M.Sc. Chemistry

(Inorganic, Organic, Physical and Analytical Chemistry)

Choice Based Credit System

(CBCS)

Revised Syllabus

(w.e.f. 2019-20)

Specific Course Outcome (Inorganic Chemistry)

Paper code and name	**PG75T101A: Inorganic Chemistry–I**
COURSE OUTCOMES	
After studying this paper, students would learn ➢ Properties of ionic compounds. ➢ Relationship between radius ratio and structure of ionic compounds. ➢ Structure and bonding in covalent inorganic compounds, based on various bonding theories viz. VSEPR, VBT and MOT. ➢ Band theory and its use in classification of materials such as conductors, insulators and semiconductors. ➢ Basics of organometallic chemistry, viz. 18 and 16 electron rules. ➢ Synthesis, structure, bonding and reactions of representative organometallics. ➢ Bonding theories in coordination compounds viz. MOT ➢ Basics of electronic spectra and magnetism. ➢ Stability of metal complexes, with reference to nature of metal and ligand. ➢ Theories of acids and bases. ➢ Basics of solid state chemistry, crystallographic methods, crystal defects and band theory.	

PARTICULARS

UNIT–I

Structures and Energetics of Ionic Crystals and Covalent Bonds:

Ionic Bond: Properties of ionic compounds, crystal lattices, closed packed structures, coordination number of an ion, radius ratio rule, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy: Born Lande equation, Born-Haber cycle, uses of Born-Haber type of calculations. Covalent character in ionic bonds, Fajan's rules, hydration energy and solubility of ionic solids.

Covalent Bond: Valence bond theory, resonance, hybridization and energetics of hybridization.VSEPR theory: Deduction of molecular shapes. MOT of homo and heteronuclear molecules and MO treatment for the molecules involving delocalized π-bonding (CO_3^{2-}, NO_3^- and CO_2).

Walsh diagrams and Bent's rule.

(12 Hours)

UNIT–II

Coordination Chemistry:

Coordination numbers 2–10 and their geometries. Crystal field theory of coordination compounds: octahedral, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields, measurement of 10 Dq and factors affecting it, CFSE, Spectrochemical series and Jahn–Teller effect.

Structural evidences for ligand field splitting: hydration, ligation and lattice energies. Evidences for covalency in M–L bonding. MO theory of coordination compounds: MO energy level diagrams for octahedral and tetrahedral complexes without and with pi–bonding.

Electronic Spectra: Spectroscopic ground terms, Orgel diagrams for transition metal complexes(T_d&O_h).

Magnetism: Types, spin moment, spin–orbit coupling.

(12 Hours)

UNIT–III

Stability of Metal Complexes, Concepts of Acids and Bases and Non-aqueous Solvents:

Stability of complexes: Step-wise and overall formation constants, factors affecting stability of metal complexes, determination of stability constants of metal complexes by spectrophotometric and polarographic methods.

Concept of acids and bases: Theories of acids and bases, Bronsted and Lewis acids and bases, Lux–Flood theory, leveling effect of solvents, hardness and softness, HSAB concept and its applications.

Non-aqueous solvents: Classification of solvents, properties of non-aqueous solvents. Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, anhydrous HF, liquid sulphur dioxide. Super acids.

(12 Hours)

UNIT–IV

Solid State Chemistry:

Crystal lattice: Unit Cell, Miller indices and planes, X–ray diffraction method, molecular solids, hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, determination simple structure, spinel and perosvskite structures.

Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors.

Perfect and imperfect crystals, intrinsic and extrinsic defects, point–, line– and plane– defects. Vacancy, Schottky and Frenkel defects. Schottky and Frenkel defect formation, colourcentres, non–stoichiometry.

(12 Hours)

Total 48 Hours

***Recommended Books**:*

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4thEdn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5th Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F. Armstrong.Oxford University Press (2010)
3. Inorganic Chemistry, 2ndEdn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)
4. Concise Inorganic Chemistry–J. D. Lee, 5thEdn, New Age International (1996).
5. Solid State Chemistry and its Applications–A. R. West, John-Wiley and sons.

6. Solid state Chemistry–N. B. Hannay, Prentice-Hall of India Pvt. Ltd. New Delhi.

Paper code and name	PG75P101A: Lab Course in Inorganic Chemistry

COURSE OUTCOMES

- Student would learn to separate and determine the metal ions using gravimetric and volumetric methods such as
  - Fe(II) + Ni (II)
  - Fe(II) + Cu(II)
  - Zn(II) + Cu(II)
  - Zn(II) + Ni(II)
- Students are also exposed to synthetic methodologies of the preparation of coordination compounds.

PARTICULARS

1. Determination of iron in hematite ore using cerium(IV) solution (0.02M) as the titrant and gravimetric determination of insoluble residue.
2. Determination of calcium and magnesium carbonates in dolomite ore using EDTA titration and gravimetric analysis of insoluble residue.
3. Quantitative analysis of copper-nickel in alloy/mixture:
   i. Copper volumetrically using KIO_3
   ii. Nickel gravimetrically using DMG
4. Determination of lead and tin in a mixture: Analysis of solder using EDTA.
5. Determination of Cr(III) and Fe(III) in a mixture: Kinetic masking.
6. Quantitative determination of iron(III) gravimetrically and calcium(II) volumetrically in a mixture.
7. Determination of iron(II) and nickel (II) in a mixture:
   i. Iron(II) volumetrically using $K_2Cr_2O_7$ solution
   ii. Nickel gravimetrically using DMG solution
8. Quantitative analysis of chloride and iodide in a mixture:
   i. Iodide volumetrically using KIO_3
   ii. Total halide gravimetrically
9. Preparation of complexes:
   i) Tris (thiourea) copper(I)sulphate monohydrate and

ii) Tris (oxalato) aluminate (III)

Recommended Books:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.

2. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc, India.

3. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D

4. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, 2003, Pearson Education Pvt. Ltd., New Delhi.

5. Practical Inorganic Chemistry– G. Pass and H. Sutcliff, Chapman and Hall Ltd (1968)

Paper code and name	**PG75T201A:Inorganic Chemistry–II**

COURSE OUTCOMES

After studying this paper, students would learn

- Synthesis, properties and structures of compounds of non-transition elements such as B, Si, P, N, S, Halogens and Noble gases.
- Structure and Properties of interhalogen compounds, oxyacids.
- Synthesis, structure and bonding in transition metal organometallic compounds.
- Classification of molecules on the basis of point groups.
- Applications of group theory in chemical bonding and spectroscopy (IR and Raman).

PARTICULARS

UNIT–I

Chemistry of Non-Transition Elements:

Alkali and alkaline earth metal complexes of crown ethers, cryptands and calixarenes and their biological importance.

Synthesis, properties and structures of boron, carbon and silicon compounds: Chemistry of higher boranes, classification, structures and MO description of bonding, framework electron counting, Wade's rules, chemistry of B_5H_9, $B_{10}H_{14}$ and $B_nH_n^{2-}$, boron nitride, borazines, carboranes, metalloboranes, metallocarboranes; silicates, silicones, graphite, graphene, carbon nanotubes and zeolites.

Hydrogen bonding and its influence on properties.

(12 Hours)

UNIT–II

Chemistry of Main Group Elements:

Nitrogen, phosphorous and sulphur compounds: Hydrides, oxides and oxy acids of nitrogen, phosphorous, sulphur and halogens. Phosphazines, phosphazene polymers, sulphur–nitrogen compounds: Binary sulphur nitrides: S_4N_4, S_2N_2 and $(SN)_x$. P–O and P–S cage compounds.

Chemistry of halogens and xenon: Interhalogens, psuedohalogens, polyhalide ions, oxyhalogen species. Xenon oxides and fluorides.

(12 Hours)

UNIT–III

Symmetry and Group Theory:

Molecular symmetry, representation of symmetry operation as matrices. Definition of groups, set of symmetry operations of molecules satisfying the condition of point groups. Representation, basis of representation, reducible and irreducible representation. The great orthogonality theorem, character tables. The direct product. Applications of group theory: Molecular vibrations; molecular vibration in symmetrical AB_2. Hybridisation (tetrahedral and trigonal planar geometries)

(12 Hours)

UNIT–IV

Organometallic Chemistry:

Organometallic compounds: Introduction, classification of organometallic compounds by bond type, nomenclature, classification of ligands σ and π ligands, hapticity of ligands, 18 and 16 electron rules, electron counting schemes. Ferrocene and ruthenocene: Preparation, structure and bonding. Complexes containing alkene and alkyne ligands: Preparation, structure and bonding. Carbene (Fischer and Schrock type) complexes: Synthesis, structure and bonding. The isolobal principles.

Use of organometallic reagents in hydrogenation, hydroformylation, isomerisation and polymerization reactions.

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4thEdn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).

2. Shriver & Atkins' Inorganic Chemistry, 5th Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F.Armstrong.Oxford University Press (2010)

3. Inorganic Chemistry, 2nd Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)

4. Concise Inorganic Chemistry–J. D. Lee, 5th Edn, New Age International (1996).

5. Chemical Applications of Group Theory, 2nd Edn-F. A. Cotton, Wiley Eastern Ltd ( ).

6. Symmetry and Spectroscopy of Molecules–K. Veera Reddy, New Age International, (2011).

7. Group Theory in Chemistry–M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)

8. Organometallic Chemistry–A unified Approach, R.C. Mehrotra and A. Singh, 2nd Edn. New Age International (2011).

9. F.A.Cotton and G.Wilkinson : Advanced Inorganic Chemistry, Wiley, 1991.

10. Basic Organometallic Chemistry – B D Gupta and A J Elias, Universities Press (2013)

Paper code and name	**PG75P201A: Lab Course in Inorganic Chemistry**

COURSE OUTCOMES

- Students would learn semi- micro qualitative analysis of salt mixtures, containing three cations and two anions viz. W, Pb, Cu, Cd, Mo, As, Fe, Cr, Ti, Zr, Ce, V, Ni, Zn, Co, Ca, Sr, Ba, Mg, K, Na, Li and halides, nitrate, sulphate, phosphate, oxalate, borate, acetate.

PARTICULARS

1. Semimicro qualitative inorganic analysis of a mixture containing three cations (including one less common cation such as W, Mo, Ti, Zr, Ce, V and Li) and two anions (one of them may or may not be interfering anion such as PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^- and CH_3COO^-).

2. Separation and determination of Zn and Mg on an anion exchanger.

3. Demonstration experiment: Determination of iron as the 8–hydroxyquinolate by solvent extraction.

Recommended Books:

1. Vogel's Text Book of Quantitative Chemical Analysis(5th Ed), G.H.Jeffrey, J.Bassette, J.Mendham and R.C.Denny, Longman, 1999.
2. Vogel's Qualitative Inorganic Analysis(7th Ed), G.Svehla, Longman (2001)

Paper code and name	**PG75O201A: Applied Inorganic Chemistry**

COURSE OUTCOMES

- Separation techniques such as ion exchange and solvent extraction.
- The principles and classification of chromatographic methods such as paper, thin layer, column and liquid chromatography.
- Analysis of data using different techniques.
- thermal methods of analysis
- The essential role of trace metals in biological processes.
- The transport and storage of dioxygen in Heame proteins.
- The structure and functions of Heamoglobin, Myoglobin, Hemocyanin etc.
- The structure and functions of metalloproteins in electron transport processes.
- The principles of transition metal coordination complexes in understanding functions of biological systems.
- The role of metals in medicines.

PARTICULARS

UNIT–I

Data Analysis:

Types of errors, accuracy and precision, methods of minimization of systematic errors, mean and standard deviation, distribution of random errors, reliability of results, comparison of results-Student t-test, F-test and chi–square test, significant figures, confidence intervals, method of least squares, calibration curve and standard addition method.

(12 Hours)

UNIT–II

Thermal Methods of Analysis and Inorganic Polymers:

Thermal methods of analysis: Thermobalance, factors influencing thermogravimetric results, differntial thermal analysis: Instrumentation for differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Applications of TG, DTA and DSC.

Inorganic Polymers:Silicones, polyphosphazenes, synthesis, structure and applications.

(12 Hours)

UNIT–III

Bioinorganic Chemistry:

Metal ions in biological systems, deficiency of trace metal ions (Fe, Zn, Cu and Mn), metal ions and chelating agents in medicine: Treatment of toxicity due to inorganics (chelation therapy) and metal complexes as therapeutic agents.

Proteins and their functions**:** Heme proteins, oxygen uptake proteins-hemoglobin and myoglobin,

(12 Hours)

UNIT–IV

Chromatography:

Gas chromatography**:** Principles, instrumentation, stationary phases and types of carrier gases used in GC. Methods of sample injection, types of detectors, programmed temperature GC, plate and plate height theory in GC. Applications of GC and use of GC-MS in detection of samples.

(12 Hours)

Total 48 hours

Recommended Books:

1. Vogel's Texbook of Quantitative Analysis. 6th Edition–J. Mendham, R. C. Denney, J. D. Branes and MJK Thomas.Publisher: Pearson Education.
2. Contemporary polymer Chemistry, Third edition–H. R. Allcock, F. W. Campe and J. E. Mark, Publisher: Pearson Education.
3. Inorganic Chemistry, 4thedn–J. E Huheey, R. L. Keiter and A. L. Keiter, Addison Wesley, 2000.
4. Inorganic Chemistry of Biological Processes, 2ndedn. –M. N. Hughes, Wiley, 1988.
5. Bioinorganic Chemistry–I. Bertini. H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books, 1998.
6. Bioinorganic Chemistry–A.K. Das, Books and Allied (P) Ltd, 2007.
7. Principles of Instrumental Analysis-Skoog, Holler and Nieman, Harcourt Afca, 2001.

8. Vogel's Text Book of Quantitative Inorganic Analysis., 4thEdn. –J. Bessett, R. C. Denney, G. H. Jeffery and J. Mendham, Longman Green and Company Ltd.

9. Quantitative Chemical Analysis, 6thEdn-D. C. Harris, W. H. Freeman and Company, New York, 2003.

Paper code and name	**PG75T301A: Advanced Coordination & Bioinorganic Chemistry**

COURSE OUTCOMES

After studying this paper, students would learn,

- To interpret the electronic spectra and magnetic properties of coordination compounds.
- Indetail about the reaction mechanism of Inorganic metal complexes and to understand the substitution reaction mechanism along with the involvement of reactive intermediates.
- Also, to understand their structure and reactivity through various inorganic reactions. This course gives idea about the way in which a reaction proceeds and its kinetics, especially for inorganic substitution reactions.
- The essential role of trace metals in biological processes.
- The transport and storage of dioxygen in Heame proteins.
- The structure and functions of Heamoglobin, Myoglobin, Hemocyanin etc.
- The structure and functions of metalloproteins in electron transport processes.
- The principles of transition metal coordination complexes in understanding functions of biological systems.
- The role of metals in medicines.

PARTICULARS

UNIT–I

Electronic spectra and magnetic properties:

Spectral properties of complexes: Term symbols for d^n ions, spectroscopic ground states, selection rules, nature of spectral bands- band shapes, band intensities, band widths, spin-orbit coupling, Orgel diagrams, Tanabe–Sugano diagrams, Racah parameters, interpretation of spectra of octahedral, distorted octahedral, tetrahedral and square planar complexes, determination of 10Dq, B′ and nephelauxetic parameterfrom absorption spectra of octahedral and tetrahedral complexes, charge transfer bands: Origin, types, and characteristics, intervalence charge–transfer bands.

Magnetism: Determination of magnetic susceptibility (Gouy and Faraday methods), diamagnetic corrections,orbital contribution, ferro–ferri– and anti–ferro magnetism, Curie law, Curie–Weiss law, effect of temperature on dia–, para–, ferro– and anti–ferromagnetic compounds, temperature independent paramagnetism, effect of spin orbit coupling on spectral and magnetic properties and spin cross–over systems.

(12 Hours)

UNIT II: Inorganic reaction mechanisms

Basic principles, lability, inertness, substitution reactions of octahedral complexes. Nature of substitution reactions: Theoretical approach to substitution mechanisms, mechanism of substitution reaction of complexes of cobalt: Acid hydrolysis and base hydrolysis of Co(III) complexes, substitution reactions of square planar complexes, reaction of Pt(II) complexes, trans–effect, theories of trans–effect, mechanism and kinetics of substitution of Pt(II) complexes. Electron tunneling hypothesis: Marcus–Hush theory, atom transfer reaction, one– and two–electron transfer. Inner sphere and outer sphere mechanisms.

(12 Hours)

UNIT–III

Bioinorganic chemistry–I

Metal ions in biological systems, essential and trace metals, disease due to metal deficiency and treatment: Iron, zinc, copper, manganese, sodium, potassium, magnesium and calcium. Metal complexes as therapeutic agents: Metal complexes in cancer therapy, metal complexes for the treatment of rheumatoid arthritis, vanadium in diabetes, metal complexes as radio diagnostic agents. Treatment of toxicity due to inorganics: Chelation therapy and requirements of a chelate/antidote. Mechanism of antidotes with poison rendering it inert: Arsenic, lead, mercury, iron, copper, plutonium, cyanide and carbon monoxide poisoning.

Ion transport across membranes and active transport of ions across biological membranes, ionophores.

Metal complexes in transmission of energy: Chlorophyll, photosystems–I and II in cleavage of water and model systems.

(12 Hours)

UNIT–IV

Bioinorganic chemistry–II

Transport and storage of dioxygen, heme proteins, oxygen uptake, functions of haemoglobin, myoglobin, hemerythrin and hemocyanins, synthetic oxygen carriers. Metal storage and transport: Ferritin, transferrin and ceruloplasmin. Electron transfer proteins:

Cytochromes, iron–sulphur proteins. Metalloproteins as enzymes: Carboxy peptidase, carbonic anhydrase, catalases, peroxidases, cytochrome P–450, cytochrome c–oxidase, superoxide dismutase, copper oxidases and vitamin B_{12} coenzyme.

Biological nitrogen fixation, in *vivo* –andin *vitro* – nitrogen fixation.

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Inorganic Chemistry-Principles of Structure and Reactivity, 4thEdn–J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5th Edn–P. Atkins, Tina Overton, J. Rourke, Mark Weller and F.Armstrong.Oxford University Press (2010)
3. Electronic absorption Spectroscopy and Related Techniques–D. N. Satyanarayana, OUP, 2001.
4. Concepts and models of Inorganic Chemistry–B.Douglas, D. McDaniel &J.Alexander, 3rdEdn. Wiley Student Edn.(2013).
5. Elements of Magnetochemistry–R. L. Dutta and A Syamal : Affiliated East-West, 1993.
6. Inorganic Chemistry of Biological Processes, (2ndedn.)–M. N. Hughes, Wiley, 1988.
7. Bioinorganic Chemistry–Asim K. Das, Books and Allied (P) Ltd, (2007).
8. Principles of Bioinorganic Chemistry–S. J. Lippard and J. M. Berga. Panima Publishing Corporation.

Paper code and name	**PG75T302A: Molecular Spectroscopy**

COURSE OUTCOMES

After studying this paper, students would be able to

- apply IR, NMR, UV-Vis, EPR, NQR and Mossbauer spectroscopie techniques in solving the structures of organic and inorganic compounds.
- interpret the spectroscopic data of unknown compounds.

- use these techniques in their future research work.
- solve the spectroscopic problems in NET/SET/GATE exams.

PARTICULARS

UNIT–I

Introduction and Vibrational Spectroscopy:

Basic concepts and Introduction:Properties of electromagnetic radiation, Wave property: Interference and diffraction. Particle property: Photoelectric effect. Regions of the electromagnetic spectrum, energies corresponding to various kinds of radiation. Interaction of electromagnetic radiation with matter (absorption, emission, transmission, reflection, dispersion, polarisation and scattering). General application. **2 Hours**

Vibrational spectroscopy:Infrared spectroscopy: Vibrational energy levels, infrared spectra of diatomic and polyatomic molecules, normal modes of vibration, force constant, selection rules, anhormonicity, the vibration–rotation spectroscopy. Infrared spectra of simple molecules and coordination compounds, changes in infrared spectra of donor molecules upon coordination (N,N–dimethylacetamide, urea, DMSO, pyridine N–oxide, ammine, cyano, cyanato and thiocyanato complexes), mono and multinuclear carbonyl complexes, nitrosyls, phosphine and arsine complexes. Change in spectra accompanying change in symmetry upon coordination (NO_3^-, SO_4^{2-}, NO_2^-, and ClO_4^-), hydrogen bonding. Instrumentation including FTIR.

Raman spectroscopy:Theory, relation with IR spectroscopy, resonance Raman stimulated hyper and inverse Raman effects. Experimental techniques, structure determination from IR and Raman spectra.

(12 Hours)

UNIT–II

Magnetic Resonance spectroscopy–I:

Nuclear magnetic resonance spectroscopy: Magnetic properties of nuclei, population of energy levels, the Larmor precession, relaxation processes, chemical shift, shielding mechanism, spin–spin interactions, rules governing the interpretation of first order spectra, effect of chemical exchange on spectra. Analysis of complex NMR spectra, ^{1}H–NMR spectra of organic molecules and complex metal ligands. Spin–systems: First order and second order patterns. Long range coupling : Spin decoupling, CIDNP and NOE. NMR shift reagents.

