Instrumentation and Applications. Voltammetry– Types (Stripping voltammetry, Cyclic voltammetry, Amperometry) – Principle, instrumentation and applications

Unit III Spectroscopic & Surface techniques

Principle, instrumentation and applications of Atomic Absorption Spectroscopy, Atomic Fluorescence Spectroscopy and Atomic Emission Spectroscopy.

Principle, instrumentation and applications of Energy dispersive spectroscopy (EDAX), Transmission electron microscopy (TEM), Scanning electron microscope (SEM) and Scanning Probe Microscopes.

Unit IV Data Analysis

Errors in chemical analysis – Classification of errors –Methods for determination of accuracy– Improving accuracy of analysis – Comparison between precision and accuracy – Significant figures – Mean, median, mode and standard deviation – Confidence interval – Propagation of measurement uncertainties – Comparison of results – “t” test, “f” test and “chi” square test – Rejection of results – Presentation of data – Correlation analysis and correlation coefficient – Linear regression – Related Problems.

Unit V Research and Teaching Methodology

Teaching – Objectives of Teaching - Phases of Teaching – Teaching methods: Lecture Method, Discussion Method, Discovery Learning, Inquiry, Problem Solving Method, Project method, Seminar – Integrating ICT in Teaching: Individualized Instruction, Ways for Effective Presentation with Power Point – Documentation – Evaluation: Formative, Summative & Continuous and comprehensive Evaluation – Later Adolescent – Psychology: Meaning, Physical, Cognitive, Emotional, Social and Moral Development – Teaching Later Adolescents.

Text Books

1. Gurdeep R. Chatwal, Sham K.Anand. *Instrumental Methods of Chemical Analysis.* Mumbai: Himalaya Publishing House.5th edition 2014.
2. Skoog D.A, West D.M.F, Holler J, Crouch. S.R. *Fundamentals of Analytical Chemistry.* Thomson Asia Pvt. Ltd. Eighth Edition, Third Reprint 2005.
3. Banwell C.N, *Fundamentals of molecular spectroscopy.* Noida: McGraw Hill Education, 4th Edition 1994.

Books for Reference

1. Anderson J, Durston B.H, Poole. M. *Thesis and Assignment Writing.* New Delhi: Wiley Eastern. 1986.
2. Sharma B.K. *Instrumental Methods of Chemical Analysis.* Goel Publishing House, 23rdEdition 2004.
3. Willard H, Merrit Jr. L, Dean. A. *Instrumental methods of analysis.* CBS Publishers and Distributers. 2004.
4. Rajammal P. Devadas. *A Handbook of Methodology of Research.*Chennai: S.R.K. Vidyalaya Press. 1976.
5. Dominoswki R.L. *Research Methods.* Prentice Hall. 1981.
6. Ebel H.F, Bliefert C, Russey W.E. *The Art of Scientific Writing.* Weinheim: VCH. 1988.
7. Joseph A, *Methodology for Research.* Bangalore: Theological Publications. 1986.
8. Douglas A. Skoog, James Holler F, Stanley R. Crouch. *Instrumental Analysis.* New Delhi, Cengage Learning India Private Limited. Eighth Indian Reprint 2011.
9. Asim K. Das, Mahua Das. *Fundamental Concepts of Inorganic Chemistry.* New Delhi: CBS Publishers & Distributers Pvt. Ltd. Volume 7, First Edition Reprint 2019.

Semester III			
Elective III	**B. Chemical Instrumentation**		
Course Code:21PCHE32	**Hrs/Week:4**	**Hrs/Sem:60**	**Credits:4**

Objectives:

- To impart the students with basic principles and concepts in Instrumental techniques.
- To understand the nature and Choice of methods of measurements.
- To learn the limits of detection and amplification.
- To demonstrate the concepts of Operational amplifiers.

Course outcome:

CO No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO1	demonstrate automatic operation and computer control	1,5	Ap
CO2	precise control of current and voltage.	6,8	Ap
CO3	differentiate modulation and demodulation	5	An
CO4	point out limitation on amplifier performance	1	Cr
CO5	predict binary logic concepts, logic gates and multi-vibrators	7	Un
CO6	distinguish visual, filter and spectrophotometers.	6	Ap
CO7	control noise level in a system.	1,7	Cr
CO8	interpret the optimal value of adjustable parameters	7,8	Ev

Semester–III			
Elective III	**B. Chemical Instrumentation**		
Course Code: 21PCHE32	**Hrs/Week: 4**	**Hrs/Sem: 60**	**Credits: 4**

Unit I Measurement and Instrumentation

Introduction - The nature of a measurement - Choice of a method of measurement - Control of variables - Basic design patterns - General properties of modules - Propagation of uncertainity - Single channel design - Limit of detection and amplification - Automatic operation and computer control.