NMR studies of nuclei other than proton, ^{13}C–NMR (including heteronuclear coupling with other nuclei viz., ^{19}F and ^{31}P): Broad band and off resonance, decopouling methods, use of ^{13}C–NMR in structural determination of organic and inorganic molecules. ^{19}F, ^{31}P, ^{11}B, ^{15}N. Spectra of paramagnetic complexes, contact shift, double resonance technique. Instrumentation including FT–NMR.

Correlation NMR spectroscopy: ^{1}H–^{1}H (COSY) and ^{13}C–^{1}H (HETEROCOSY) methods.

(12 Hours)

UNIT–III

Magnetic Resonance spectroscopy–II and Mössbauer Spectroscopy:

Electron Paramagnetic Resonance (EPR) Spectroscopy: Basic principles, selection rules, intensity, width, position of spectral line, multiplet structure of EPR spectra, hyperfine interaction, spin–orbit coupling, zerofield splitting and Kramer's degeneracy, rules for interpreting spectra, factros affecting the magnitude of values. Instrumentation. Applications to the study of free radicals, coordination compounds, biological studies and rate of electron exchange reactions.

Nuclear Quadrupole Resonance (NQR) Spectroscopy**:** Quadrupole nuclei, quadrapole movement, electric field gradient, the NQR experiment, structural information from NQR spectra.

Mössbauer Spectroscopy: Introduction, principles, conditions for Mössbauer spectroscopy, parameters from Mossbauer spectra, isomer shifts, electric quadrupole interaction, magnetic interactions, Mossbauer spectrometer. Applications in structure determination of $Fe_3(CO)_{12}$, Prussian blue, oxyhemerythrin, hexacyanoferrates, nitropruside, tin halides.

(12 Hours)

UNIT–III

Electronic Spectroscopy and Mass Spectrometry:

Electronic spectroscopy:Molecular electronic absorption spectroscopy (UV–Visible), electronic spectra of diatomic molecules, electronic transitions, selection rules, assignment of transition, band intersities, substituent and solvent effect and change transfer transitions. Application to organic and inorganic molecules.

Photoelectron spectroscopy:Basic principles: Photo–electric effect, ionisation process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA and chemical information from ESCA. Instrumentation. Auger electron spectroscopy, basic ideas.

Mass Spectrometry:Ionization and mass analysis. Instrumentation. Methods of ionization: EI, CI, DI, SI methods.

Fragmentation: Principles, odd electron ($OE^{\cdot+}$)and even electron (EE^{+}) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Fragmentation of inorganic and oraganic compounds: (i) normal and branched alkanes. (ii) alkenes. (iii) benzene and its derivatives. (iv) alcohols. (v) aldehydes. (vi) ketones. (vii) acids. (viii) esters. (ix) ethers. (x) amines. (xi) nitro compounds. (xii) halo compounds.

(12 Hours)

Total 48 Hours

***Books Recommended**:*

1. Fundamentals of Molecular Spectroscopy - C. N. Banwell.
2. Physical Methods in Chemistry - R .S. Drago, Saunder college.
3. Structural Methods in Inorganic Chemistry - E. A. Ebsworth, D. W. H. Ranbin and S.Cradock, ELBS.
4. Infrared Spectra of Inorganic and Coordination Compounds - K. Nakamoto.
5. Infrared Spectroscopy - C.N.R. Rao.
6. Electron Absorption Spectroscopy and Selected Techniques - D. N. Satyanarayana, University Press India Ltd. Hyderabad.
7. Introduction to Spectroscopy – D.L.Pavia, G.M.Lampman and G.S.Kriz, Thomson Learning, Singapore (2001)
8. Spectroscopic Identification of organic compounds – R. M. Silverstein and F. X. Webster, 6th Edition, Wiley and Sons, India Ltd. (2006).
9. Interpretation of Mass Spectroscopy–McLafferty.

Paper code and name	**PG75T303A: Selected topics in Inorganic Chemistry**

COURSE OUTCOMES

After studying this paper, students would understand

- Synthesis, structure and bonding in metal carbonyl clusters.
- Structure and bonding in metal halide clusters.

- Preparation, structure and bondingof metal nitrosyls,
- Chemistry of dinitrogen and dioxygen complexes.
- analysis of pesticides and insecticides.
- analysis of fuel and fertilisers.
- Chemistry of lanthanoids and actinoids
- Flurescence, phosphorescence and photochemistry of transition metal complexes.

PARTICULARS

UNIT–I

Metal Clusters:

Metal π-acceptor complexes: Metal carbonyls, preparative methods, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, magnetic and X-ray evidences of structures, MO representation of bi– and tri–nuclear carbonyls, reactions of metal carbonyls. Metal carbonylates and carbonyl halides: Preparation and important reactions. Chemistry of metal nitrosyls: Preparation, structure and bonding, dinitrogen and dioxygen complexes. Metal–metal bonding in carbonyls and halides, evidences for M–M bonding, factors favouring M–M bond formation. Metal clusters: Bi–, tri–, tetra–, penta– and hexanuclear metal clusters and bonding in metal clusters.

(12 Hours)

UNIT–II

Lanthanides and actinides:

Correlation of general properties of d–block elements with those of 4f and 5f elements.

Lanthanide series: Introduction, electronic structure, oxidation states, lanthanide contraction, abundance and extraction (solvent extraction and ion–exchange methods), lanthanides as shift reagents, chemical properties of compounds of lanthanides in II, III, and IV oxidation states. Magnetic properties, colour and spectra.
Actinides: Electronic structure and position in the periodic table, oxidation states, occurrence and synthesis of elements. Spectral and magnetic properties of compounds of actinides in comparison with those of lanthanides and d–block elements. Chemistry of separation of Np, Pu & Am from U & fission products. Uranium: Isotope separation/enrichment and chemistry of uranium salts.

(12 Hours)

Unit–III

Fuel analysis and agricultural chemistry:

Fuels: Solid, liquid and gaseous fuels, ultimate and proximate analysis, calorific values, grading of coal. Liquid fuels: Flash point, aniline point, octane number and carbon residues. Gaseous fuels: Producer gas and water gas.

Analysis of soil: Inorganic and organic components of soil, collection and preparation of soil samples for analysis. Measurement of soil moisture, pH, total nitrogen, phosphorous, silica, lime, magnesia, manganese, sulphur and alkali salts.

Fertilizers: Fertilizer industries in India, manufacture of ammonia, ammonium salts, urea, nitrates, phosphates and superphosphates and mixed fertilizers.

(12 Hours)

UNIT–IV

Photoinorganic chemistry:

Photochemical Reactions: Prompt and delayed reactions, quantum yield, laws of photochemistry, recapitulation of fluorescence and phosphorescence, d–d and charge transfer reactions. Excited states of metal complexes, energy transfer under conditions of weak interaction and strong interaction, exciplex formation. Conditions of the excited states to be useful as redox reactants: Photosubstitution, photooxidation, photoreduction and photochemical reactions of transition metal complexes including $[Ru(bipy)_3]^{2+}$ and $[Fe(bipy)_3]^{2+}$. Application to photovoltaics: Water photolysis and carbon dioxide reduction. Solar energy conversion and storage.

(12 Hours)

Recommended Books:

1. Inorganic Chemistry–Principles of Structure and Reactivity, 4thEdn-J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5th Edn-P. Atkins, Tina Overton, J. Rourke, Mark Weller and F.Armstrong.Oxford University Press (2010)
3. Concepts and models of Inorganic Chemistry-B.Douglas, D. McDaniel &J.Alexander, 3rdEdn. Wiley Student Edn.(2013).
4. Fundamentals of photochemistry–K. K. Rohatgi-Mukherjee, Revised Edn. New Age International.
5. Ferraudi G. L, Elements of Inorganic photochemistry, Wiley Eastern, 1988
6. Photochemistry and Photophysicsof Ru(11) polylpyridine complexes in the Bologna group. From early studies to recent developments, Coodinatiom chemistry reviews, Vincenzo Balzani, Alberto Juris, 211, 97-115 ((2001).
7. F.A.Cotton and G.Wilkinson : Advanced Inorganic Chemistry, Wiley, 1991.

8. Environmental Chemistry–A. K. De (Wiley Eastern).
9. Environmental Chemistry–S. K. Banerji, (Prentice Hall India), 1993.

Paper code and name	**G75P301A: Lab Course in Inorganic Chemistry**

COURSE OUTCOMES

- Students are exposed to different synthetic methodologies of coordination compounds.
- Students are made to understand the characterization of prepared complexes by, various analytical methods viz. elemental analysis, metal percentage determination, chloride and sulphate determination etc.
- Student would learn to establish the composition of coordination compounds.
- Students are trained to scan, IR, NMR, UV-Vis spectra of prepared compounds and to interpret the observed spectra.

PARTICULARS

I. Preparation of selected coordination compounds

1. Bis(glycinato)copper(II) complex: cis–and trans–forms.
2. $Co(DMG)_2$ model for Vit B_{12} and reactions.
3. Hexaamminecobalt(III) chloride
4. Mercuric phenyl acetate
5. Pentaamminechloridocobalt(III) chloride.
6. Preparation of nitro- and nitrito-complexes. (examples for linkage isomers)
7. Separation of optical isomers of cis–$[Co(en)_2Cl_2]Cl$.
8. Tris(thiourea)copper(I) sulphate monohydrate.
9. Hexaamminenickel(II) chloride.
10. Mercury tetrathiocyanatocobaltate(II).
11. Tris(acetylacetanato)manganese(III).
12. Trans and cis-potassium dioxalatodiaquochromate(III).
13. N, N–bis(salicylaldehyde)ethylenediaminecopper(II).

II. Characterization

1. Elemental analysis.
2. N_2 analysis by Kjeldahl's method.

3. Metal ion determination in above complexes.
4. Anion determination in above complexes.
5. IR, Electronic, NMR, Magnetic and CV studies wherever possible.
6. Interpretation of UV-VIS, IR and NMR spectra.

Recommended Books:

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Basett, R. C. Denney, H. Jeffery and J. Mendham, Longmans, Green and company Ltd.
2. Practical Inorganic Chemistry-G. Pass and H. Sutcliff, Chapman and Hall Ltd. (1968).
3. General Chemistry Experiments-A. J. Elias, University Press.

Paper code and name	**PG75P302A: Lab Course in Inorganic Chemistry**

COURSE OUTCOMES

- Students are exposed to use the instruments such as, colorimeter, potentiometer, conductometer for the determination of metal ions/halides.
- Students would learn to determine the composition of coordination complexes by colorimetry.

PARTICULARS

Instrumental methods of analysis

1. Colorimetry: (i) Determination of Fe using o–Phenanthroline, (ii) Determination of Zr using Alizarin red S, (iii) Determination of Ti by H_2O_2 method, (iv) Determination of Mn / Cr /V in steel samples, (v) Job's method for Fe-1,10-phen complex, (vi) Mole ratio method–Zr + Alizarin red-S, (vii) Slope ratio method–Cu + en complex, (viii) Determination of stability constant of (7), (ix) Determination of pK_a of an indicator (methyl red) in aqueous solution.
2. Conductometry: (Cl^-, Br–, $I^-$and SO_4^{2-})
3. Potentiometry: (Halide mixture and Co^{2+} vs. ferricyanide)
4. Electrogravimetric analysis (Cu and Ni mixture)
5. Magnetic susceptibility determination

Recommended book:

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Basett, R. C. Denney, H. Jeffery and J. Mendham, Longmans, Green and company Ltd.

Paper code and name	PG75P303A: Lab Course in Inorganic Chemistry

COURSE OUTCOMES

Students are exposed to the analysis of food and drug by analysing.

- iodine in common salt.
- calcium in milk powder.
- vitamin-c in tablets.
- iron in tablets.
- aspirin content in tablets.

Particulars

1. Determination of vitamin C in juice/tablet by titrimetric method.
2. Fluorimetric determination of riboflavin (Vit B_2) in tablets.
3. Determination of iron in pharmaceuticals by visual and potentiometric titration using cerium(IV) sulphate.
4. Determination of sulpha drugs by potentiometry using $NaNO_2$ and iodometric assay of penicillin.
5. Assay of aspirin/caffeiene/phenacetin by spectrophoptmetry/titrimetry
6. Determination of vitamin A in vanaspathi by UV spectrophotometry
7. Analysis of a soil sample for (i) Available phosphorus by spectrophotometry, (ii) Nitrate-nitrogen/nitrite nitrogen/ammonia nitrogen by spectrophotometry, (iii) sodium and potassium by flame photometry.
8. Analysis of fertilizers: Urea and super phosphates

Recommended Books:

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company. Inc.
3. Standard methods of chemical analysis-F. J. Welcher (6th Edn., Vol. 3 Part–B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments–A. J. Elias, University Press.

Paper code and name	PG75T401A: Instrumental Methods of Analysis.

COURSE OUTCOMES

After studying this paper, students would understand the working principles and applications of various instrumental methods such as.

- atomic absorption and emission spectroscopy
- molecular luminescence spectroscopy
- electrophoresis and gel filteration
- coloumetry and amperometry
- ion selective electrodes
- thermal methods of analysis
- polarography, voltammetry and stripping analysis
- light scattering methods

PARTICULARS

UNIT–I

Optical methods:

Atomic absorption spectrometry: Theory, instrumentation, different types of nebulizers, non flame techniques, electrothermalvapourisers, cold vapour AAS determination of mercury, interferences, differences between AAS and flame photometry and analytical applications of AAS.

Emission spectroscopy: Inductively coupled plasma optical emission spectrometry, theory and applications.

Molecular luminescence spectroscopy: Theoretical basis for fluorescence and phosphorescence, instrumentation, factors affecting fluorescence, its applications in quantitative analysis and in the study of biomolecules.

X–ray fluorescence elemental analysis.

(12 Hours)

UNIT–II

Analytical methods–I

Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, coulometric titrations (amperometriccoulometric): Principles, apparatus, comparison of coulometric titrations

with conventional titrations, automatic coulometric titrations and applications.
Amperometry: Principle, titrations, advantages and limitations. Applications.
Ion selective electrodes: Glass ion selective electrodes, crystalline solid state ion selective electrodes, liquid–based ion selective electrodes and gas sensing electrodes.
Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography. Applications.
(12 Hours)

UNIT–III

Analytical methods–II

Polarography: Theory of classical polarography, polarograms, polarographic currents. Halfwave potential, oxygen interference, advantages and limitations. Pulse polarography. Applications of polarography.

Electrogravimetric analysis: Theory, apparatus, deposition and separation, electrolytic separation of metals, applications.

Electrophoresis: Theory and classification. Factors influencing the mobility-macromolecular size and charge, interaction with supporting electrolyte, pH and concentration discontinuities. Factors affecting electrophoretic phenomena-electrolysis, Electroosmosis, temperature and supporting media. Instrumentation. Methodology-preparation of gels-staining and destaining. Capillary electrophoresis methods - capillary zone electrophoresis, capillary gel electrophoresis.

Light-Scattering methods: Nephelometry and turbidometry-Principle, instrumentation and applications.

(12 Hours)

UNIT–IV

Analytical methods–III

Thermal method of analysis: Introduction. Thermogravimetric analysis (TGA): Types of thermogravimetric analysis, principles, factors affecting the results, heating rate, furnace, instrument control/data handling. Instrumentation and applications.

Differential thermal analysis (DTA): Theory, variables affecting the DTA curves. Differences between TGA and DTA. General principles, instrumentation and applications.

Differential scanning calorimetry (DSC): Basic principle, differences between DTA and DSC. Instrumentation, power compensated DSC, Heat flux DSC. Applications.

Thermomechanical analysis. Dynamic mechanical analysis.

Voltammetry: Fundamentals of voltammetry. Cyclic voltammetry: Principles and

applications. Stripping analysis: Stripping voltammetry, basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications, determination of lead in water by voltammetry.

(12 Hours)

Total: 48 Hours

***Recommended Books**:*

1. Instrumental Analysis, D. A. Skoog, F. J. Holler and S.R.Crouch, Cengage Learning (2007).
2. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
3. Analytical Chemistry, G.D. Christian, 6th edition, Wiley–India (2007).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning PvtLtd.NewDelhi(2009).
5. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).
6. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California(1990).
7. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7thEdition,CBS Publishers, New Delhi, 1988.

Paper code and name	**PG75T402A: Material, Nuclear and Environmental Chemistry**

COURSE OUTCOMES

After studying this paper, students would receive the awareness of

- nuclear reactions and use of nuclear energy in generating electricity.
- safety measures to be adopted in handling radioactive materials.
- Composition of atmosphere.
- Various types of pollutants related to soil, water and air.
- Use of chemistry in the betterment of society.
- Nanomaterials and electron microscopes.
- Synthetic methods for nanomaterials and carbon nanotubes.
- Principle & types of LED, LCD
- The advantages and disadvantages of LED and LCD.
- Properties of glass, ceramics and clay products.

PARTICULARS

Unit–I

Nanomaterials and Electron Microscopies.

Nanomaterials: Introduction, terminology, novel optical properties, nanolayers, carbon nanotubes, nanowires, quantum dots, nanocomposites, thin films, nanofoam, nanoclusters, smart nanostructures. Top–down and bottom-–up fabrication: Solution–based and vapour–phase synthesis of nanomaterials, physical vapour deposition, chemical vapour deposition, sol–gel synthesis, combustion method and hydrothermal method.

One–dimensional control (CNT's and inorganic nanowires), two–dimensional control (quantum wells and solid–state superlattices) and three–dimensional control.

Electron microscopies: Scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM). Scanning probe microscopies: Scanning tunneling microscopy (STM) and atomic force microscopy (AFM).

Nanosensors: Electrochemical sensors and biosensors.

(12 Hours)

UNIT–II

Nuclear Chemistry:

Nuclear reactions, nuclear fission and fusion, nuclear reactor, units of radiation energy, G–value. Chemical Dosimetry: Fricke and ceric sulphate dosimeters. Radiation chemistry of water. A brief introduction to radiolysis of liquids and solids.

Health and safety aspects: Biological effects of radiation, permissible exposure of radiation dose and radioactive waste management.

Radioanalytical techniques and isotopes: Radioactive techniques, tracer technique, neutron activation analysis, applications of radiation chemistry/isotopes (radiation synthesis, polymerization, medicine &, food irradiation). Radiometric titrations and ^{14}C dating.

(12 Hours)

UNIT–III

Air pollution and Water Pollution:

Air pollutants, prevention and control, green house effect and acid rain. Carbon monoxide: Industrial and transportation sources. SO_x–sources, control technique, scrubbing, limestone injection process. Ozone hole and CFC's. Photochemical smog and PAN. NO_x: sources and NO_x, control techniques. Particulates: Size distribution. Bhopal gas tragedy. Noise pollution.

Origin of waste water, types, water pollutants and their effects. Sources of water pollution: Domestic, industrial, agricultural soil and radioactive wastes as source of pollution. Measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, sulphate, fluoride, phosphate and different forms of nitrogen in natural and polluted water.

Determination and significance of BOD, COD and TOC. Pesticides as water pollutants and analysis.

Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Heavy metal pollution. Chemical speciation:Biochemical effects of heavy metals (Hg, As, Pb, Se).

(12 Hours)

UNIT–IV

Chemistry of Selective Materials:

Glasses, oxide glasses, bond type, viscosity, Zachariasen's rules, criteria of Sun and Rawson, chalcogenide glass, the photocopying process, glass ceramics, applications, ceramics–structures, mechanical properties and application, clay products, refractories, characterisation properties and applications.

LED: Principle, types, advantages and disadvantages of LED displays.

Liquid crystal display (LCD): Properties, twisted nematic field display, advantages and disadvantages of LCD, comparison of LCD & LED.

Shape memory alloys (SMA): Classification, working principles, non–linear optical materials and second harmonic generators.

(12 Hours)

Total: 48 Hours

Paper code and name	**PG75T403A: Organometallic and Solid State Chemistry**

COURSE OUTCOMES

Students would understand the

- Metal ions as catalysts and their importance in synthetic procedures.
- Catalysts in industrial applications such as, Wacker's process, Hydroformylation, Monsanto acetic acid synthesis, Water gas shift reaction, Fischer-Tropsch synthesis, Alkene polymerization, etc.
- Structures of solids.
- Optical properties of solids and their applications.
- Magnetic properties of solids and their applications.
- Phenomenon of superconductivity and its applications.
- Alloys and phase diagrams.

PARTICULARS

UNIT–I

Organometallic Chemistry:

Chemistry of organometallic compounds with π–bonding ligands: Synthesis, structure, sSpectroscopy, reactions and bonding in metal–carbon π–bonded systems involving di–hapto to hexa–hapto ligands viz, olefins, acetylenes, allylic moieties, butadienes, cyclobutadienes, cyclopentadienes and arenes. Organometallic polymers.

(12 Hours)

UNIT–II

Fluxinol behaviour of Organometallic Compounds:

Rates of rearrangement and techniques of study. Stereochemical non–regidity in organometallic compounds, ring whizzing in η^1–Cp complexes, interchange of η^1–and η^5–Cp rings, allyl and allene complexes. Scrambling of carbonyl groups in metal carbonyls.

2 Hours

Homogeneous and heterogeneous catalysis invivolng metal complexes and organometallic complexes. Teminology in catalysis, oxidative additions and oxidative coupling reductive elimination, insertion reactions, hydrogenation of alkenes and related reactions, hydroformylation (Monsanto, Cativa and Wacker Processes), carbonylation, isomerisation and olefin polymerisation oligomerisation reactions. Water gas shift reaction.

8 Hours

Organometallic reagents in organic synthesis: Organo–iron, organo–copper and organo–palladium compounds. **8 Hours**

(12 Hours)

UNIT–III

Solid State Chemistry:

Electrical properties: Survey of electrical properties and materials. **1 Hour**

Super conductivity: Nature and properties of super conductivity materials, Meisner effect, type–I and II super conductors, theories, high temperature oxide super conductors, junction involving metal, super conductor and super conductor. Applications. **4 Hours**

Ionic conductivity: Alkali halides–vacancy conduction. Silver chloride–interstitial conduction. Solid electrolytes: β–alumina, AgI and Ag^+ ion solid electrolytes. Anion conductors, requirements for conductivity. Applications.

2 Hours

Magnetic properties: Mechanism of ferro– and anti–ferro magnetic ordering, selected examples of magnetic materials, their structures and properties, metals and alloys, transition metal oxides, spines, garnets, ilemenites, perovskites, magneto plumbites, applications and structure–property relation. **3 hours**

Optical properties: Luminescence and phosphors, configurational coordinate model, some phosphor material, antistokes, phosphors and lasers. **2 Hours**

(12 Hours)

UNIT–IV

Mechanical Properties and Structural Transformation of Solids:
Mechanical properties & dislocations in solids: Edge dislocations & screw dislocations.
Structural transformation of solids: Solid solutions, Hume–Rothery rules, substitutional solid solutions and interstitial solid solutions, solid solution mechanism, experimental methods for studying solid solutions (X–ray powder diffraction and density measurements).

Alloy systems: Phase diagrams, two and three component systems, study of alloy systems, steels with reference to iron, carbon systems and copper– zinc system.

(12 Hours)

Total 48 Hours

Paper code and name	**PG75D404A**: **Project Work**

COURSE OUTCOMES

Project work is carried out by the students under the guidance of teachers in the department. A topic of research is chosen by the students, in consultation with the respective mentors.

Students gather a complete knowledge in carrying out the research, which would help them in their higher studies (such as Ph.D programme) and in industrial career.

Student may get a publication on successful completion of his/her project work.

PARTICULARS

The project work may include in–plant training in industries/short term work in the department/other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof.

In case of the students who would work outside the campus, the supervising staff member may visit to the work place at least once during the period and may be eligible for TA–DA as per the University rules.

Paper code and name	PG75P401A: Lab Course in Inorganic Chemistry

COURSE OUTCOMES

Student would learn

- Cyclic voltammetric method.
- Determination of fluoride content and acidity of water.
- Ion exchange methods for purification of water.
- Importance of TG–DTA in analysis of compounds.
- Analysis of backing soda.
- Determination of iron in food samples.

PARTICULARS

1. Determination of available K/Na in soil by flame photometry
2. Nephelometric/Turbidimetric determination of sulphate/phosphate.
3. Cyclic voltammetric studies on potassium ferrocyanide/ potassium ferricyanide.
4. TG–DTA studies of various hydrated solids-$CuSO_4.5H_2O$, $CaC_2O_4.H_2O$ and MgC_2O_4 mixture.
5. Determination of fluoride in drinking water by spectrophotometry.
6. Estimation of total cation concentration in water by ion-exchange method.
7. Determination of iron in mustard seed by spectrophotometry.
8. Determination of copper by potentiometric titration using EDTA.
9. Conductometric determination of total acidity of waste water.
10. Analysis of copper/calcium by PFHS method
11. Analysis of Na_2CO_3 and $NaHCO_3$ in baking soda by acid base titration

***Recommended Books**:*

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.
2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, inc.
3. Standard methods of chemical analysis-F. J. Welcher (6th Edn., Vol. 3 Part-B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments-A. J. Elias, University Press.

Paper code and name	**PG75P402A: Lab Course in Inorganic Chemistry**

COURSE OUTCOMES

Students are trained to analyse water samples for the determination of

- colour, pH, and temperature.
- dissolved oxygen, COD, BOD and oxidising power.
- chloride and sulphate ions.
- calcium, magnesium ions.
- temporary and permanent hardness.
- Analysis of heavy metals in waste water and sea water.
- Acid content in soft drinks.
- Preparation and characterization of nanoparticles.
- Analysis of glass and ceramics

PARTICULARS

1. Determination of COD of a water sample.
2. Determination of phosphates in detergents.
3. Determination of dissolved oxygen (DO) by Winkler's method.
4. Determination of nitrate & nitrite in water samples and sea water.
5. Analysis of heavy metals in waste water and sea water (Pb, Hg etc. by spectrophotometry).
6. Determination of alkalinity of water samples.
7. Determination of phosphoric acid content in soft drinks.
8. Hardness of water by soap solution method
9. Determination of TDS in water samples.
10. Preparation and characterization of nanoparticles.
11. Analysis of glass and ceramics

References:

1. Vogel's Text Book of Quantitative Inorganic Analysis–J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.

2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, Inc.

3. Standard methods of chemical analysis–F. J. Welcher (6th Edn., Vol. 3 Part–B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.

4. General Chemistry Experiments–A. J. Elias, University Press.

Paper code and name	**PG75P403A**: **Lab Course in Inorganic Chemistry**

COURSE OUTCOMES

Students are exposed to the analysis of industrial samples such as,

- Determination of total acidity in beverages.
- Analysis of antacids.
- Analysis of tablets.
- Analysis of milk powder.
- Analysis of cement.
- Analysis of urine.

PARTICULARS

1. Determination of total acidity of vinegar and wines by acid-base titration.
2. Determination of calcium in calcium gluconate/calcium carbonate tablets/injections and of calcium in milk powder by EDTA titration.
3. Determination of aluminium and magnesium in antacids by EDTA titration.
4. Determination of saccharin in tablets by precipitation titration.
5. Analysis of cement.
6. Analysis of Type metal–Sn gravimetrically and Sb titrimetricallyusing $KBrO_3$
7. Determination of magnesium in milk of magnesium tablets by ion-exchange chromatography.
8. Conductometric titration of sodium acetate with HCl and NH4Cl with NaOH.
9. Analysis of urine for (i) urea and uric acid by titrimetrysnd spectrophotometry (ii) Sulphate by precipitation titration after ion–exchange separation (iii) Sugar by Benedict's reagent.
10. Analysis of blood for (i) cholesterol by spectrophotometry and (ii) bicarbonate by acid–-base titration

Recommended Books:

1. Vogel's Text Book of Quantitative Inorganic Analysis-J. Bassett, R. C. Denney, G. H. Jaffery and J. Mandham, Longmans, Green and Company Ltd.

2. Chemical analysis of foods and food products-Morris B. Jacobs (3rd Edn.), D. Van Nostrand Company, inc.
3. Standard methods of chemical analysis–F. J. Welcher (6th Edn., Vol. 3 Part-B), D. Van Nostrand Company, Inc. Indian, United States and European Pharmacopea.
4. General Chemistry Experiments–A. J. Elias, University Press.

Specific Course Outcome (Organic Chemistry)

Paper Code and Name	**PG75T102B: ORGANIC CHEMISTRY-I**
COURSE OUTCOMES	
The above course gives the requisite benefits to the students as- ➢ The localized chemical bonding helps the students to understand the hybridization bond distance, bond angles, bond energies etc..to the modern ideas in chemical technology. ➢ The study of reaction mechanism impart the internal energy changes in reaction as well as nature of the intermediate in the organic reactions. ➢ In the study of organic reactions the exploration of stereochemistry and conformational analysis gives the ideas of structure of organic molecules and their enantiomers, diastereomers,e pimers etc.. to the student to get the depth knowledge about the organic molecules. ➢ To study the internal energetic π electrons in the aromatic compounds the gives the ideas regarding nature of organic reactions to the modern temples called as industry to understand by the students. ➢ To overall view the studies of concepts in the organic chemistry reveals that the most exciting organic reactions and their products called organic molecules are	

exploited in various industries to explore the knowledge to the students.

UNIT–I

Bonding in Organic Molecules:

Localized chemical bonding: Hybridization index, bonding in cyclopropane, bond distances, bond angles, bond energies, bond polarity, dipole moment and calculation of heat of reactions.

Delocalised chemical bonding: Conjugation, cross conjugation, steric inhibition of resonance, hyperconjugation, tautomerism, valence tautomerism. Bonding in fullerenes.

Bonding weaker than covalent: Hydrogen bonding, EDA complexes, inclusion compounds, complexes of crown ethers, catenanes and rotaxanes.

Structure and reactivity: Brönsted-Lowry concept of organic acids, conjugate acids and bases, pH, pKa values. Electronic, steric, and solvent effects on their strengths. General and specific acid base catalysis, running scale of acidity. Lewis acids and bases. HSAB concept.

(12 Hours)

UNIT–II

Organic Reaction Mechanisms:

Classification of organic reactions: Meaning and importance of reaction mechanism. Methods of determination of reaction mechanisms: Kinetic methods, order and molecularity, mechanistic implications from rate laws.

Non–kinetic methods: Product identification, cross over experiments, study of intermediates, isotopic labeling, kinetic isotope effects and stereochemical studies.

Nucleophilic substitutions (aliphatic): Mechanisms of S_N2, S_N1 (rearrangements in S_N1 reactions) and S_Ni, $S_{RN}1$ pathways. Effects of structure, leaving groups and ambident nucleophiles.

Elimination Reactions: E_2, E_1, E_1CB pathways. Stereochemistry, product proportions in dehydration of alcohols, alkyl halides (chiral and achiral), Hoffmann and Saytzeff rules. Substitution v/s elimination and pyrolytic eliminations.

(12 Hours)

UNIT-III

Stereochemistry and Conformational Analysis:

Elements of symmetry and chirality, optical isomerism, optical activity, specific rotation. molecules with one asymmetric center. Fischer, Wedge and 3D representations, DL and RS systems indicating configuration. Ring compounds, molecules with two chiral centers: Fischer, Saw–Horse, Newmann projections and their transformations.

Enantiomers, diastereomers, epimers, racemization, resolution. Stereochemical correlation. Pseudo–asymmetric compounds.

Geometrical isomerism: E–Z nomenclature, configuration of geometrical isomers and *syn*– &

anti– isomers.

Conformational analysis: Conformational study of n–Butane, ethylene, chlorohydrin, 1,2–dichloroethane, 2-aminoethanol, di– & tri–substituted cyclohexanones and Curtin–Hammett principle.

(12 Hours)

UNIT–IV

Aromaticity:

Aromaticity and Huckel's rule: HMO theory, energy level diagrams, möbius systems, benzenoid and non–benzenoid aromatic compounds. Tropones, tropolones, borazine and azulene.

Heterocyclic Systems: Systems of the type pyrrole, pyridines, pyrilium cation, ferrocene. alternant and non-alternant hydrocarbons. Aromaticity of charged rings (3-8 membered), non aromatic, anti–aromatic and homo aromatic systems.

Physical methods to study aromaticity: X-ray, UV and ^{1}H–NMR methods.

Ring current as criteria for aromaticity. Annulenes and heteroannulenes [10-18].

(12 Hours)

Total 48 Hours

Books Recommended:

1. Organic Chemistry–P. Y. Bruice, 7th Edition, Pearson Education Pvt. Ltd., New Delhi (2013).
2. Organic Chemistry–S. H. Pine, McGraw-Hill, London (1987).
3. Mechanism and Structure in Organic Chemistry–1965, by E.S. Gould.
4. Organic Chemistry–R. T. Morrison and R.T. Boyd, Prentice Hall, New Delhi (1994).
5. Organic Chemistry–T. W. Graham Solomons, 4th Edition, John Wiley and Sons (1988).
6. Organic Chemistry–G. M. Loudon, 4th Edition, Oxford University Press, New York (2002).
7. Organic Chemistry Volume–I, II–I. L. Finar, 6th Edition, ELBS London (2004).
8. Organic Chemistry–F.A. Carey, 4th Edition, McGraw Hill (2000).
9. Advanced Organic Chemistry, Reactions, Mechanism and Structure–J. March, 3rd Edition, Wiley Eastern Ltd. (2004).
10. Stereochemistry–Conformation and Mechanism–P. S. Kalsi, Wiley–Eastern Ltd, New Delhi (1992).

11. Guidebook to Mechanism in Organic Chemistry–P. Sykes. Orient Longman, London (2002).

12. Aromaticity–P. J. Garratt, McGraw Hill Book company (1971).

Paper Code and Name	**PG75P102B: LAB COURSE IN ORGANIC CHEMISTRY-I**

COURSE OUTCOMES

- The theoretical study of the organic reactions are proved by the synthesis of targeted organic molecules for further application in various industries.
- The students shall understand the imaginary organic reactions through the synthetic study of internal mechanistic transformations of one organic molecule to the another organic molecule.

Preparation of the following organic compounds:

1. Benzoic acid and benzyl alcohol from benzaldehyde (Cannizarro reaction).
2. Cyclohexanone from cyclohexanol.
3. Reduction of *p*-nitrobenzaldehyde to *p*-nitrobenzylalcohol.
4. 2,4-Dinitrophenol from chlorobezene.
5. Benzil from benzaldehyde.
6. m–Nitroaniline from nitrobenzene.
7. m–Nitro benzoic acid from ethyl benzoate.
8. Benzanilide from benzophenone (Beckmann rearrangement).
9. p–Bromoaniline from acetanilide.
10. p–Nitroaniline from acetanilide.

Recommended Books:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S.Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.

2. A Hand book of Organic Chemistry–by H. T. Clarke.

3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.

4. Lab Experiments in Organic Chemistry–by Arun Sethi, New Age International Ltd. New Delhi. 2006.

Scheme of Examination:

i.	Duration of examination	: 04 hours
ii.	Experiments	: 35 marks
iii.	Viva-Voce & Journal	: 05 marks
iv.	Internal assessment	: 10 marks
	Total	: 50 marks

Paper Code and Name	**PG75T202B: ORGANIC CHEMISTRY-II**

COURSE OUTCOMES

The above course gives the benefits to the students as-

- The students will be able to understand the aliphatic and aromatic electrophilic substitutions and nucleophilic reaction mechanism. This gives an insight into the organic reactions.
- Advanced stereochemistry course makes the students to differentiate the prochidal and achiral molecules, enantiomers, homotopic and diasterotopic ligands.
- This course also helps the students to classify and understand the reactions of mono and disaccharides.
- The students are made aware of classification an d reactions of five membered heterocycles.

UNIT–I

Reaction Mechanism:

Aliphatic electrophillic substitutions: Bimolecular pathways. S_E2, S_E1 and S_Ei mechanisms. Reactions involving double bond shifts, α-halogenation of aldehydes, Ketones, aliphatic diazonium coupling, nitrosation at carbon bearing active hydrogen, mercury exchange reactions.

Aromatic electrophillic substitutions: Mechanisms of aromatic, nitration, sulphonation, halogenation, isotope effects, energy profile diagrams. Kinetic and thermodynamic control, amination and sulphonation, Hammond's Postulate, o/p ratio, ipso–substitution, Vilsmeir Haack, Pechmann and Fries rearrangement.

Aromatic nucleophilic substitutions: S_NAr, S_N1 and aryne pathways. Meisenheimer complexes, mechanism and synthetic applications of vicarious nucleophilic substitution (VNS), Von-Richter, Goldberg, Bucherer, Shiemann reactions and Smiles rearrangement.

(12 Hours)

UNIT–II

Advanced Stereochemistry:

Prochirality: Homotopic, enantiotopic and diastereotopic atoms, groups and faces.

Stereochemical descriptors: Application to reduction of carbonyl compounds, cyanohydrin formation, addition of water to alkenes.

Optical activity due to molecular dissymmetry: Allenes, spiranes, biphenyls, atropisomerism, molecular crowding.

Conformational analysis of cyclohexane, mono substituted and disubstituted (1,2, 1,3, 1,4) cyclohexanes. *cis*- and *trans*–decalins. Chirality of cyclohexanes.

(12 Hours)

UNIT–III

Carbohydrates:

Monosaccharides: Conformational representation of monosaccharides and their transformations. Determination of configuration of the monosaccharides, mechanism of mutarotation–base catalyzed isomerisation of aldoses and ketoses. Epimerisation, anomeric effect, glycosides, ether and ester derivatives of carbohydrates. Acetone, amino (β-D-glucosamine, galactosamine, N-acetylmuramic acid (NAMA), N-acetyl neuraminic acid (NANA) and deoxysugars. Oxidation and reduction reactions of carbohydrates.

Disaccharides: Structure elucidation of maltose, lactose, sucrose, gentiobiose and meliobiose.

Trisaccharides: Raffinose and melezitose.

Polysaccharides: Structure and degradation of starch, cellulose and glycogen.

(12 Hours)

UNIT–IV

Chemistry of heterocycles: Nomenclature of heterocyclic compounds: (i) Hantzhsch–Widmann (ii) Replacement Nomenclature

Structure, synthesis, reactivity and chemical reactions of indole, quinoline, isoquinoline, thiazole, imidazole, benzimidazole, coumarin, chromones, flavones and isoflavones.

(12 Hours)

Total 48 hrs

Recommended Books:

1. Advanced Organic Chemistry part A and B–F. A. Carey and R. J. Sundberg, 4th Edition, Plenum Publishers (2000).
2. Advanced Organic Chemistry, Reactions, Mechanism and Structure–J March, 3rd Edition, Wiley Eastern Ltd. (2004).
3. Guide Book to Mechanism in Organic chemistry–Peter Sykes Oriant- Longman (1985).
4. Stereochemistry of Carbon Compounds–Eliel, Tata McGraw Hill, New Delhi (1976).
5. Stereochemistry of Organic Compounds, Principles and Applications – D. Nasipuri, Wiley Eastern Ltd (1992).
6. Organic Chemistry Vol–I, II, III–S. M. Mukherji, S. P. Singh and R. P. Kapoor, New Age International Ltd, New Delhi (2000).
7. Organic Chemistry Volume–I, II– I. L. Finar, 6th Edition, ELBS London (2004).
8. Chemistry of Carbohydrates–G. C. Percival.
9. Carbohydrates –Chemistry and Biochemistry –Pigman and Harton.
10. Heterocyclic Chemistry–T. L. Gilchrist, 3rd Edition, Pearson Education Delhi, (2005).
11. Heterocyclic Chemistry –J.A. Joule and G.F. Smith, 2nd Edition, Van Nostrand London (1978).
12. Heterocyclic Chemistry–R. K. Bansal, 3rd Edition, New–Age Interantional, New Delhi, 2004.
13. https://profiles.uonbi.ac.ke/sderese/files/upc_213nomenclature_of_heterocyclic_compounds_0.pdf

Paper Code and Name	PG75P202B: LAB COURSE ORGANIC CHEMISTRY

COURSE OUTCOMES

- The students understand the quantitative estimation of acid, amide , ester and glucose.
- Students will understand how the molecular weight is determined by the base hydrochloride method.
- The chemical transformation of organic compounds to the products by the preparation of derivative thus trains the students about synthetic organic chemistry.

1. Quantitative Estimation of the following Organic compounds: (i) Acid (ii)Acid + Amide (iii) Acid + Ester (iv) Molecular weight determination by base hydrochloride method (v) Phenol (Bromometric method).

2. Preparations of derivatives of heterocycles like coumarins, quinolines, benzimidazoles, benzoxazines, pyrazoles by convention, microwave and by sonication.

3. Preparations based on functional group reactions of organic compounds like aldehydes, ketones, esters, phenols etc.

Note: Any two of the above experiments will be prescribed for the examination.

Scheme of Examination

i.	Duration of examination	:	04 hours
ii.	Experiments	:	35 marks
iii.	Viva-Voce & Journal	:	05 marks
iv.	Internal assessment	:	10 marks
	Total	:	50 marks

Recommended Books:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.

2. A Hand book of Organic Chemistry–H.T. Clarke.

3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M.V. Govindachari.