Unit II Operational amplifiers

The operational amplifiers – Limitations on amplifier performance – Mathematical operations - Differentiation - Integration - Measurement of current and voltage - Precise control of current and voltage.

Unit III Signal-to-Noise Optimisation

Sensitivity and detection limits – Noise – Minimising Noiseinasystem – Signal averaging - Modulation: Chopping - Demodulation: Phase sensitive detection-Other methods of Optimising Signal-to-Noise ratio.

Unit IV DigitalElectronics

Binary logic concepts - Logic gates - Multivibrators - Counters - Wave shaping – Analog to digital convertors – Instruments and Digital computers.

Unit V Instrumentation for Optical Absorption Spectrometry

VisualPhotometers-FilterPhotometers-Spectrophotometer-DoublebeamSpectrophotometer - Recording Spectrophotometers - Optimal value of adjustable parameters – Multiple internal reflection assembly – Rapid scanning spectrometer – Non-dispersive Photometers – Photometric titration equipment – Fourier transform Spectrometers.

Textbooks

1. Strobel H.A. *Chemical instrumentation-A systematic approach to Instrumentation Alanalysis.* Phillipines: Addison-Wesley Publishing Company Inc. 2nd Edition 1973.

Books forReference

1. Jeffery G.H, Bassett J, Mendham J, Denney R.C. *Vogel's Text book of Qualitative chemical analysis.* Essex: Longman Scientific and technical. 5th Edition1989.
2. Skoog D.A, Hollar F.J, Crouch S.R. *Principles of Instrumental analysis.* Belmont CA: Thompson Brooks/Cole. 6th Edition 2007.

Semester III	
Self-Study Course – Course on Competitive Exams	
Code: 21PCHS31	**Credits: 2**

Objectives:

- To provide a platform to the students for building the fundamentals of basic mathematics for competitive examinations preparation strategy.
- Establish a framework to help students acquire knowledge and expertise necessary to secure employment opportunities in the government sector.

Course Outcome:

CO No.	Upon completion of this course, students will be able to	PSO addressed	CL
CO 1	solve real life problems requiring interpretation and comparison of various representations of ratios	2,6	Ap
CO 2	distinguish between proportional and non-proportional situations and when appropriate apply proportional reasoning	6	An
CO 3	solve problems applying probabilistic reasoning to make decisions	2	Ap
CO 4	evaluate claims based on empirical, theoretical and subjective probabilities	6,4	Re
CO 5	create and use visual displays of data	4	Cr
CO 6	solve problems using high speed mental calculations	6	Ap
CO 7	understand the basic concepts of logical reasoning skills	1,4	Un
CO 8	acquire satisfactory competency in use of data analysis	7	Un

Semester III	
Self-Study Course **Course on Competitive Exams**	
Code: 21PCHS31	**Credits: 2**

UNIT I

Number System (Including divisibility) – HCF and LCM (Including Factors, Multiples and Prime Factorization).

(Chapter: 1 & 2, pages 1 – 46)

UNIT II

Fractions and Decimals – Square and Square roots, Cube and Cube Roots, Indices and Surds.

(Chapter: 3 & 4, pages 47 – 94)

UNIT III

Time, Work and Wages (Including Pipes & Cistern) – Time, Speed and Distance (Including Trains, Boats and Stream, Circular Motion, Races and Games.

(Chapter: 15 & 16, pages 317 - 374)

UNIT IV

Permutations & combinations and Probability.

(Chapter: 18, pages 391 - 416)

UNIT V

Set Theory (Including Venn Diagram) – Data Analysis and Data Interpretation (Including Caselet, Table, Line Graph, Bar Graph, Mixed Bar).

(Chapter: 24 & 27, pages 559 – 570, 615 – 648)

Text Books:

1. Er.Deepak Agarwal, Gupta D.P. *Rapid Quantitative Aptitude with Shortcuts and Tricks for Competitive Exam.* Disha Publication.

Books for Reference

1. Dr. Aggarwal R.S. *Quantitative Aptitude for Competitive Examinations* S. Chand Publication.

2. Rajesh Verma, *Fast Track Objective Arithmetic.* Arihant Publication.