4. Lab Experiments in Organic Chemistry–Arun. Sethi, New Age International Ltd. New Delhi. 2006.

5. Experimental Organic Chemistry–L. M. Harwood, and C. J. Moody, Blackwell Scientfic, London, 1989.

6. Practical Organic Chemistry–W. Kemp, McGraw Hill, London, 1967.

PG75T301B : ORGANIC SPECTROSCOPY	No of teaching hours
The above course gives important spectroscopic study and students are able to prove the structure of organic molecules as- ➢ The students will be able to understand the structure of organic molecules after studying the theoretical and experimental study of spectroscopic techniques.	
Electronic and Vibrational Spectroscopy: Introduction, energy considerations, experimental methods, Beer–Lambert's law, theory and classification of electronic transitions, terminology, substituent and solvent effects. UV spectral study of alkenes, dienes, polyenes, carbonyl and aromatic compounds. Steric effects, isobestic points, model compounds and charge transfer bands. Vibrational Spectroscopy: Introduction, experimental methods, units, notation and regions. FT–IR, sampling techniques, complementarity of IR and Raman. Fundamental vibrations, overtones, Fermi resonance, group frequencies, factors affecting group frequencies: Conjugation, inductive, resonance, steric effects. Mechanical coupling, applications of IR in the study of H–bonding, stereoisomerism and tautomerism. Identification of the following organic compounds by IR: Alkanes, alkenes, alkynes, aromatic compounds, aldehydes, ketones, alcohols, thiols, acids, acid chlorides, amides, amines, esters, halides, nitro compounds, etc.	**12**
UNIT–II **Proton Magnetic Resonance Spectroscopy:** Introduction, magnetic properties of nuclei, resonance condition. Field frequency diagram, precession of nuclei, relaxation. Intstrumentation: CW and FT–NMR techniques. Sample handling. Chemical shift, mechanism of shielding and deshielding in alkanes, alkyl halides, alkenes, aromatic compounds, carbonyl compounds and annulenes. Chemical shifts of different types of organic compounds. Empirical rules. Equivalence of protons: Chemical and magnetic equivalence. Spin–spin coupling, geminal–vicinal coupling, relative intensities. Karplus equation–Curve. Spin–systems, first order and second order patterns. Long range coupling: Spin decoupling, CIDNP and NOE. Lanthanide Shift reagents. Proton attached to elements other than carbon (OH, NH and SH). Exchange phenomena and temperature effects.	**12**
Multi–Nuclear NMR and Correlation Spectroscopy: ^{13}C–NMR, broad band and off resonance decoupling methods of detection. ^{13}C–chemical shifts of different classes of organic compounds: Alkanes, alkyl halides, alkenes, alcohols, ethers, carbonyl compounds and aromatic	**12**

compounds. $^{13}C–^{1}H$ coupling DEPT. Introductory aspects of $^{15}N–$, $^{19}F–$, $^{31}P–$, $^{10}B–$, ^{11}B –NMR. Correlation NMR Spectroscopy: Theory, pulse sequences. FT–methods. $^{1}H–^{1}H$ (COSY) and $^{13}C–^{1}H$ (HETEROCOSY) methods	
Mass Spectrometry and Composite Problems: Ionisation and mass analysis. Instrumentation, methods of ionization, EI, CI, DI, SI methods. Fragmentation: Principles, odd electron ($OE^{\cdot+}$) and even electron (EE^{+}) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Stevenson rule. Fragmentation of: (i) normal and branched alkanes. (ii) alkenes (iii) benzene and its derivatives (iv) alcohols (v) aldehydes (vi) ketones (vii) acids (viii) esters (ix) ethers (x) amines (xi) nitro compounds (xii) halo compounds (xii) peptides. McLafferty and McLafferty + 1 rearrangement. Calculation of molecular formula. Calculation of H–deficiency index. Composite problems: Applications of UV, IR, NMR and MS methods and chemical reactions in structure elucidation of organic compounds.	**12**
PG75T302B : STEREOCHEMISTRY AND REACTION MECHANISM	
The above course gives the benefits to the students as- ➢ Dynamic stereochemistry course makes the students to understand stereospecific and stereoselective reactions along with asymmetric synthesis. ➢ Stereochemistry of compounds other than carbon are studied and makes the students to understand stereochemistry of cyclic, acyclic and other compounds containing hetero atoms. ➢ The students are able to study the reaction mechanism of nucleophilic substitutions at allylic and triagonal carbon atom with stability of intermediates. ➢ This course also helps the students to study addition and elimination reactions along with the stereochemistry products and their proportions in the organic reactions.	
UNIT–I **Dynamic Stereochemistry:** Stereoselectivity in organic synthesis, stereospecific and stereoselective reaction, principle of stereoselectivity, stereoselectivity in addition, elimination and substitution reaction. Asymmeteric Synthesis: Chiral pool synthesis, enantioselectivity and diastereoselectivity in acyclic system, addition of nucleohphiles to carbonyl group, Cram's rule and Prelog's rule for diastereselection. 1,2–Addition predictions: Various outcomes using predictive models such	**12**

as Cram chelate and Felkin–Anh. Chiral Auxiliaries: Chiral auxiliaries in aldol condensations and Diels–Alder reaction. Oxazolidinones and chiral sulphoxides. Chiral Reagents: Isopinocamphenylboranes, BINOL and DIBAL. Chiral Catalysts: Calculation of enantiomeric excess, asymmetric epoxidation–Sharpless and Jacobsen Katsuki asymmetric epoxidation, epoxidation using dioxiranes. Stereochemistry of catalytic hydrogenation: Metal (Pd, Pt, Ni) catalyzed hydrogenation, diimide reduction, rhodium and Ruthenium catalysts with chiral phosphine ligands like (R)–PROPHOS, (R)–BINAP and (R, R)–DIOP. Asymmetric transformations, stereochemistry of carbene and nitrene addition.	
UNIT–II **Stereochemistry of Compounds other than Carbon:** Stereochemistry of nitrogen compounds: Quaternary ammonium salts, amines, tertiary amine oxides, oximes**,** determination of configuration of aldoximes and ketoximes, stereochemistry of compounds (cyclic and acyclic) containing nitrogen. Stereochemistry of Phosphorus compounds, arsenic, sulphur compounds and silicon compounds.	**12**
UNIT–III **Reaction Mechanism–I:** Nucleophilic substitution at allylic and trigonal carbon atom, Tsuji–Trost reaction. Neighbouring group participation: Definition, participation of σ, π cyclpropane aromatic rings in nucleophilic substitution reaction. Nucleophilic substitution at silicon. Addition Reactions: Electrophilic addition across alkenes, *cis- and trans-* alkenes and dienes. Addition of nitrogen, oxygen and aulphur nucleophiles across carbonyl compounds.	**12**
Reactive Intermediates and Activating agents Reactive Intermediates**:** Formation, structure, stability and reactions of the following reactive intermediates: Carbocations (classical and non–classical), carbanions, carbenes (identification by ^{1}H NMR and ^{13}C NMR), carbenoids, free radicals (ESR of organic free radicals), nitrenes, ylides, Wittig and Tebbe olefination, enamines and Stork enamine reactions. Applications of the following in organic synthesis: Acetyl chloride, antimony pentachloride, borontrifluoride etherate, copper (I) trifluoromethane sulphonate, ethylaluminium dichloride, lithium halides	**12**

and lithium perchlorides	
PG75T303B CHEMISTRY OF NATURAL PRODUCTS	
The above course gives the benefits to the students as- ➢ The students understand the important steroidal harmones and their structure synthesis stereochemistry and spectral features. ➢ The students will be aware of natural alkaloids and terpenes which are being exploited inpharmaceutical industry and perfumery industry along with photochemical synthesis of some important narcotic alkaloids. ➢ In the ongoing teaching, the students are enable to make more focus on Natural fatty acids and Prostaglandins which are having remarkable applications in various oleochemical and pharmaceutical industry, ➢ This course also helps the students to understand the biomolecules such as nucleosides, nucleotides and peptides with amino acid sequences. To over all view, the studies of natural products reveal the structures of the most exciting biomolecules, natural fatty acids, prostaglandins and steroidal harmones	**12**
Steroids and Steroidal Hormones: Structure, synthesis, stereochemistry and spectral features of cholesterol and ergosterol. Steroidal Hormones: Estrogenic hormones–estrone, androgenic hormones–androsterone, corpus luteum hormones–progesterone.Transformations in steroids and hormones	**12**
Plant Products: Structure, synthesis, stereochemistry and spectral properties (wherever applicable) of the following: Alkaloids: Papaverine, reserpine, morphine, lysergic acid, physostigmine, yohimbine. Photochemical synthesis of nuciferene, corydaline and tylophorine. Terpenoids: α–Cadeine, zingiberene, α–Pinene, gibberillic acid, camphor, caryophyllene, abietic acid and farnesol.	12
Prostaglandins and Lipids: Prostaglandins: Introduction, nomenclature, classification and biological	**12**

role of prostaglandins. Structure elucidation and stereochemistry of PGE1. Synthesis of prostaglandins by Corey and Stork routes. Lipids: Sphingolipids, phospholipids, cyanolipids and glycolipids, naturally occurring fatty acids and their triglycerides, essential fatty acids, unusual fatty acids, methods of isolation: Gunstone's partition method. Reactions of fatty acids: Fischer– and trans–esterification, oxidation, hydrogenation, margarine and acyl group transfer reactions. Analytical values: Cetane number. Applications of GC, IR, ^{1}H–NMR, ^{13}C–NMR and MS techniques in the study of their structures. Emulsions and biodiesel. Oleochemicals and their applications in the synthesis of heterocycles	
Biomolecules: Structure and synthesis of nucleosides and nucleotides. Methods of formation of internucleotide bonds. Polynucleotides, structure, formation and hydrolysis products of DNA and RNA. Role of nucleic acids in protein synthesis. Genetic code. Peptide bond formation, structure and stereochemistry. Peptide linkage, primary structure of peptides. C–terminal amino acid determination (hydrazinolysis), N–terminal amino acid determination. Edman's and Sanger's method. Application of dansyl chloride, partial hydrolysis of peptides. Mass spectra of peptides. Synthesis of Peptides: Oxytocin, glutathione, merrifield Solid phase peptide synthesis. Structure of proteins. Reaction and mechanism of biochemical reactions associated with thiamine pyrophosphate, pyridoxal phosphate, Vit B_{12}, flavin and NADH.	**12**
PG75P301B: Lab Course in Organic Chemistry	
➢ The binary mixture analysis helps the students to understand the nature, physical properties and functional group of the unknown organic compounds. ➢ This course also helps the students to know about separation and purification techniques. **CHO(Pr)–3.4: LAB COURSE IN ORGANIC CHEMISTRY** Identification of the nature, bulk separation, purification and qualitative analysis (using ether) of the binary mixture of the following classes: Acids, bases, phenols and neutral compounds (without derivatives). ***Recommended Books***: 1. Vogel's Textbook of Practical Organic Chemistry Revised by B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997. 2. A Hand book of Organic Chemistry by H. T. Clarke.	

3. A Laboratory Manual of Organic Chemistry by B. B. Dey and M. V. Govindachari.

4. Lab Experiments in Organic Chemistry by Arun Sethi, New Age International Ltd. New Delhi. 2006.

Scheme of Examination

Duration of examination	:	04 hours
Experiments	:	35 marks
Journal and Viva	:	05 marks
Internal Assessment	:	10 marks
Total	:	50 marks

PG75P302B: LAB COURSE IN ORGANIC CHEMISTRY

- The chemical transformations of organic compounds to the other products by preparation of derivatives which will train the students in the synthetic organic chemistry.
- The students get the training in chromatographic techniques particularly inTLC and column chromatography.

1. Applications of computers in structure, stereochemistry, mechanism and conformational studies of organic compounds.

2. Chromatographic techniques: TLC and column chromatography.

3. Preparation of derivatives.

Recommended Books:

1. Applications of Computers in Chemistry.–Raman
2. Computers and Their Applications to Chemistry–Ramesh Kumari, Narosa Publishing House (2002)
3. Vogel's Textbook of Practical Organic Chemistry Revised - B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.
4. A Hand book of Organic Chemistry–H. T. Clarke.
5. A Laboratory Manual of Organic Chemistry - B. B. Dey and M.V. Govindachari.
6. Lab Experiments in Organic Chemistry – by Arun Sethi, New Age International Ltd. New Delhi. 2006.

Scheme of Examination

Duration of examination	:	04 hours

Experiments : 35 marks Journal and Viva : 05 marks Internal Assessment : 10 marks Total : 50 marks	
PG75P303B: LAB COURSE IN ORGANIC CHEMISTRY ➢ The students will learn the extraction methods for natural products and isolation methods. ➢ Students will learn how to assign the structure of natural products by spectroscopic methods. **Isolation, Characterization of Natural products:** 1. Cysteine from human hair. 2. Hesperidine from orange peel. 3. Caffeine from tea leaves. 4. Myristine from nutmug. 5. Piperine form black pepper. 6. Azaleic acid from castor oil. 7. Lycopene from tomato. ***Recommended Books:*** 1. Unitized Experiments in Organic Chemistry- Brewester and McEveen 2. Vogel's Textbook of Practical Organic Chemistry Revised -B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997. 3. A Hand book of Organic Chemistry –H.T.Clarke. 4. A Laboratory Manual of Organic Chemistry - B.B.Dey and M.V. Govindachari. 5. Lab Experiments in Organic Chemistry –Arun. Sethi, New Age International Ltd. New Delhi. 2006. 6. Natural products, A Laboratory Guide – R .Ikan Academic Press, London 1969. 7. Chemistry of Natural Products, S. V. Bhat, B. A. Nagasampagi, M. Sivakumar, Narosa Publishers, 2010. **Scheme of Examination** Duration of examination : 04 hours	

Experiments : 35 marks Journal and Viva : 05 marks Internal Assessment : 10 marks Total : 50 marks	
CHOT-4.1 ORGANIC SYNTHESIS	
The above course gives the benefits to the students as- ➢ The students we able to understand the retrosynthetic analysis to get a target and helps to make them for the research work. ➢ The study of newer reagents and reactions make the students to recent development in the synthesis of most potential biomolecules. Studies on oxidations and reductions enable the students to differentiate the methods involved in the organic synthesis	
UNIT – I **Synthetic Design and retrosynthetic analysis:** Protecting groups in organic synthesis: Principe of protection, protection of hydroxyl (–OH), amino ($–NH_2$, –NH), carboxylic (–COOH), carbony (RCOR′) groups, their synthetic applications and methods of deprotection. Retrosynthetic analysis: Terminology, synthon, synthetic equivalent, functional group interconversion and disconnection approach, one group C–X and two group disconnections. Applications of C–C disconnection in the synthesis of substituted 1,1–, 1,2– 1,3– and 1,4– bifunctional compounds. Retrosynthetic analysis and forward synthesis for alcohols, benzocaine, acetone cyanohydrin, *p*–methoxy acetophenone, 6–methyl quinoline, pirindol, 6–methoxy indole –3–acetic acid. Application to the synthesis of juvabione, taxol, longifolene, Prelog–Djerassi lactone.	**12**
UNIT–II **Oxidations and Reductions:** Oxidations: Oxidation of organic compounds using $KMnO_4$, PCC, OsO_4, CrO_3, $K_2Cr_2O_7$, SeO_2, $Pb(OAc)_4$, HIO_4, oxygen, Oppaneur oxidation, Swern oxidation, ozonolysis. Hydroboraton– isomerisation and oxidation. Application in the synthesis of esters, E–Z alkenes, conjugated dienes, alkynes. Conditions: Catalytic oxidation and Pt, photosensitized oxidation of alkenes, oxidation with molecular oxygen, aromatization, silver based reagents. Reductions: Reduction of organic compounds using the following reagents: $LiAlH_4$, $NaBH_4$, lithium hydridoalkoxyaluminates, MPV reduction, catalytic hydrogenation, dissolving metal reduction (including acylion	**12**

condensation), Clemmensen reduction. Birch Reduction, Wolf–Kishner reduction (Huang–Minlon modification), Raney–Ni desulphurisation	
UNIT–III **Newer Reactions:** Mechanism and strategic applications of the following named reactions: Suzuki coupling, Prins reaction, Shapiro reaction, Mitsunobu reaction, Robinson annulation, Junjappa–Ila aromatic and heteroaromatic annulations, Pauson–Khand reaction, Simon–Smith reaction, Huisgen 1,3–dipolar cycloaddition reaction, O′Donnell Aminoacid synthesis, Heck arylation, Desmartin reaction, Houben–Hoesch reaction, Sonogashira reaction, Buchwald–Hartwig reaction.	**12**
UNIT–IV **Newer Reagents:** Methods of preparation, mechanism of action and application of the following reagents in Organic synthesis: DCC, 1,3–dithiane (Corey–Seebach reaction), LDA, DDQ, Wilkinson catalyst, crown ethers, trimethyl silyl iodide, trimethyl silyl cyanide, hydrosilane, Iwanov reagent, Peterson reaction, Julia olefination, Woodward and Prevost hydroxylations, Lawesson's reagent	**12**
PG75T401B: PHOTOCHEMISTRY AND PERICYCLIC REACTIONS	
The above course gives the benefits to the students as- The students are able to understand the classifications and features of pericyclic reactions and are being useful in research work. ➢ Students understand the molecular rearrangements, mechanistic pattern etc. ➢ The biochemical mechanism is useful for students to study the bio-chemical reaction associated with enzymes and vitamins.	
UNIT–I **Organic Photochemistry:** Bonding and antibonding orbitals, principles of photochemistry, photochemical processes, singlet and triplet states, energy transfer and photosensitisation, photochemical reactions, photoreduction, Photochemical fragmentation reactions: Norish type–I, type – II cleavages (Yang cyclisation)–di–pi methane rearrangement, optical pumping, photochemistry of cyclohexadienones, photo–Fries rearrangement, Paternò–Büchi reaction, photochemistry of alkenes, benzenes,	

cyclohexanes and photochemistry of vision.	
UNIT–II **Pericyclic Reactions:** Pericyclic reactions: Classification and features, molecular orbital symmetry, frontier orbitals of ethylene, 1,3–butadiene, 1,3,5–hexatriene and allyl systems. Electrocyclic processes: Introduction, Woodward–Hoffmann rules for 4n– and (4n+2)–π systems, stereochemistry under thermal and photochemical conditions. Cycloaddition reactions: Introduction, supra facial and antra facial addition, [2+2] and [4+2] cycloaddition reaction (Diels–Alder reaction) FMO analysis under thermal and photochemical conditions. Sigmatropic rearrangements: Classification, FMO approach for [1,3], [1,5] and [3,3] sigmatropic rearrangements, supra and antra facial hydrogen shifts. Walk, Claisen–Cope, oxy–Cope and aza–Cope rearrangements. Vitamin-D group isomerizations	
UNIT–III **Molecular Rearrangement:** Molecular Rearrangement: Classification and general mechanistic pattern for electrophile, free radical and nucleophile rearrangement. Mechanisms of the following rearrangement: (i) C–C migration: Wagner–Meerwein, pinacol–pinacolone, dienone–phenol, benzilic, Favorskii, Sommelet–Hauser, Stevens, Smiles, Fritsch–Butenberg–Wiechell. (ii) C–N migration: Benzidine rearrangement, Neber, Beckmann, Hofmann, Curtius, Lossen, Schmidt. (iii) C–O migration: Baeyer-Viliiger, Dakin, Payne (including *aza* and *thia*), hydroperoxide, Crigee, Rupe, Ferrier, Petasis, Bamford–Stevens. (iv) O–C miigration**:** Baker–Venkataraman, Fries and Wittig rearrangements.	
UNIT–IV **Organo–Lithium, –Magnesium, –Zinc, and –Tin Compounds:** Organolithium and organomagnesium: Preparation, properties of organolithium and organomagnesium compounds and their uses in organic synthesis and in the preparation of organometallic compounds, Gilman reaction, LDA. Organozinc compounds: Preparation, structure and bonding, applications in C–C bond forming reactions *viz*., Simmons–Smith reaction, Negishi coupling, Fukuyama coupling, Barbier reaction and zinc acetylides.	
PG75T403B HETEROCYCLIC AND MEDICINAL CHEMISTRY	

The above course gives the benefits to the students as- ➢ The students are made aware of the classification, nomenclature and reactions of three, four and seven membered heterocycles. ➢ The students are able to understand transformations, photochemistry and rearrangements of heterocycles. ➢ This course also helps to the student to study modern theories of drug actions and SAR studies and chemotherapy.	
Heterocyclic Chemistry–I Chemistry of three, four, and seven membered heterocycles with one heteroatom. Three membered: oxiranes, aziridines and thiranes. Four membered: oxetanes, azetidines and thietanes. Seven membered: oxepines, azepines and thiepines.	
UNIT–II **Heterocyclic Chemistry–II** Transformations, Photochemistry and rearrangement in heterocycles. Transformations of: (i) coumarins to benzofurans, (ii) sydnones to pyrazoles, (iii) chromones to pyrazoles (iv) furans to pyridines and (v) pyrroles to pyridines. Heterocycles in functional group fransformations: (i) alkanes from thiophenes, (ii) cycloalkanes from pyrazolines, (iii) dienes from pyrroles (iv) alcohols from isoxazodiolines (v) esters from trichlorocyanuric acid, (vi) acetylenes from 1,2,3-selenadiazoles and (vii) deoxygenation of phenols tetrazoles. Rearrangements in heterocycles: (i) Dimroth rearrangement, (ii) Boultan–Katritzky rearrangement and (iii) Fischer Indole cyclisation.	
UNIT–III **Medicinal Chemistry–I:** Modern theories of drug action, concept of receptors, computer aided drug design, qualitative and quantitative SAR. Sulfa drugs: Sulfadiazines, sulfamethazines, sulfaguanidines, sulfaisoxozoles and sulfamerazine. Analgesics: Classification of narcotic and non–narcotic analgesics. Narcotic: Opium alkaloids, morphine, metopon, benzomorphan and phenazocine. Non–Narcotic: 4–Phenylpiperidines, pethidine, di–isopropylamines, methadone, pyrazolones and antipyrine. Anti–Fertility Drugs: Steroidal and non–steroidal compounds,	

norethindrone, mestranil, norgestrol and non–steroidal antifertility drugs.	
Medicinal Chemistry–II: Antineoplastic agents: Nitrogen mustards, chlorabucil, sarcolycin dopan and cyclophosphomide. Pteridines: Amethopterin, pyrimidines, 5–fluorouracil, cis–platines, anti–platines, etc. Antibiotics: Structure, synthesis, stereochemistry and spectral features of the following antibiotics: natural penicillins, semisynthetic penicillins, patulin, chloramphenicol, steptomycin, structural features and uses of common antibiotic drugs. Norfloxacin, rifamycin and amoxycillin.	
PG75D401B :PROJECT WORK In this course students are exposed to extensive literature survey which will help them to understand the given research problem. ➢ The students will be exposed to the spectroscopic methods which will help them to synthesize the previously unknown molecules. ➢ The outcome of research work is being published in the international journals of repute which makes students to inspire in the future research field.	
Preparation of Derivatives / Spectral Analysis	
The project work may include in–plant training in Industries/short term work in the department/other educational institutions/R&D organizations/data mining/review of current literature/theoretical methods/computer applications. Experimental work may involve studies on synthesis/measurements/study of properties/characterization by physical methods/activities for reported/unreported research or any suitable combination thereof.	
PG75P401B: LAB COURSE IN ORGANIC CHEMISTRY	
➢ The students will be trained in purification methods by column chromatographic techniques	
Multi-step preparation of organic compounds involving various reactions like addition, elimination, oxidation, hydrolysis etc. and purification methods like distillation and crystallization.	

Recommended Books:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A. J. Hannaford, P.W.G. Smith, A. R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M. V. Govindachari.
4. Lab Experiments in Organic Chemistry–Arun Sethi, New Age International Ltd. New Delhi. 2006.

Scheme of Examination

Duration of examination	:	04 hours
Experiments	:	35 marks
Journal and Viva	:	05 marks
Internal Assessment	:	10 marks
Total	:	50 marks

PG75P402B : LAB COURSE IN ORGANIC CHEMISTRY

- The Ternary mixtures analysis helps the students to study the nature, physical properties and functional group of the unknown organic compounds.
- This course also helps the students to know about separation and purification techniques.

Ternary mixture analysis (without derivatives). Qualitataive analysis of three component mixture containing amino acids, low boiling liquids, nitrophenols etc.

Books Recommended:

1. Vogel's Textbook of Practical Organic Chemistry Revised–B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997.
2. A Hand book of Organic Chemistry–H. T. Clarke.
3. A Laboratory Manual of Organic Chemistry–B. B. Dey and M.V. Govindachari.
4. Lab Experiments in Organic Chemistry–Arun Sethi, New Age International Ltd. New Delhi. 2006

Scheme of Examination

Duration of examination	:	04 hours
Experiments	:	35 marks

Journal and Viva : 05 marks Internal Assessment : 10 marks Total : 50 marks	
PG75P403B : LAB COURSE IN ORGANIC CHEMISTRY	
➢ The chemical transformations of organic compounds to the other products by preparation of derivatives which has trained the students in the synthetic organic chemistry. ➢ Further students are beings exposed to prove the structure of organic molecules by spectroscopic methods. ➢	
Preparation of Derivatives / Spectral Analysis ***Recommended Books:*** 1. Vogel's Textbook of Practical Organic Chemistry Revised - B. S. Furniss, A. J. Hannaford, P.W.G. Smith, A.R. Tatchell, 5th Edition, Addison Wesley Longman Limited, UK, 1997. 2. A Hand book of Organic Chemistry–H. T. Clarke. 3. A Laboratory Manual of Organic Chemistry - B. B. Dey and M. V. Govindachari. 4. Lab Experiments in Organic Chemistry– y Arun Sethi, New Age International Ltd. New Delhi. 2006. **Scheme of Examination** Duration of examination : 04 hours Experiments : 35 marks Journal and Viva : 05 marks Internal Assessment : 10 marks Total : 50 marks	

Specific course outcome (Physical Chemistry)

Paper Code and Name	PG75T103C: PHYSICAL CHEMISTRY: QUANTUM CHEMISTRY, REACTION KINETICS, THERMODYNAMICS & ELECTROCHEMISTRY AND INTRODUCTION TO POLYMERS
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course helps students a better understanding to describing and predict the behaviour of matter at atomic and molecular level.
2.	At the end of this course, the students will learn, the kinetics and mechanism of reactions take place and also the significance of activation parameters.
3.	In this course, the students will learn, the energy of activation and entropy of a chemical reaction
4.	This course provides the fundamentals of polymers, their synthesis and degradation.

PARTICULARS	Teaching Hours (Total. 48)
Unit 1: Quantum Mechanics	
Review of classical mechanics: Equation of motion for a particle, Newtonian, Lagrangian and Hamiltonian equations of motion, elementary wave motion. Operators, eigen values and expectation values, commuting operators, linear operator and Hermitian operators. Solutions of Schrödinger equations of a free particle, particle in a box problem: in one and three dimensions, degeneracy, reflection and penetration of a particle in a one-dimensional box of semi-infinite barrier, a particle in a box of finite walls. Rigid rotator, derivation of selection rules for transitions in rotating molecule, linear harmonic oscillator, Hermite polynomials. Equation for the hydrogen atom in spherical polar coordinates and an indication of the method of its solution, the quantum numbers and their significance**.** Hydrogen-like atoms, properties of the H–atom wave functions. Electronic energy states of H–atom. Many electron systems and the self-consistent field method. Electronic configurations in the periodic table. Pauli exclusion principle.	12 Hours

UNIT–II: Reaction Kinetics:	
A critical account of collision and transition state theories. Kinetics and mechanism: Steady state approximation and simple examples relating kinetics to mechanism.Theories of Unimolecular reactions: RRKM theory. Isomerisation of methyl isocyanide. Chain Reactions, examples of chain reactions, general aspects of chain reactions. Chain-length, chain transfer reactions, chain inhibition, kinetics of branching chain reactions and explosion limits.	12 Hours
UNIT–III: Thermodynamics:	
Thermodynamic criteria for spontaneous chemical changes. Systems at (i) constant volume and temperature and (ii) constant pressure and temperature (derivation of $dA \leq 0$ & $dG \leq 0$). Dependence of free energy on pressure and temperature. Standard free energies and their determination. Relation between free energy change and equilibrium constant. Gibbs–Helmholtz equation and their55ifferrent forms. The pressure dependence of free energy of non–ideal gases and fugacity. Standard state for non-ideal gas. Equilibrium constant for system of non–ideal gases. Lewis and Randall rule. Temperature dependence of free energy and equilibrium constants. Partial miscibility, activity and activity coefficients of components of solutions, partial molar quantities and their determinations. Gibbs–Duhem equation and the calculation of activity of a component in solutions. Duhem–Margules equation. Ternary systems and phase diagram of ternary systems.	12 Hours
UNIT–IV: Polymers :	
Review on basic concepts of polymers and their classifications. Homopolymers, copolymers, terpolymers, addition polymers and condensation polymers with examples. Comparison between addition polymers and condensation polymers. Tacticity with examples of polystyrene and PMMA. Elastomers, difference between elastomer and thermoplastic, approaches to increase processability. Techniques of free–radical polymerization: Bulk, solution, suspension, emulsion and precipitation polymerization. Reactions of vinyl polymers**:** Functional group reactions, ring-forming reactions and block & graft copolymer formation. Crosslinking reactions:peroxide crosslinking, sulphur vulcanization, radiation crosslinking, photo crosslinking, electron beam crosslinking and miscellaneous crosslinking reactions. Polymer degradation: Chemical, thermal and radiation degradations.	12 hours

REFERENCES

1. Introduction to Quantum Chemistry by A. K. Chandra, Ed. 3, Tata McGraw Hill, New Delhi, 1988.
2. Quantum Chemistry by R. K. Prasad, New Age International Publications, New Delhi, 1997.
3. Quantum Chemistry by Eyring, Walter and Kimball, John-Wiley, New York.
4. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996.
5. Fundamentals of Physical Chemistry by Maron and Lando.
6. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4).
7. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
8. Physical Chemistry by Daniels and Alberty, Wiley, New York.
9. Physical Chemistry Through Problems by S. K. Dogra and S Dogra, Wiley Eastern, New Delhi.
10. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London.
11. Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi.
12. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
13. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
14. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
15. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
16. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
17. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
18. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
19. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

Paper Code and Name	PG75P103C: LAB COURSE IN PHYSICAL CHEMISTRY
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course is designed in such a way that it provides a bridge to the students and attempts to make a link between their undergraduate experiments to master level.
2.	The aim is to make students gain familiarity with a variety of physicochemical measurement techniques of some basic physical chemistry experiments like spectrometry, conductometry, potentiometry, law etc.
3.	Also familiarize the students with general information and chemical mathematics, calibration of glassware's, concentration measures of solutions and treatment of experimental data

PARTICULARS	Teaching Hours
1. General Information and Chemical mathematics: Calibration of glasswares, concentration measures of solutions- concept of normality, molarity, molality and mole fraction, prepration of standard solution. Treatment of Experimental data – Errors, type of errors, Accuracy and precision. Mean deviation, standard deviation, significant figures, Methods of average and least squares. 2. Spectrophotometry: To obtain the absorption curve of $KMnO_4$ solution on a colorimeter and hence verify Beer–Lamberts law. 3. Potentiometery: Determination of the dissociation constant of dibasic acids (minimum two acids and titration with NaOH) 4. Conductance: Simultaneous estimation of $H_2C_2O_4$ and HCl in the mixture conductometrically by titrating with NaOH. 5. Distribution law: Studying the distribution of benzoic acid between water and benzene and hence determine the degree of association of benzoic acid in benzene.	

6. Viscosity: Determination of viscosity average molecular weight of polystyrene in toluene by Ubbelohde Viscometer

7. Thermochemistry: Determine the relative strength of CH_3COOH and $ClCH_3COOH$ by calorimetric method.

8. Reaction Kinetics: Determination of activation parameters of the reaction of acid hydrolysis of methyl acetate at two different temperatures.

9. Cryoscopy: Determination of cryoscopic constant of benzene and nitrobenzene

10. Refractometry: Analysis of a binary mixture (glycerol and water) by refractive indices measurement.

REFERENCES

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
3. Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York.
4. Experimantal Physical Chemistry by W. G. Palmer, Cabridge University Press, London.
5. Advanced Physico-Chemical experiments by J. Rose. 6. Text Book of Physical Chemistry by S. Glasstone, , McGraw Hill,London.
6. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
7. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
8. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.
9. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

Paper Code and Name	PG75T203C: PHYSICAL CHEMISTRY–II MOLECULAR SPECTROSCOPY, ELECTRONIC SPECTROSCOPY, THERMODYNAMICS, REACTION KINETICS AND INTRODUCTION TO POLYMERS
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course demonstrates the development of physical science.
2.	This course describes the arrangement of atoms and molecules in crystalline solids and also exhibits how crystalline solids show strong diffraction patten when exposed to X-rays, neutron and electrons.
3.	This course helps to understand the solvent and ionic strength effects on kinetics of solutions and also about Stopped-Flow technique.
4.	This course helps in understanding the basics of redox reactions at surface of the electrode and also helpful in understanding the electric double layer at inter-phase region between the electrode and electrolyte.

PARTICULARS	Teaching Hours (Total. 48)
UNIT–I: Microwave Spectroscopy and X–ray Diffraction	
Microwave spectroscopy: Gaseous microwave spectra and rotational transitions: Study of inversion of ammonia and hindered rotations in molecules. Instrumentation. Stark effect in molecular spectra, first and second order Stark effects. X–ray diffraction: Origin and production of X-rays, interaction of X–rays with matter: Absorption, scattering and diffraction. Reciprocal lattice: Brag's law in reciprocal space. Instrumentation: Sources, filters, monochromatic detectors. Crystal structure: Unit cell, lattices, planes and miller indices. Debye-Scherrer powder methods and Weissenberg camera. Numerical problems.	12 Hours
UNIT–II: **Reaction Kinetics:**	
Kinetics in Solution:Effect of solvent, pressure and ionic strength for ion–ion, ion–neutral molecule type reactions and cage effects. Potential energy surfaces, methods employed in the construct of potential	12 Hours

surfaces, calculating reactions. Fast Reactions:Techniques for fast reactions, flow methods, stopped flow technique, relaxation methods and flash photolysis. Numerical problems.	
UNIT–III: Electrochemistry:	
Introduction to electrochemistry, Debye-Huckel and Bjerrum models and the corresponding theoretical expression for activity coefficient and Debye–Huckel–Onsagar theory of conductance of strong electrolytes. Electrochemistry of Solution: Activity of ions in solution, solvation number and their determination, ion-solvent interactions, ion-ion interactions and free energy of ions in solution and triple ion formation, conductance minima and free energy of ions in solution. Born model for calculating the free energy of ion-solvent interaction and its modifications. The enthalpy and entropy of ion–solvent interaction. Electrical double layer: Electrocapilarity, Lippman equation (surface excess), theories of electrical double layer: Helmholtz–Perrin, Gouy–Chapman and Stern theories. Effect of ions on zeta potential. Over potentials, exchange current density, derivation of Butler–volmer equation and Tafel plot.	12 Hours
UNIT–IV: Polymer chemistry	
Transitions in polymers: Definition of glass transition temperature (T_g) and flow temperature (T_f) and melting temperature (T_m), thermal behaviour of amorphous and crystalline polymers, factors affecting the T_g.Plasticizers, properties and their effect on T_g of PVC and diethylhexylsuccinate, efficiency of plasticizers, comparison of T_g and T_m. T_g of copolymers and polymer blends, relation between T_g and T_m. Polymer molecular weight: Number average and weight average molecular weights, polydispersity and molecular weight distribution in polymers. Numerical problems on determination of molecular weights. Kinetics of polymerization: Kinetics of free-radical addition polymerization, cationic polymerization, anionic polymerization, copolymerization and determination of reactivity ratios. Polymer synthesis: Ziegler–Natta polymerization (isotactic and syndiotactic) and its limitations. Metallocene catalysis polymerization (isotactic). Metathesis polymerization: Acyclic diene metathesis polymerization (ADMET) and ring opening metathesis polymerization (ROMP). Group transfer polymerization (GTP) and advantages of GTP.	12 hours
REFERENCES	
1. Fundamentals of Molecular Spectroscopy by C. N. Banwell, Tata McGraw Hill 1. Publishing Co., New Delhi. 2. An introduction to Molecular Spectroscopy by G. M. Barrow, McGraw	

Hill, New York.
3. Molecualr Spectra and Molecular Structure:I Spectra of Diatomic Molecules by G.
4. Herzberg, Van Nostrand, Princeton.
5. Physical Chemistry by P. W. Atkins, ELBS, London.
6. Physical Chemistry by G. M. Barrow, McGraw Hill, New York.
7. Atomic and Molecular Spectroscopy by M. C. Gupta, New Age International Publishers, New Delhi.
8. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
9. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
10. Chemical Kinetics by K. J. Laidler, McGraw Hill, 1950.
11. Kinetics and mechanism of chemical transformations by J. Rajaraman and J. Kuriacose, McMillan.
12. Theory of rate processes by S. Glasstone, K. J. Laidler and H. Eyring, McGraw- Hill, 1941.
13. Thoeries of Chemical recation Rates by K. J. Laidler, McGraw-Hill, 1969.
14. Techniques of Organic by Weissberger(ed.), Interscience, Vol.VIII, 1963,
15. Kinetics of Chemical Changes in Solution by E. S. Amis, MacMillan, 1948
16. The Foundations of Chemical Kinetics by S. W. Benson, MacGraw-Hill, 1960.
17. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London
18. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York.
19. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London.
20. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
21. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
22. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
23. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
24. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
25. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.

Paper Code and Name	PG75P203C: LAB COURSE IN PHYSICAL CHEMISTRY
COURSE OUTCOMES (COs)	
This lab course aims to develop further the skills and techniques gained during last semester experiments.	
1.	It consists of several experiments that use different techniques to explore fundamental concepts of solubility of a solute, cyoscopic determination of the degree of dissociation of a given strong electrolyte, spectrophotometry, conductance. Potentiometry, viscometry, etc.
2.	This course also helps the students to learn thermal behaviour of crystalline and amorphous polymers and also synthesis and kinetics of polymerization

PARTICULARS	Teaching Hours
1. Solubility: Determine the heat of solution of a solute (e.g oxalic acid or benzoic acid) by solubility method. 2. Coulometric titration: Titration of I_2 against $Na_2S_2O_3$. 3. Cryoscopy: Determination of the degree of dissociation of a given strong electrolyte and the determination of the number of ions present in the solute using cryoscopy method. 4. Spectrophotometry: To obtain the absorption spectra of coloured complexes (Ferric-thiocyante and Cupric–ammonia complexes) and hence verify the Beer–Lambert's law and estimation of metal ions in solution by spectrophotometry. 5. Conductance: (i) Determination of equivalent conductance of a weak electrolyte at different concentrations and the applicability of Ostwald's law. (ii) Determination of equivalent conductance of a weak electrolyte from Kohlrausch's law. 6. Potentiometry: Potentiometric determination of formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{4+}/ Ce^{3+} or Cr^{6+}/ Cr^{3+} couples by titrating Fe^{2+} solution with Ce^{4+} or Cr^{6+}. 7. Reaction Kinetics: Investigation of autocatalytic reaction between potassium permanganate and oxalic acid in the presence of H_2SO_4.	

8. Viscosity: Determination of limiting viscosity number (Staudinger index) of polystyrene. 9. pH metry: Titration of acetic acid against NaOH and hence determine the acid dissociation constant (K_a).	
REFERENCES	
1. Findlay's Practical Physical Chemistry, 9th edition, revised by B. P. Levitt, Longman, London. 2. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longman, London. 3. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York. 4. Experiments in Physical Chemistry by Daniels, Alberty and Willams McGraw Hill, New York. 5. Laboratory Physical Chemistry by Oelke/M.A.C.T.L.A.C. 6. Experimental Physical Chemistry by W. G. Palmer, C.U.P., London. 7. Advanced Physico-Chemical Experiments by J. Rose. 8. Text Book of Physical Chemistry by S. Glasstone, Macmillon and Co., London. 9. Text Book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow. 10. Advanced Practical Physical Chemistry by J. B. Yadav. Goel Publishing House. 11. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers. 12. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition, 2007.	

Paper Code and Name	**PG75T301C: QUANTUM MECHANICS, DIFFRATION & GROUP THEORY**
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course covers the application and solution ofthe Schrodinger equation in spherical polar coordinates and Schrodinger's equation for atoms of many electron systems.
2.	Elemental analysis by emission spectroscopy

3.	This course explains the locations of atoms and molecules in crystalline solids and also exhibits how crystalline solids show strong diffraction pattern when exposed to x-rays, neutrons and electrons.
4.	Group theory helps to know the structure and behaviour of molecules and crystals depending on their different symmetry.

PARTICULARS	**Teaching Hours (Total. 48)**
UNIT–I: Quantum Mechanics:	
Equation for hydrogen atom and its solutions, separation of variables, the phi, theta and radial equations, the problems of spherical symmetry. Approximate methods in quantum mechanics: variation method and variation theorem, linear variation functions, secular equations and secular determinants. Application of variation method to hydrogen molecule ion, hydrogen molecule and normal helium atom. Perturbation theory (first order and non-degenerate), application of perturbation theory to the helium atom.	12 Hours
UNIT–II: **Atomic Structure and Atomic Spectra:**	
A summary of the hydrogen spectrum. Alkali spectra and alkali like spectra, spark spectra and arc spectra. Moseley lines. Helium and alkaline earth spectra. Multiplet structure of line spectra. Doublet structure of alkali spectra and compound doublets, triplets and singlets of alkaline earths and helium, prohibition of intercombinations. Multiplicities and term symbols. Space Quantization: Zeeman effect, normal and anomalous Zeeman effects, Paschen–Back effect and Stark effect.	12 Hours
UNIT–III: Symmetry Properties of Molecules and Group Theory	
Introduction to symmetry, molecular symmetry, symmetry elements, symmetry operations and matrix method in symmetry. Molecular point groups: point groups identification of point groups, construction of group multiplication tables, symmetry species and point group character tables. Reducible and irreducible representations, properties of irreducible representation, Mulliken symbolism rules for irreducible representation, structure of character tables, the standard reduction formula and the great orthogonality theorem. Normal mode analysis: number of normal modes of vibrational symmetry types, infrared and Raman activity, Rule of mutual	12 Hours

exclusion.	
UNIT–IV: Diffraction Studies:	
X-ray diffraction: Reciprocal lattice, indexing of single crystal rotation photographs, determination of molecular parameters, the structure factor calculations, Fourier series and phase problems. Refinements of Fourier procedures and general concept of solution of structures. Neutron diffraction: Neutron diffraction and differences from X-ray diffraction. Electron diffraction: Theoretical principles, structure analysis: visual comparison of intensities, radial distribution function and its refinements. The rotating sector method.	12 hours
REFERENCES	
1. Quantum Mechaincs–L.T.Schiff, Prentice–Hall. 2. Quantum Chemistry–H. Eyring, J. Walter and G. E. Kimball, John Wiley. 3. Quantum Mechanics–An Introduction–H. L. Strauss, Prentice Hall of India. 4. Quantum Mechanics–L. Pauling and E.B.Wilson, McGraw Hill. 5. Contemporary Quantum Chemistry–J. Goodisman, Plenum/Rosetta. 6. Quantum Chemistry–K. S. Pitzer, Prentice-Hall 7. Introductory Quantum Mechanics-Valdimir Rojanstry. 8. Quantum Chemistry–John P.Lowe. 9. Quantum Chemistry –Ira N. Levine, Prentice Hall of India Pvt. Ltd. 10. Quantum Chemistry–Donald A. McQuarrie, Viva Book Pvt. Ltd. 11. Physical Chemistry–P.W. Atkins, Clarendon Press, Oxford, 1970. 12. Molecular Quantum Mechanics–P.W.Atkins, Clarendon Press, Oxford, 1970. 13. Introduction to Quantum Chemistry–J. M. Anderson. 14. Introduction to Quantum Mechanics–R. H. Dicke, J. P. Wittke. 15. Indroductory Quantum Chemistry–A. K. Chandra, Tata McGraw Hill, New Delhi 1994. 16. Quantum Mechanics in Chemistry-M.W. Hanna. 17. Quantum Chemistry–R .K. Prasad, New Age International Publishers, New Delhi. 18. Atomic Spectra and Atomic structure–G. Herzberg, Van Nostrand 19. Chemical Applications of Group Theory–F.A.Cotton, Wiley Eastern, New Delhi 20. Molecular Symmetry–D.S.Schonlnd, Van Nostrand Comp.London,1965 21. Symmetry in Chemistry-Jeffe and Orchin, Wiley Inter Science, NewYork. 22. Symmetry, Orbitals and Spectra–Jeffe and Orchin, -Jeffe and Orchin,	

Wiley Inter Science, New York, 1971.
23. Electron Diffraction–T.B. Rymer, Methuen, London,1970
24. Neutron Diffraction–G.E.Becon
25. Symmetry in Molecules–J.M.Hollar
26. X-Ray Crystallography–Buerger
27. Diffraction Methods–Wernard
28. Chemical Crystallography–L.W.Bunn. N.Y.and Oxford,1945
29. Crystals and X–Rays K.landsdale, N.Y.1945
30. Crystal Structure Analysis–M.J.Berger, John Wiley and Sons, N.Y.1960
31. The Determination of Molecular Structure–P.J.Wheatley, Clarendon, Oxford,1960
32. Physical Chemistry–G.M.Barrow, McGraw Hill, New York, 1991
33. X-ray Diffraction–D.B.Cullity, Mass Addison, Wesley, 1978.

Paper Code and Name	**PG75P302C: SPECTROSCOPY & VOLTAMMETRY**
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course covers the theory that allows us to deduce the bond lengths and bond angles from rotational spectra experiments. Vibrational spectra provide information on bond lengths, bond strength and molecular geometry.

2.	NMR Technique is a powerful tool for the elucidation of molecular structure. Also, it helps us to gain insight into bonding and molecular structure.
3.	The EPR spectroscopy is helpful in elucidating the structures of paramagnetic complexes and CD and ORD spectra are useful in gross structural determination of organic compounds.
4.	Voltametric techniques are useful in understanding the type of reactions at electrode surface and quantitative determination of electroactive compounds.

PARTICULARS	**Teaching Hours (Total. 48)**
UNIT–I: Rotational and Vibrational Spectroscopy	
Rotation of polyatomic molecules: classification of molecules, momental ellipsoid, energy levels of linear, symmetric, spherical and asymmetric top molecules and their symmetry properties. Selection rules. Thermal distribution of rotational energy levels. Infrared rotational spectra and non rigid rotor treatment. Vibration of molecules: Molecule as harmonic oscillator, vibrational eigen functions and eigen values. Hermite polynomials, calculation of transition of probabilities and selection rules. The anharmonic oscillator, energy levels, selection rules and IR spectra. Anhormonicity and Morse equations. **Rotation-vibration spectra of polyatomic molecules: Rotation - vibration spectra, shapes of absorption bands in case of (i) linear, (ii) symmetric top, (iii) spherical top and (iv) asymmetric top, molecules. Isotopic effects. Applications of IR spectroscopy. Numerical problems on IR spectroscopy.**	12 Hours
UNIT–II::**Nuclear Magnetic Resonance-I:**	
Magnetic properties of nuclei: concept of nuclear spin, interaction between spin and external magnetic field, energies and energy levels of nuclear spin states, population of energy levels. Larmor precession, relaxation processes and relaxation times, theoretical principles underlying NMR, experimental set up and instrumentation: continuous wave and pulsed Fourier transform technique in NMR. Concept of chemical shift, shielding and deshielding mechanisms, diamagnetic–anisotropy, ring currents. Spin–spin coupling, coupling constants and rules governing the interpretation of first order ^{1}H–NMR spectra and elucidation of structure. Kinetic applications.	12 Hours
UNIT–III: Magnetic Resonance Spectroscopy-II and Optical Spectroscopy	
Nuclear quadrupole resonance spectroscopy: Theory and instrumentation, effect of magnetic field on the spectra, relationship between electric field gradients and molecular structure. Applications. The interpretation of eQq	12 Hours

data, effect of crystal latties on the magnitude of eQq. Structural information from NQR spectra. Electron spin resonance spectroscopy:Introduction and theortical principles. Intensity, frequency, position and representation of ESR absorptions. Hyperfine structure of ESR absorptions. Zero field splitting and Kramer's degeneracy. Instrumentation. Applications to the study of free radicals and compounds with unpaired electrons: ESR spectra of hydrogen and nitrogen atoms, semi–quinone ion, napthalene negative ion, methyl radical and methyl substituted radicals. Measurements of distribution of unpaired electron density in radicals. Study of coordination compounds by ESR technique. Optical rotatory dispersion and circular dichroism: Simple theoretical account and instrumentation. Treatment of data, applications to gross structure determination, octant rule, determination of stereochemistry and absolute configuration.	
UNIT–IV: Voltammetry:	
Voltammetry: Principles, and instrumentation, voltammetric techniques: Linear sweep voltammetry, staircase and square wave voltammetry, anodic stripping voltammetry, cathodic stripping voltammetry, cyclic voltammetry, normal and diferential pulse voltammetry and their theoretical aspects, electrodes, cells and their set-up. Electron transfer (ET) or charge transfer process:reversible ET, irreversible ET, quasi reversible ET and their diagnostic tests. Applications of voltammetric techniques. Polarography: Principles, dropping mercury electrode (DME), instrumentation, linear scan polorography, polarography currents, polarograms. Diffusion current at dropping electrodes, residual currents, advantages and disadvantages of dropping mercury electrode, current-sampled polarography, half wave potentials. Pulse polarography. Applications.	12 hours
REFERENCES	
1. Introduction to Molecular Spectroscopy–G.M.Barrow, McGraw Hill 2. Physical Methods in Inorganic Chemistry-R. S. Drago East-West Press, New Delhi. 3. Molecular Spectroscopy–J D. Graybeal. McGraw Hill 4. Spectroscopy, Volume I,II,III Ed–B.P. Straughan and S. Walker Chapman Gall, 1976. 5. Molecular Magnetic Resonance Spectroscopy–R.M.L.Bell and R.K. Harris 6. Spectra of Diatomic Molecules, G. Hertzberg-D. Van Norstrand Co. Inc. Prenceton N.J. 1950 7. Infrared and Raman Spectra of Polyatomic molecules–G.Hertzberg, D. Van Norstrand	

Co.Inc. Prenceton N.J. 1950
8. Absorption Spectroscopy–R.P.Bauman.
9. Molecular' Structure : A Physical Approach–J.C.D. Brand and J.C. Speakaman, Edward Arnold Ltd., London.
10. Microwave Spectroscopy–J.M. Sugden and C.N. Kenny.
11. Fundamentals of Molecular Spectroscopy–C. N.Banwell, Tata-Mcgraw Hill, New Delhi, 1975.
12. Microwave Spectroscopy–D. Gordy, W.V.Smith and R.F.Trambarulo, John Wiley and Sons, N.Y. 1969.
13. Molecular Vibrations–E.B.Wilson, J.C. Decius and P.G.Cross.
14. Nuclear Magnetic Resonance–E.R.Andrew, Chambridge University Press, Cambridge, 1955.
15. Nulcear Magentic Resonance–J.D. Roberts, McGraw Hill Book Co. N.Y. 1959.
16. Microwave Spectroscopy–C.H. Townes and A.L. Schawlow, McGraw Hill Book Co. N.Y. 1955.
17. Treatise on Physical Chemistry–H.S.Taylor and S. Glasstone, Vol. I and II, D.Van Nostrand, N.Y. 1957.
18. Basic Principles of Spectroscopy–Raymand Chang. McGraw Hill, Kogakusha Tokyo, 1971.
19. Theoretical Chemistry–S. Glasstone.
20. Instrumental Methods of Analysis–Willard, Merit and Dean, Tata McGraw Hill, New Delhi, 1993.
21. Introduction to Magnetic resonance–A Carrington and A.D. Mclachlan, Harper Rao.
22. Electrochemical Methods: Fundamentals and Applications–A. J. Bard and L. R. Faulkner
23. An Introduction to Electrochemistry by S. Glasstone, Van Nostrand, London
24. A Text book of Electrochemistry by G.F.A. Kortum and J.O.M. Bockris, Elsevier, New York.
25. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy Vol. I and Vol. II, Butterworths, London.

Paper Code and Name	PG75T303C:STATISTICAL MECHANICS AND POLYMER CHEMISTRY
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course provides methods for calculation ofmicroscopic properties of many particle systems in terms of microscopic properties using statistical laws.
2.	This course provides the information of properties and applications of polymers in industry and biomedical field and also how electrochemical cell can be used to obtain the power.
3.	This course helps the students to understand how the polymer membranes are used in water and solvent purification technique and also provides utilization of information in various fields of science and Technology.

PARTICULARS	Teaching Hours (Total. 48)
UNIT–I: STATISTICAL MECHANICS & POLYMER CHEMISTRY- I	
Microscopic and macroscopic systems. Microstates and macrostates. Assemblies of independent localised and non-localised systems. Phase space or γ-space and μ-space. Ensembles. Classical statistics: Maxwell–Boltzmann distribution for ideal gases and mixture of gases. Determination of Lagrangian multipliers, alpha and beta. Heat capacities of solids: Einstein's theory of heat capacity of solids, Debye's theory, characteristic temperature and use of Debye equation for the determination of heat capacity at low temperature. Entropies and heat capacities of ortho–, para–hydrogen systems, comparision of third law entropies with statistical entropies.	12 Hours
UNIT–II**: Statistical Mechanics and Statistical Thermodynamics–II:**	
Quantum statistics: Bose–Einstein, Fermi–Dirac and comparison with Maxwell–Boltzmann statistics. Numerical problems. Partition functions: Definition of partition function and separation of partition functions. Translational, Sackur–Tetrode equation, rotational, vibrational and electronic partition functions for monoatomic, diatomic and polyatomic gaseous molecules.Equipartition of energies.	12 Hours
UNIT–III: Polymer Chemistry and Fuel cells:	

Dendrimers and hyper-branched polymers:introduction to dendrimers, methods of preparation, common properties and applications. Synthesis of polyamidoamines using devergent route and dendratic polyether macromolecules using convergent route. Hyper–branched polymers, preparation of aromatic polyesters by the self-condensation of 3, 5–bis (acetoxy)benzoic acid. Polymeric nonlinear optical: Materials, definition, classification of NLO materials, basic molecular characteristics of second–order NLO materials, types of second–order NLO materials with examples, schematic representation of experimental setup for the measurement of second harmonic generation (SHG). Preparation of polyimide from diamino NLO chromophores. Semiconducting polymers: basic criteria for semiconducting properties, electrochemical polymerization, precursor route to poly (p–phenylenevinylene) (PPV) and synthesis of poly (3–alythiophene). Fuel cells: Introduction, difference between conventional cell and a fuel cell, limitations, advantages, types of fuel cells. Construction and working of hydrogen–oxygen and methanol–oxygen fuel cells. Applications of fuel cells.	12 Hours
UNIT–IV: Polymer Membrane Chemistry:	
Polymer membranes in separation science: mechanism of transport in polymeric membranes and rejection performance, and industrial applications of micro filtration (MF) and ultrafltration (UF) membranes. Reverse osmosis (RO): principles of RO process and determination of its efficiency in terms of flow of water and salt. Preparation of polyamide and cellulose based RO membranes. Electrodialysis:principle of ED, working model of ED. Preparation of ion-exchange membranes grafted on polyethylene film using styrene and chloromethylstyrene. Preparation of styrene-divinyl benzene based ion exchange membranes. Preparation of anion exchange membranes using chloromethylated polysulfone and 4, 4'–bipyridine. Preparation of sulfonated poly(phosphazene) membrane. Preparation of ion exchange membrane using 4–vinyl pyridine and ephichlorohydrin. Applications of Electrodialysis. Vinyl polymers (preparation, properties and commercial importance): polyethylene, polypropylene, polystyrene, polymethylmethacrilate, polyvinyl chloride, polytetrafluoroethylene. Polyesters: poly(ethylene terephthalate). Polyamides: aramides (Kevlar and Nomex), polyimides, polysulphone, polyurethanes, polyureas. Natural polymers: polyisoprenes, chitosan.	12 hours
REFERENCES	
1. Statistical Mechanics–N. Davidson, McGraw–Hill, 1962 2. Introduction to Statistical Thermodynamics–M. Dole, Prentice Hill. 1954	

3. Statistical Thermodynamics–R. H. Fowler and E. A. Guggenheim, Cambridge University Press, 1939.
4. An Introduction to Statistical Mechanics–T. L. Hall, Addison Wesley, 1960.
5. Introduction to Statistical Mechanics–G. S. Rushbrook, Oxford University Press, 1949.
6. Statistical Mechanics–J. E. Mayer and M. G. Mayer, John Willey, 1940.
7. Textbook of Physical Chemistry by A. Singh and R. Singh, Campus Books International, New Delhi
8. Polymer Chemistry: An Introduction- Malcolm P. Stevens, Oxford University Press, 1999.
9. Contemporary Polymer Chemistry–Harry R. Allcock and Frederick W. Lampe, Printice-Hall, 1981.
10. Principles of Polymer Chemistry–P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
11. Polymer Chemistry Properties and Applications–Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
12. Text Book of Polymer Chemistry–Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
13. Polymer Science–V.R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age
14. International Publisher, 2001
15. Polymer Modifiers and Additives–John T. Lutz, Jr., Richard F. Grossman, (eds.), Marcel-Dekker, NY, 1989.
16. An Introduction to the Mechanical Properties of Solid Polymers–I. M. Ward, D. W.
17. Hadley, John Wiley & Sons, 1993.Polymer Chemistry Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
18. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
19. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001
20. Dendrimers and Dendron: Concepts, Synthesis and Applications, G. R. Newkome, C. N.
21. Moorefield and F. Vogtle, Wiley–VCH Publisher, 2001.
22. Special Plymers for Electronics and Optoelectronics, J. A. Chilton and M. T. Goosey, (eds.), Chapman and Hall, 1992
23. Nonlinear Optics of Organic Molecules and Polymers, Hari Singh Nalwa and Seizo Miyata (eds.), CRC Press, 1997.
24. Introduction to Nonlinear Optical Effects in Molecules and Polymers, P. N. Prasad and David J. Williams, Wiley and Sons, 1990.
25. Liquid Crystalline Polymers, A. M. Donald, A. H. Windle, Cambridge

University Press, 1992.
26. Nonlinear Properties of Organic Molecules and Crystals Vol. 1, D. S. Chemla, J. Zyss (eds), Academic Press, Inc. (London), 1987.
27. A text book of Physical Chemistry, A. Singh and R. Singh, Campus Books , New Delhi.
28. Comprehensive Physical Chemistry, New Age International, New Delhi.
29. Ion exchange membranes, methods and processes for production thereof and uses in specific application–T. Amimbhavi, P.V. Kulkarni, M.Y. Karidurganavar, **US Patent 6,814,865B1**
30. Ion Exchange Membranes: Prepration, Properties and Applications–M. Y. Karidurganavar, A. A. Kittur, S. S. Kulkarni, Ion Exchange Technology–I, Springer.

Paper Code and Name	**PG75P301C: LAB COURSE IN PHYSICAL CHEMISTRY**
COURSE OUTCOMES (COs)	
1.	This lab course is designed to expand and deepen the knowledge in the variety of experimental methods presented in physical chemistry laboratory previously.
2.	This lab is based on several sets of advanced experiments on various topics in physical chemistry including viscosity, verification of the Debye-Huckel-Onsagr equation conductometrically, reaction kinetics, potentiometric estimation ofa mixture of halides, cryoscopy, pH-metry, spectrophotometric estimation of metal ion. etc.

PARTICULARS	**Teaching Hours**
1. Viscosity: Determination of number average molecular weight by hydroxyl end group analysis. 2. Conductance:Verification of the Debye-Huckel-Onsagr equation for strong electrolytes. 3. Reaction Kinetics: Studying the acid catalysed kinetics of oxidation of glycene by chloramine-T (CAT) and hence determination of order of reaction w.r.t. CAT and glycene and hence overall order of the reaction. 4. Potentiometry: Potentiometric estimation of a mixture of a halides, (KCl, KBr and KI) by titrating against $AgNO_3$	

5. Cryoscopy: Determination of the molecular weight of the given solute by the vacuum flask method.

6. pH metry: Determine the acid and base dissociation constant of an amino acid and hence find its isoelectric point

7. Refractometry: Analysis of a binary mixture (glycerol and water) by refractive indices measurement.

8. Spectrophotometry:Individual and simultaneous estimation of Fe(III) and Cu(II) spectrophotometrically by titrating against EDTA.

9. X-Ray diffraction: To determine the lattice constant and Bravais lattice using X-ray diffraction pattern.

10. Zeeman effect: Study the Zeeman effect and determine e/m ratio of electron.

REFERENCES

1. Findlay`s Practical Physical Chemistry, 9th edition, revised by B.P.Levitt.
2. Practical Physical Chemistry by A.M.James and F.E.Prichard
3. Experiments in Physical Chemistry by Shoemaker and Garland 4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al.
4. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C.
5. Experimental Physical Chemistry by W.G. Palamer
6. Advanced Physico-chemical experiments by J.Rose
7. Experimental Physical Chemistry by V.D.Athwale and Paul Mathur, New Age International Publishers.
8. Text book of Physical Chemistry by S.Glasstone
9. Text book of quantitative analysis by A. I. Vogel
10. Advanced Practical Physical Chemistry by J. B. Yadhav, Goel Publishing house, Meerut.

Paper Code and Name	PG75P302C: LAB COURSE IN PHYSICAL CHEMISTRY
COURSE OUTCOMES (COs)	
1.	This lab course is designed with the aim that student demonstrates capabilities such as experiment design and implementation with an emphasis on safety rules. demonstrating measurement capabilities, analysis and discussion, developing independent thinking abilities.
2.	This lab is based on the following set of advanced experiments on various topics in physical chemistry including adsorption, conductometric titration of moderately weak acid with strong base, determination of degree of hydrolysis of urea hydrochloride by studying kinetics of hydrolysis of methyl acetate using HCl and equinormal urea hydrochloride solutions, acid and base dissociation constants of an amino acid and its isoelectric point, etc.

PARTICULARS	Teaching Hours
1. Surface Tension: Variation of surface tension of aqueous solutions of a liquid (n–propyl alcohol) with concentration and determination of limiting cross sectional area of the alcohol molecule. 2. Adsorption: Invesitigation of adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir's adsorption isotherm. 3. Conductance: Moderatley weak acid like salycylic acid vs NaOH (Salt line method and alkali method). 4. Reaction Kinetics: Determination of degree of hydrolysis of urea hydrochloride by studying kinetics of hydrolysis of methyl acetate using HCl and equinormal urea hydrochloride solutions. 5. Potentiometry: (i) Acid and base dissociation constants of an amino acid and its isoelectric point and (ii) Mean ionic activity coefficent of hydrochloric acid at different concentrations using a concentration cell without transference: influence of ionic strength on the mean ionic activity coefficient. 6. Refractometry: Variation of refractive index with composition of mixture (e.g., CCl_4 and $CH_3COOC_2H_5$). 7. Transport Number: Tranference number of Ag^+ and Cl^- ions by making boundary method.	

8. Viscosity: Determination of molecular weight of polyhexamethylene sebacamide (nylon 6, 10) by amine end group anlaysis. 9. Optics: To determine the wavelength of He–Ne laser by measuring the fringe width from interference pattern.	
REFERENCES	
1. Findlay`s Practical Physical Chemistry, 9th edition, revised by B. P. Levitt. 2. Practical Physical Chemistry by A. M. James and F. E. Prichard. 3. Experiments in Physical Chemistry by Shoemaker and Garland. 4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al. 5. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C. 6. Experimental Physical Chemistry by W.G. Palamer 7. Advanced Physico–Chemical Experiments by J. Rose 8. Experimental Physical Chemistry by V .D. Athwale and Paul Mathur, New Age International Publishers. 9. Text Book of Physical Chemistry by S. Glasstone 10. Text Book of Quantitative Analysis by A. I. Vogel	

Paper Code and Name	**PG75P303C: LAB COURSE IN PHYSICAL CHEMISTRY**
COURSE OUTCOMES (COs)	
1.	This lab course is designed to provide students with idea of scientific activity.
2.	This laboratory is based on several sets of experiments covering a wide range of topics in physical chemistry such as solubility study, the effect of addition ofan electrolyte onthe solubility of an organic acid. construction of phase diagram of three component system. studying the kinetics of saponification of ethyl acetate by conductance method. determination of step wise heat of neutralization of a poly basic acid. reaction kinetics of H_2O_2 and HI: clock reaction, etc.

PARTICULARS	Teaching Hours
1. Solubility: Study the effect of addition of an electrolyte (NaCl, KCl, Na_2SO_4 and K_2SO_4) on the solubility of an organic acid (Benzoic acid or salicylic acid). 2. Phase equilibria: Construction of phase diagram of three component system (water, benzene and ethanol or acetic acid, water and chloroform or benzene). 3. Conductance: Studying the kinetics of saponification of ethyl acetate by conductance method and hence determine the rate constant. 4. Thermochemistry: Determination of step wise heat of neutralization of a polybasic acid. 5. Reaction Kinetics: Reaction kinetics of H_2O_2 and HI: Clock reaction. 6. Potentimetry: Potentiometric determination of stability constant of Cu^{2+}–EDTA complex. 7. Cryoscopy: Determination of degree of dissociation of given electrolytes (KCl, urea) using cryoscopy method. 8. Refractometry: Molar refraction of a solid substance by dissolving it in a solvent. 9. Solid state: Determine the curie temperature of ferromagnetic material. 10. X-ray diffraction: Determine the linear position and inter planar spacing using X-Ray diffraction patterns.	
REFERENCES	
1. Findlay`s Practical Physical Chemistry, 9th edition, revised by B.P.Levitt. 2. Practical Physical Chemistry by A.M.James and F.E.Prichard 3. Experiments in Physical Chemistry by Shoemaker and Garland 4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al. 5. Laboratory Physical Chemistry by Oelke/ M.A.C.T.L.A.C.	

6. Experimental Physical Chemistry by W.G. Palamer 7. Advanced Physico–chemical experiments by J.Rose 8. Experimental Physical Chemistry by V.D.Athwale and Paul Mathur, New Age International Publishers. 9. Text book of Physical Chemistry by S.Glasstone 10. Text book of quantitative analysis by A.I.Vogel 11. Advanced Practical Physical Chemistry by J.B. Yadhav, Goel Publishing house, Meerut.	

Paper Code and Name	PG75T401C: QUANTUM MECHANICS AND SOLID-STATE CHEMISTRY
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course describes the quantum mechanical treatment of the molecules by using different theories.
2.	The course solid state chemistry provides the properties and applications of solids.

PARTICULARS	**Teaching Hours (Total. 48)**
UNIT–I: Chemical Bonding–I	
Electronic structure of diatomic molecules. The Born–Oppenheimer approximation. Valence bond and molecular orbital theories of chemical bonding, comparison of the two theories. Applications of valence bond and molecular orbital theories to hydrogen molecule and hydrogen molecule ion. Improvements in the Hitler–London wave functions. Bonding and antibonding molecular orbitals. Molecular orbital theory applied to homonuclear and heteronuclear diatomic molecules, molecular electron configuration and calculation of bond order. Slater orbitals, Hartree–Fock self-consistent field method for many electron atoms. Configuration interaction and Roothaam equations.	12 Hours
UNIT- II: Chemical Bonding–II	
Localized and non–localized molecular orbitals, hybridization and direct valence. Quantum mechanical treatment to sp–, sp^2– and sp^3–hybridization and the geometry associated with sp–, sp^2– and sp^3–orbitals.	12 Hours

Conjugated and aromatic molecules: Huckel molecular orbital theory and MO description of normal and cyclic butadienes, ethylene and aromatic molecules (benzene as an example), calculation of delocalization energies, fractional bond orders, charge density calculations and extended Huckel theory.	
UNIT–III: Solid State Chemistry–I	
Introduction, properties of Solids: Malleability, ductility, elasticity, plasticity, brittleness hardness, enantiotropy, monotropy and isomorphism. Allotropy and polymorphism of solids. Bonding in solids: Ionic, covalent, metallic, molecular and hydrogen bonded crystals. Lattice energy of ionic crystals. Numerical problems. Imperfection in solids: Types of defects including Frenkel and Schottky defects, thermodynamics of Frenkel and Schottky defects. Reactivity in solid state: Introduction, thermodynamics, classification, experimental methods for the study, kinetic equation, energy of activation of solid-state reactions, diffusion mechanism in solid state reactions, factors affecting the reactivity of solids.	12 Hours
UNIT–IV: Solid State Chemistry–II	
Semiconductors: Bonding and conductivity, mechanism of conductivity, energy bands in semiconductors, impurity conductors, p–n and n–p–n junctions and importance of semiconductors. Superconductors: Occurrence of super conductivity, its destruction by magnetic fields, effect of I.R. and isotope effect, B.C.S. theory of superconductivity applications	12 hours
REFERENCES	
1. Quantum Mechaincs–L.T.Schiff, Prentice–Hall. 2. Quantum Chemistry–H. Eyring, J. Walter and G. E. Kimball, John Wiley. 3. Quantum Mechanics–An Introduction- H. L. Strauss, Prentice Hall of India. 4. Quantum Mechanics–L. Pauling and E.B.Wilson, McGraw Hill. 5. Contemporary Quantum Chemistry–J. Goodisman, Plenum/Rosetta. 6. Quantum Chemistry–K. S. Pitzer, Prentice–Hall 7. Introductory Quantum Mechanics–Valdimir Rojanstry. 8. Quantum Chemistry– John P.Lowe. 9. Quantum Chemistry–Ira N. Levine, Prentice Hall of India Pvt. Ltd. 10. Quantum Chemistry–Donald A. McQuarrie, Viva Book Pvt. Ltd. 11. Physical Chemistry–P.W. Atkins, Clarendon Press, Oxford, 1970. 12. Molecular Quantum Mechanics–P.W.Atkins, Clarendon Press, Oxford, 1970. 13. Introduction to Quantum Chemistry–J. M. Anderson. 14. Introduction to Quantum Mechanics–R. H. Dicke, J. P. Wittke. 15. Indroductory Quantum Chemistry–A. K. Chandra, Tata McGraw Hill,	

New Delhi 1994.
16. Quantum Mechanics in Chemistry–M.W. Hanna.
17. Quantum Chemistry–R .K. Prasad, New Age International Publishers, New Delhi.
18. Solid State Chemistry–N.B.Hanna
19. Solid State Physics–A.J.Dekkar, Mac Millon, India Ltd.1993
20. Solid State Chemistry–C.N.R.Rao, Cambridge, CUP
21. Solid State Physics, Edited by R.Kube and Takeo Nagamiya McGraw Hill Book Co. Inc.
22. Introduction to Solids–L.V.Azaroff, McGraw Hill, New York.
23. Solid State Chemistry and its Applications–A. R. West, John Wiley 1998

Paper Code and Name	**PG75T402C: CATALYSIS AND POLYMER CHEMISTRY**
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	This course describes the reaction kinetics of homogeneous and heterogeneous catalyzed reactions and industrial applications.
2.	This course gives the different methods available for the polymer weight determination.
3.	This unit provides the information regarding thermal characterization techniques and method of polymer fabrication and synthesis of polymers.

PARTICULARS	**Teaching Hours (Total. 48)**
UNIT–I: Homogeneous Catalysis:	
Homogeneous Catalysis: Introduction, general catalytic mechanism: equilibrium treatment and steady-state treatment, activation energies for catalysed reactions. Acid-Base catalysis: General acid–base catalysis, mechanism of acid-base catalysis, catalytic activity and acid-base strength, salt effects in acid-base catalysis and specific acid-base catalysis: Bronsted relation and linear free energy changes. Acidity functions: Zucker–Hammett hypothesis and Bunnett hypothesis. Enzyme Catalysis: Influence of substrate concentration, pH, temperature and inhibitors, transient-phase kinetics. Mechanism of enzyme catalysis: Michaelis–Menten mechanism and Lineweaver–Burk plot.	12 Hours
UNIT–II**: Adsorption and Heterogeneous Catalysis**	

Adsorption: The phenomenon of adsorption and thermodynamics of adsorption, adsorption isotherms, Langmuir adsorption isotherm, Langmuir constant and Gibbs energy of adsorption, Langmuir adsorption with lateral interaction, BET adsorption isotherm, Freundlich isotherm and adsorption on heterogeneous surface. Heterogeneous catalysis: Catalysis at surfaces, mechanism of heterogeneous catalysis: Langmuir–Hinshelwood mechanism and Eley–Rideal mechanism. Transition–state theory of heterogeneous surface reaction: Rates of chemisorption, rates of desorption, unimolecular and bimolecular surface reactions. Industrial applications of heterogeneous catalysis. Comparison of homogenous and heterogeneous reaction rates.	12 Hours
UNIT–III: Polymer Rheology and Molecular Weight Determination:	
Rheological Properties: Introduction, Hook's law, Newton's equation and stress-strain behaviour in polymers. Measurements of average molecular weights: Osmometry, viscometry, light scattering, and gel permeation chromatography. Practical significance of polymer molecular weight and related numerical problems. .	12 Hours
UNIT–IV: Thermal and Polymer Fabrication Techniques	
Thermal method of analysis: Introduction, thermal characterization techniques: Thermogravimetric analysis (TGA) and differential thermal analysis (DTA), introduction, experimental procedure, advantages and disadvantages of TGA/DTA. Differential scanning calorimetry (DSC): Introduction, experimental setup, heat capacity, glass transition temperature, crystallization, melting and determination of percent crystallinity. Methods of Polymer Fabrications: Fabrication of polymer films, solution casting, melt pressing, melt extrusion and bubble blown. Fabrication of shaped polymer objects: compression moulding, injection moulding, reaction injection moulding, blow moulding, extrusion moulding and calendaring. Spinning industrial polymers: Solution spinning and melt spinning	12 hours
REFERENCES	
1. Physical Chemistry by G. M. Barrow, McGraw Hill, New York, 1996. 2. Fundamentals of Physical Chemistry by Maron and Lando. 3. Physical Chemistry by P. W. Atkins, ELBS, London, 1990 (Ed. 4). 4. Physical Chemistry by K. Vamulapalli, Prentice Hall of India Pvt. Ltd., New Delhi, 1997. 5. Physical Chemistry by Daniels and Alberty, Wiley, New York. 6. Physical Chemistry Through Problems by S. K. Dogra and S Dogra, Wiley Eastern, New Delhi. 7. A Text Book of Physical Chemistry by Samuel Glasstone, McMillan, London.	

8. Atomic Structure and Chemical Bonding by Manas Chanda, Tata McGraw Hill Publishing Co., New Delhi.
9. Chemical Kinetics by K. J. Laidler, Tata McGraw Hill Publishing Co., New Delhi.
10. Kinetics and Reaction Mechanisms by Frost and Pearson, Wiley, New York.
11. Chemical Kinetics, K. J. Laidler. Mcgraw–Hill 1950.
12. Theory of rate processes, S. Glasstone, K. J. Laidler and H. Eyring Mcgraw-Hill 1941.
13. Kinetics and Mechanism, A Frost and R. G. Pearson, John Wiley, 1953.
14. The foundations of Chemical Kinetics, S. W. Benson, McGraw-Hill,1960.
15. Kinetics of Chemical Changes in Solution, E. S. Amis, McMillan, 1948.
16. The Kinetics of Chemical Change, C. N. Hinshelwood, Oxford, 1942.
17. Free Radical Mechanisms, E.W.R. Steacies, Reinhold, 1946.
18. Techniques of Organic Chemistry, Weissberger (Ed) Vol VIII, Investigations of Rates and Mechanism of Reactions Interscience, 1963.
19. Theories of Chemical Reactions Rates, K .J. Laidler, McGraw-Hill, 1969.
20. Comprehensive Physical Chemistry, New Age International, New Delhi.
21. Polymer Chemistry: An Introduction, Malcolm P. Stevens, Oxford University Press, 1999.
22. Contemporary Polymer Chemistry, Harry R. Allcock and Frederick W. Lampe, Printice–Hall, 1981.
23. Principles of Polymer Chemistry, P. Bahadur and N. V. Shastri, Narosa Publisher, 2002
24. Polymer Chemistry: Properties and Applications, Andrew Peacock and Allison Calhoun, Hanser Publisher, 2006.
25. Text Book of Polymer Chemistry, Fred W. Billmeyer, Jr., Wiley Publisher, 1984.
26. Polymer Science, V. R. Gowariker, N. V. Viswanathan and Jayadev Sreedhar, New Age International Publisher, 2001.
27. Membrane Technology in the Chemical Industry-S. P. Nunes and K. V. Peinemann (Eds.), Wiley–VCH Publisher, 2001.
28. Membranes for Industrial Wastewater Recovery and Reuse–Simon Judd and Bruce Jefferson (Eds.), Elsevier.
29. Membrane Processes, R. Rautenbach and R. Albrecht, Wiley and Sons, 1989.
30. A text book of Physical Chemistry, A. Singh and R. Singh, Campus Books, New Delhi.

Paper Code and Name	PG75T403C: SPECTROSCOPY AND MICROSCOPY
COURSE OUTCOMES (COs)	
After completing this paper, the students will be able to:	
1.	The Raman spectroscopy is commonly used in chemistry to provide a structural fingerprint by which molecules can be identified.
2.	The mass spectrometry is helpful in determining the structure of a compound by observing its fragmentation and its uses in analytical laboratories.
3.	Photoelectron spectroscopy involves the study of the electronic structure of molecules. Mossbauer spectroscopy is used to study nuclear structure with the absorption and reemission of gamma rays.
4.	Microscopic techniques make it possible to assess the morphology, composition, physical properties, and dynamic behaviour of materials.

PARTICULARS	Teaching Hours (Total. 48)
UNIT–I: Raman Spectroscopy:	
Introduction to scattering phenomenon, Raman effect: Theories of Raman effect (Classical and quantum theory). Concept of polarizibility and polarizibility ellipsoid. Rotational–Raman Spectra and vibrational–Raman spectra of Molecules. Symmetry selection rule and prohibition of inter–combination, influence of nuclear spin in case of homonuclear diatomic molecules, ortho– and para–modifications. Rotational–vibrational–Raman spectra, rule of mutual exclusion. Polarization of Raman lines and depolarization ratio. An introduction to Laser resonance Raman spectroscopy. Structure elucidation using combined Raman and infrared spectroscopy (e.g.H_2O, N_2O and CO_2). Numerical problems.	12 Hours
UNIT–II: Mass Spectrometry:	
Mass Spectrometry: Introduction, theoretical principles and instrumentation: ionization and ionization methods (electron ionization, chemical ionization, desorption ionization and electron spray ionization techniques). Mass analyser (magnetic deflection and time of flight mass analyser). Metastable ions. Ionization and appearance potentials, experimental determination of ionization and appearance potential and applications in mass spectrometry.	12 Hours

Fragmentation: Principles, Stevenson rule, odd electron ($OE^{\cdot+}$)and even electron (EE^{+}) ions, molecular ion and base peak, fragmentation pattern and correlation with structure. Isotope effects in chloro and bromo compounds. McLafferty rearrangement. Nitrogen Rule. Application of mass spectrometry in structure diagnosis and determination of empirical molecular formula from the peak intensities of molecular ion and isotopic peaks. Numerical problems.	
UNIT–III: Photoelectron and Mössbauer Spectroscopy	
Photoelectron Spectroscopy: Introduction, photoelectric effect, instrumentation. Valence and binding energies, molecular term symbols, shift in energies due to chemical effects. Augar electron spectroscopy (AES), its advantages and limitations. Electron spectroscopy for chemical analysis (ESCA). Applications to free molecules and surfaces. Mössbauer Spectroscopy: Theoretical principles, Mössbauer effect, conditions for Mössbauer spectroscopy and instrumentation. Resonance line shifts, chemical shifts, electric quadrupole interactions and magnetic interactions. Applications of Mossbauer Spectroscopy	12 Hours
UNIT–IV: Microscopy:	
Introduction to Microscopy. Scanning electron microscopy (SEM): Introduction, principle and instrumentation, sample preparation, scanning process, image formation and applications of SEM. Transmission electron microscopy (TEM): Introduction, principle and instrumentation, sample preparation, advantages/disadvantages and applications of TEM. Atomic force microscopy (AFM): Introduction, principle, imaging modes, topographic image, advantages/disadvantages and applications of TEM. Attenuated total reflectance (ATR) spectroscopy: Introduction, principle, sampling method, crystal methods for ATR, factors affecting the spectrum, sampling: liquid and solid sampling. Applications. Photoacoustic spectroscopy: Introduction, principle, photoacoustic effect, advantages and limitations of photoacoustic spectroscopy, examples and applications of photoacoustic spectroscopy.	12 hours
REFERENCES	
1. Introduction to Molecular Spectroscopy–G. M. Barrow, McGraw Hill, New York. 2. Physical Methods in Inorganic Chemistry–R. S. Drago, East-West Press, New Delhi	

3. Molecular Spectroscopy–J. D. Graybeal, McGraw Hill.
4. Spectroscopy, Vol. I,II and III. Ed.–Walker and Straughan, Chapman Hall, 1976.
5. Infrared and Raman Spectra of Polyatomic Molecules–G. Hertzberg, Van Nostrand, New York, 1954.
6. Absorption Spectroscopy–R.P.Bauman, Wiley New York,1952.
7. Introduction to Photoelectron Spectroscopy–P.K.Ghosh., John Wiley
8. Photoelectron Spectroscopy–T.H.D. Eland. Butterworth, London, 1974.
9. Fundamentals of Molecular spectroscopy–C.N.Banwell, Tata McGraw Hill, New York,1985.
10. Magneto chemistry–P.Selwood , Interscience, New York, 1956.
11. Techniques in Organic Chemistry, Vol.I. Interscience, 1963
12. Mass Spectroscopy: Organic Applications-K.Beiman, McGraw Hill.
13. Introduction to Mass Spectroscopy and its Applications–R.W. Kiser, Prentice Hall, Englewood–Cliff (NJ) 1965.
14. Basic Principle of Spectroscopy–Raymond Chang, McGraw Hill Kogakusha, Tokyo, 1971.
15. Physical Chemistry G.M.Barrow–McGraw Hill, New York, 1991.
16. Instrumental Methods of Analysis–Willard, Merritt and Dean, Tata MacGraw Hill, New Delhi, 1993.
17. Molecular Interpretation of Mass Spectroscopy–F. W. Mclafferty and W. A. Benzamin.
18. Molecular Spectroscopy–I.N.Levin, Interscience.

Paper Code and Name	PG75P401C: LAB COURSE IN PHYSICAL CHEMISTRY
COURSE OUTCOMES (COs)	
1.	This course is planned to familiarize and introduce the students to modern laboratory instrumentation and experimental techniques in physical chemistry.
2.	It consists of a number of experiments that use different techniques to explore fundamental concepts in variation of solubility of an organic acid, studying the kinetics of saponification of ethyl acetate by conductance method and hence determine the rate constant, thermochemistry. reaction kinetics, etc.

PARTICULARS	Teaching Hours
1. Viscosity: Viscosity of air by Rankine`s method. 2. Solubility: Variation of solubility of $Ca(OH)_2$ in NaOH solution and hence determination of the solubility product of $Ca(OH)_2$. 3. Thermochemistry: (i) Heat of reaction (precipitation/formation) of $BaSO_4$. (ii) Heat of transition of Glauber's salt ($Na_2SO_4.10H_2O$) 4. Surface Tension: Critical micelle concentration of a soap molecule. (e.g., Potassium laureate). 5. Potentiometry: Determination of degree of hydrolysis and K_h of aniline hydrochloride 6. Polarimetry: Kinetics of inversion of sucrose and determination of catalytic coefficient. 7. Cryoscopy: Determination of activities of electrolytes and non-electrolytes using cryoscopy method. 8. Spectrophometry: Investigation of complex formation between Fe^{+3} and salicyclic acid and determination of empirical formula, stability, ΔG value calculation and pH effects. 9. Glass transition temperature: Determination of glass transition temperature by dilatometer. 10. Solid state: To determine the electron–phonon coupling constant of copper	
REFERENCES	
1) Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt.	

2) Practical Physical Chemistry by A.M.James and F.E.Prichard 3) Experiments in Physical Chemistry by Shoemaker and garland 4) Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al. 5) Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C. 6) Experiments in Physical Chemistry by W.G.Palmer 7) Advanced Physico–Chemical experiments by J.Rose 8) Experimental Physical Chemistry by V.D.Athwale and Paul Mathur , New Age International Publishers. 9) Text Book of Physical Chemistry by S.Glasstone 10) Text Books of quantitative analysis by A.I.Vogel 11) Advanced Practical Physical Chemistry by J.B.Yadhav, Goel Publishing House, Meerut. 12) Computers and their applications to Chemistry, Ramesh Kumari, Narosa. 13) A Lab Manual of Polymers, S. M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.	

Paper Code and Name	**PG75P402C: LAB COURSE IN PHYSICAL CHEMISTRY**
COURSE OUTCOMES (COs)	
1.	This course is intended to acquaint the students with the practice of experimental physical chemistry and to provide an introduction to this area of modern scientific activity.
2.	This laboratory is based on several sets of experiments covering a wide range of topics in physical chemistry such as comparison of cleansing powers of two detergent samples, construction of phase diagram of three component system, cryoscopy, mobility of ions, influence of ionic strength on the solubility of $CaSO_4$ and determination of its thermodynamic solubility product and mean ionic activity.

PARTICULARS	Teaching Hours
1. Surface Tension: Comparison of cleansing powers of two detergent samples. 2. Phase Equilibria: Phase diagram of napthalene & diphenyl system, acetamide & salicylic acid and picric acid and benzene systems. 3. Conductance: Determination of the ionic conductance of Cu^{2+} at infinite dilution by Hittorf's method. 4. Reaction Kinetics: Studying the kinetics of photodegradation of indigocarmine (IC) using ZnO/TiO_2 as photocatalyst and study the effect of ZnO/TiO_2 and IC on the rate of photodegradation. 5. Potentiometry: Stability of the complex $Ag(NH_3)_2$ (concentration cells) 6. Solubility: Influence of ionic strength on the solubility of $CaSO_4$ and determination of its thermodynamic solubility product and mean ionic activity. 7. Cryoscopy: A study of complex formation between mercury and potassium halides using cryoscopy method. 8. Mobilities of ions: Determination of the ionic conductance of Cu^{2+} at infinite dilution by Hittorf's method. 9. Solid State: To determine the energy gap of semiconductor by resistivity measurement using four probe method. 10. Potentiometry: Determination of Hammet constant of ortho–, meta– and para–amino/nitro benzoic acid by pH measurements.	
REFERENCES	
1) Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt. 2) Practical Physical Chemistry by A. M. James and F. E. Prichard 3) Experiments in Physical Chemistry by Shoemaker and Garland 4) Experiments in Physical Chemistry by Daniels, Alberty and Williams. 5) Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C. 6) Experiments in Physical Chemistry by W .G. Palmer 7) Advanced Physico-Chemical Experiments by J .Rose 8) Experimental Physical Chemistry by V. D. Athwale and Paul Mathur, New Age International Publishers. 9) Text Book of Physical Chemistry by S. Glasstone 10) Text Books of Quantitative Analysis by A. I. Vogel 11) Advanced Practical Physical Chemistry by J. B. Yadhav, Goel Publishing	

House, Meerut. 12) Computers and their applications to Chemistry, Ramesh Kumari, Narosa. 13) A Lab Manual of Polymers, S.M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.	

Paper Code and Name	PG75P403C: LAB COURSE IN PHYSICAL CHEMISTRY
COURSE OUTCOMES (COs)	
1.	This lab course is designed so that the students learn how to describe experimental results and analyse them quantitatively and develop the ability of scientific communications through written reports and frontal presentations
2.	The experiments include, determination of molecular surface energy and association factor, determination of formula of the complex formed between copper ions and ammonia by distribution method, kinetics of oxidation of 2-propanol by chromic acid and determination of Transport number of Ag^+ and NO^- in solution (concentrationcells).

PARTICULARS	Teaching Hours
1. Surface Tension: Molecular surface energy and association factor. 2. Phase Equilibria: Formula of the complex formed between copper ions and ammonia by distribution method. 3. Refractometry: Ionization constant of bromphenol blue. 4. Reaction Kinetics: Kinetics of oxidation of 2-propanol by chromic acid and determination of effect of addition of Mn(II) on the reaction rate. 5. Reaction Kinetics: Studying the kinetics of reaction between CAT and indigocaramine spectrophotometrically and determination of rate constant 6. Potentiometry: Transport number of Ag^+ and NO_3^- in solution (concentration cells) 7. Viscosity: Effect of temperature on the viscosity of the liquid Viscosity of	

air by Rankine`s method. 8. Solid state: Determination of magnetic susceptibility of paramagnetic substance by Quinke's method 9. Solid state: Determine the relative integrated intensities of ZnS by Debye Scherrer pattern. Computer applications: The students will be taught to operate a PC and how to run standard programs and packages such as MS-WORD, EXCEL, ORIGIN, SIGMA PLOT, CHEM SKETCH etc. and solve chemistry problems. Problems will be taken preferably from physical chemistry for plotting first and second derivative curves, linear plots etc. Problems from chemical kinetics, polymer chemistry, analytical chemistry, electrochemistry, spectroscopy etc. will be solved.	
REFERENCES	
1. Findlay's Practical Physical chemistry, 9th edition, revised by B.P. Levitt. 2. Practical Physical Chemistry by A.M.James and F.E.Prichard. 3. Experiments in Physical Chemistry by Shoemaker and garland. 4. Experiments in Physical Chemistry by Daniels, Alberty and Williams et.al. 5. Laboratory Physical Chemistry by Oelke / M.A.C.T.L.A.C. 6. Experiments in Physical Chemistry by W.G.Palmer. 7. Advanced Physico–Chemical experiments by J.Rose. 8. Experimental Physical Chemistry by V.D.Athwale and Paul Mathur , New Age International Publishers. 9. Text Book of Physical Chemistry by S.Glasstone. 10. Text Books of quantitative analysis by A.I.Vogel. 11. Advanced Practical Physical Chemistry by J.B.Yadhav, Goel Publishing House, Meerut. 12. Computers and their applications to Chemistry, Ramesh Kumari, Narosa. 13. A Lab Manual of Polymers, S.M. Ashraf, Sharif Ahmed, Ufana Riaz, I.K. International New Delhi.	

Specific Course Outcome (Analytical Chemistry)

Paper Code and Name	PG75T104D: ANALYTICAL CHEMISTRY

COURSE OUTCOMES

After studying this paper, students will learn

- The classification of analytical techniques, classical quantitative techniques (volumetry and gravimetry) with regard to regard to minimization of errors, mechanism of precipitation and factors influencing precipitation, coprecipitation and post-precipitation, usage of organic reagents in gravimetric analysis,
- Selection of suitable indicators in various titrimetric analysis such as neutralization reactions, redox reactions, complexometric reactions and precipitation reactions. The application of these titrimetric methods for inorganic analysis.
- The classification and theory of various chromatographic methods such as column chromatography, TLC, HPLC, GC and Ion-exchange chromatography.
- The applications, advantages and limitations of various chromatographic techniques.
- Use of solvent extraction method in the quantitative determination of metal ions.

UNIT–I

Language of Analytical Chemistry, Data Treatment and Gravimetric Analysis:

Language of analytical chemistry: Definition of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Selection of an analytical method: Accuracy, precision, sensitivity, selectivity, robustness and ruggedness. Figures of merit of analytical methods: Sensitivity, detection limit and linear dynamic range.

Errors and Treatment of analytical Data: Limitations of analytical methods–Errors: determinate and indeterminate errors, minimization of errors. Statistical treatment of finite samples, measures of central tendency and variability, mean, median, range, standard deviation and variance. Student's t-test, confidence interval of mean. Testing for significance and comparison of two means and two standard deviations. Comparison of an experimental mean and a true mean. Criteria for the rejection of an observation, Q–test. External standard calibration, the least squares methods, regression equation and correlation coefficient.

Gravimetric analysis: Mechansim of precipitation, factors influencing precipitation, coprecipitation, postprecipitation and organic reagents used in gravimetry (oxime and dmg).

(12 Hours)

UNIT–II

Titrimetric Methods:

Titrimetric Analysis: Principles of titrimetric analysis. Classification of reactions in titrimetry.

Titrations based on acid-base reactions: Titration curves for strong acid and strong base, weak acid and strong base and weak base and strong acid titrations. Titration curves, quantitative applications, selecting and standardizing a titrant, inorganic analysis, alkalinity, acidity and ammonium salts.

Complexometric titrations: Indicators for EDTA titrations, theory of common indicators, titration methods employing EDTA, direct, back and displacement titrations, indirect determinations, titration of mixtures using masking and demasking agents.

Redox Titrations: Balancing redox equations, calculation of the equilibrium constant of redox reactions, titration curves, theory of redox indicators, calculation of standard potentials, determination of chemical oxygen demand (COD) in natural and waste waters.

Precipitation titrations: Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate, the Volhard, the Mohr and the fajan's methods

(12 Hours)

UNIT–III

Separation Methods–I:

Fundamentals of chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase and nature of adsorbents.

Column chromatography: Theories, plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency, Van Deemter's equation and its modern version, interrelationships, capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations.

Thin layer chromatography (TLC): Definition, mechanism, efficiency of TLC plates, methodology, selection of stationary and mobile phases, development, spray reagents, identification and detection, reproducibility of R_f values, qualitative and quantitative analysis.

High performance liquid chromatography (HPLC): Instrumentation, pumps, column packing, characteristics of liquid chromatographic detectors, UV and fluorescence detectors, advantages and applications.

(12 Hours)

UNIT–IV

Separation methods–II

Gas chromatography (GC): Principle, instrumentation, columns, study of detectors, thermal conductivity, flame ionization and mass spectrometry, factors affecting separation, retention volume, retention time and applications.

Ion exchange chromatography (IEC): Definition, principle, requirements for ion-exchange resin, types of ion-exchange resins, resin properties-ion-exchange capacity and its determination, resin selectivity and factors affecting the selectivity, applications of IEC in purification and recovery processes.

Solvent extraction: Nernst partition law, efficiency and selectivity of extraction. Extraction systems: Extraction of covalent neutral molecules, extraction of uncharged metal chelates and synergic extraction, extraction of ion-association complexes-non chelated complexes and chelated complexes. Use of salting out agents. Methods of extraction–batch and continuous extractions. Applications (special emphasis on extraction of iron and copper).

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
2. Analytical Chemistry, G.D. Christian, 6th edition, Wiley–India (2007).
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd. New Delhi(2009).
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt. Ltd.(2007).
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California(1990).

Paper Code and Name	**PG75P104D: LAB ANALYTICAL CHEMISTRY**

COURSE OUTCOMES

I. Organic Chemistry Practical

Quantitative analysis

1. Titrimetric Estimation of amino acids.
2. Estimation of glucose by Bertrand's method.
3. Estimation of keto group.
4. Iodine value of oil (Chloramine - T method)
5. Estimation of Nitro group by reduction using $SnCl_2$.

Qualitative Analysis

Separation of binary mixture of organic compounds using ether and identification of separated compounds by systematic qualitative organic analysis.

Please Note: 1) Individual organic compounds are to be given after the candidate reports the nature of the mixture. 2) Ether insoluble acids and ether insoluble Neutral organic compounds may be given. 3) Low boiling liquids and Amino acids need not be given.

The following mixtures may be given.

1. Acid + Base
2. Acid + Neutral
3. Base + Neutral
4. Phenol + Acid
5. Base + Phenol

II. Physical Chemistry Practicals

1. Determination of molecular radius of glycerol molecule by viscosity method.
2. Estimation of metal ions of ferric-thiocyante and cupric-ammonia complexes by spectrophotometrically.
3. Determination of relative strength of acids (HCl and H_2SO_4) by studying the hydrolysis of methyl actetate.
4. Determination of dissociation constants of weak monobasic acids potentiometrically by titrating against NaOH.
5. Comparison of strengths of chloroacetic acid and acetic acid using conductometric method.
6. Determine the dissociation constant of acetic acid pH-metrically by titrating against NaOH.

Recommended Books:

1. Practical Physical Chemistry by A. M. James and F. E. Prichard, Longmans, London.
2. Experiments in Physical Chemistry by Shoemaker and Garland, McGraw Hill, New York.
   Experiments in Physical Chemistry by Daniels, Alberty and Willams, McGraw Hill, New York.
3. Experimantal Physical Chemistry by W. G. Palmer, Cabridge University Press, London.
4. Advanced Physico-Chemical experiments by J. Rose. 6. Text Book of Physical Chemistry by S.
5. Glasstone, , McGraw Hill,London.
6. Text book of Quantitative Analysis by A. I. Vogel, ELBS, Harlow.
7. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.
8. Experimental Physical Chemistry by V. D. Athawale and Parul Mathur, New Age International Publishers.

9. Advanced Physical Chemistry Experiments by Gurtu and Gurtu, Pragati Prakashan Educational Publishers, 3rd Edition 2007.

Scheme of Examination:

i. Duration of examination	:	04 hours
ii. Experiment	:	35 marks
iii. Viva-Voce & Journal	:	05 marks
iv. Internal assessment	:	10 marks
Total	:	50 marks

Paper Code and Name	**PG75T301D: Instrumental Methods of Analysis.**

COURSE OUTCOMES (COs)

After studying this paper, students will learn,

- Principles, theory, instrumentation and analytical applications of various optical methods such as AAS, emission spectroscopy and molecular luminescence spectroscopy.
- Principles, theory, instrumentations and analytical applications of coulometry, amperometry, polarygraphy, electrophpresis, electrogravimetry, supercritical fluid chromatography, voltammetry, nephelometry and turbidometry besides their advantages of each method.
- The types and importance of ion-selective electrodes in selective determination.
- The use of thermal methods such as TGA, DTA, and DSC for characterization of inorganic compounds, polymers, pharmaceutical etc.

UNIT–I

Optical Methods:

Atomic absorption spectrometry: Theory, instrumentation, different types of nebulizers, non flame techniques, electrothermal vapouriser, cold vapour AAS determination of mercury, interferences, differences between AAS and flame photometry and analytical applications of AAS.

Emission Spectroscopy: Inductively coupled plasma optical emission spectrometry–theory and applications.

Molecular Luminescence Spectroscopy: Theoretical basis for fluorescence and phosphorescence, instrumentation, factors affecting fluorescence, its applications in quantitative analysis and in the study of biomolecules. X-ray fluorescence elemental analysis.

(12 Hours)

UNIT–II

Analytical methods–I

Coulometric methods of analysis: General discussion, coulometry at controlled potential, apparatus and general technique, applications, coulometric titrations (amperometric coulometric): Principles, apparatus, comparison of coulometric titrations with conventional titrations, automatic coulometric titrations and applications.

Amperometry: Principle, titrations, advantages and limitations and applications.

Ion selective electrodes: Glass ion selective electrodes, crystalline solid state ion selective electrodes, liquid–based ion selective electrodes and gas sensing electrodes.

Supercritical fluid chromatography (SFC): Properties of supercritical fluids, instrumentation and operating variables, comparison of SFC with other types of chromatography and applications.

(12 Hours)

UNIT–III

Analytical methods–II:

Polarography: Theory of classical polarography, polarograms, polarographic currents. Halfwave potential, oxygen interference, advantages and limitations. pulse polarography and applications of polarography.

Electrogravimetric analysis: Theory, apparatus, deposition and separation, electrolytic separation of metals and applications.

Electrophoresis: Theory and classification, factors influencing the mobility–macromolecular size and charge, interaction with supporting electrolyte, pH and concentration discontinuities. Factors affecting electrophoretic phenomena–electrolysis, electroosmosis, temperature and supporting media. Instrumentation. Methodology: Preparation of gels–staining and destaining. Capillary electrophoresis methods: Capillary zone electrophoresis and capillary gel electrophoresis.

Light–scattering methods: Nephelometry and turbidometry: Principle, instrumentation and applications.

(12 Hours)

UNIT–III

Analytical methods–III

Thermal method of analysis: Introduction.

Thermogravimetric analysis (TGA): Types of thermogravimetric analysis, principles, factors affecting the results, heating rate, furnace, instrument control/data handling. Instrumentation and applications.

Differential thermal analysis (DTA): Theory, variables affecting the DTA curves, differences between TGA and DTA, general principles. Instrumentation and applications.

Differential scanning calorimetry (DSC): Basic principle, differences between DTA and DSC.

Instrumentation, power compensated DSC, heat flux DSC and applications.

Thermomechanical analysis and dynamic mechanical analysis.

Voltammetry: Fundamentals of voltammetry. Cyclic voltammetry: Principles and applications.

Stripping analysis: Stripping voltammetry, basic principles, electrodes used for stripping analysis, apparatus for stripping analysis, applications and determination of lead in water by voltammetry.

(12 Hours)

Total 48 hours

***Recommended Books**:*

1. Instrumental Analysis, D. A. Skoog, F. J. Holler and S.R.Crouch, Cengage Learning (2007).
2. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
3. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
4. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt. Ltd. New Delhi(2009).
5. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).
6. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California(1990).
7. Instrumental Methods of Analysis by H.H. Willard, L.L. Merritt and J.A. Dean, 7th Edition,CBS Publishers, New Delhi, 1988.

Paper Code and Name	**PG75T302D: MOLECULAR SPECTROSCOPY**

COURSE OUTCOMES (COs)

After studying this paper, students will learn

- Importance of interaction of electromagnetic radiation with matter.
- The principle, theory and instrumentation of various spectroscopic techniques.
- Application of different spectroscopic techniques (UV-Vis, IR, NMR, EPR, Mossbauer) in the structural elucidation of organic/Inorganic compounds, biomolecules etc.

UNIT–I

Basic concepts, Electronic Spectroscopy and Mass Spectrometry:

Properties of electromagnetic radiation.

Wave property: Interference and diffraction. Particle property: Photoelectric effect.

Regions of the electromagnetic spectrum, energies corresponding to various kinds of radiation. Interaction of electromagnetic radiation with matter (absorption, emission, transmission, reflection, dispersion, polarisation and scattering). General application.

Electronic spectroscopy: Molecular electronic absorption spectroscopy (UV–Visible), electronic spectra of diatomic molecules, electronic transitions, selection rules, assignment of transition, band intersities, substituent and solvent effect and change transfer transitions. Application to organic and inorganic molecules.

Mass Spectrometry: Ionization and mass analysis.
Fragmentation: Principles, odd electron ($OE^{\cdot+}$) and even electron (EE^{+}) ions, molecular ion and base peak, nitrogen rule, metastable ions. Isotope effects in chloro and bromo compounds. Fragmentation of inorganic and oraganic compounds

UNIT–II

Vibrational Spectroscopy:
Vibrational spectroscopy: Infrared spectroscopy: Vibrational energy levels, infrared spectra of diatomic and polyatomic molecules, normal modes of vibration, force constant, selection rules, anhormonicity, the vibration–rotation spectroscopy. Infrared spectra of simple molecules and coordination compounds, changes in infrared spectra of donor molecules upon coordination (N,N–dimethylacetamide, urea, DMSO, pyridine N–oxide, ammine, cyano, cyanato and thiocyanato complexes), mono and multinuclear carbonyl complexes, nitrosyls, phosphine and arsine complexes. Change in spectra accompanying change in symmetry upon coordination (NO_3^-, SO_4^{2-}, NO_2^-, and ClO_4^-), hydrogen bonding. Instrumentation including FTIR.
Raman spectroscopy: Theory, relation with IR spectroscopy, resonance Raman stimulated hyper and inverse Raman effects. Experimental techniques, structure determination from IR and Raman spectra.

(12 Hours)

UNIT–III

Magnetic Resonance spectroscopy:

Nuclear magnetic resonance spectroscopy: Magnetic properties of nuclei, population of energy levels, the Larmor precession, relaxation processes, chemical shift, shielding mechanism, spin–spin interactions, rules governing the interpretation of first order spectra, effect of chemical exchange on spectra. Analysis of complex NMR spectra, ^{1}H–NMR spectra of organic molecules and complex metal ligands. Spin–systems: First order and second order patterns.

Long range coupling : Spin decoupling, CIDNP and NOE. NMR shift reagents.
NMR studies of nuclei other than proton, ^{13}C–NMR (including heteronuclear coupling with other nuclei viz., ^{19}F and ^{31}P), ^{19}F, ^{31}P, ^{11}B, ^{15}N. Spectra of paramagnetic complexes, contact shift, double resonance technique. Instrumentation including FT–NMR.

(12 Hours)

UNIT–IV

Electron Paramagnetic Resonance and Mössbauer Spectroscopy:
Electron Paramagnetic Resonance (EPR) Spectroscopy: Basic principles, selection rules, intensity, width, position of spectral line, multiplet structure of EPR spectra, hyperfine interaction, spin–orbit coupling, zerofield splitting and Kramer's degeneracy, rules for interpreting spectra, factros affecting the magnitude of values. Instrumentation. Applications to the study of free radicals, coordination compounds, biological studies and rate of electron exchange reactions.

Mössbauer Spectroscopy: Introduction, principles, conditions for Mössbauer spectroscopy, parameters from Mossbauer spectra, isomer shifts, electric quadrupole interaction, magnetic interactions, Mossbauer spectrometer. Applications in structure determination of $Fe_3(CO)_{12}$, Prussian blue, oxyhemerythrin, hexacyanoferrates, nitropruside, tin halides.

(12 Hours)

Total 48 Hours

***Books Recommended**:*

10. Fundamentals of Molecular Spectroscopy - C. N. Banwell.
11. Physical Methods in Chemistry - R .S. Drago, Saunder college.
12. Structural Methods in Inorganic Chemistry - E. A. Ebsworth, D. W. H. Ranbin and S.Cradock, ELBS.
13. Infrared Spectra of Inorganic and Coordination Compounds - K. Nakamoto.
14. Infrared Spectroscopy - C.N.R. Rao.
15. Electron Absorption Spectroscopy and Selected Techniques - D. N. Satyanarayana, University Press India Ltd. Hyderabad.
16. Introduction to Spectroscopy – D.L.Pavia, G.M.Lampman and G.S.Kriz, Thomson Learning, Singapore (2001)
17. Spectroscopic Identification of organic compounds – R. M. Silverstein and F. X. Webster, 6th Edition, Wiley and Sons, India Ltd. (2006).
18. Interpretation of Mass Spectroscopy–McLafferty.

Paper Code and Name	PG75T303D: Selected Topics in Analytical Chemistry-I.

COURSE OUTCOMES (COs)

After studying this paper, students will learn

- Classification, properties and analytical and biological applications of different types of sensors
- The importance of various elements in biological systems, their structural and functional roles such as dioxygen transportation and storage, electron transfer in different processes, metalloenzymes etc.
- Use of metal complexes in medicine.
- The overview, principles and types of automated systems and their advantages and disadvantages in the analysis.
- Use of computer software programmes in chemistry for better understanding.

Paper Code and Name	PG75P301D: Lab course in Analytical Chemistry–I

COURSE OUTCOMES

After carrying out the experiments mentioned in this paper, students will learn

- The hands on experience of various analytical instruments such as nephlometer/turbidometer (sulphate/phosphatecontent in ground water) and colorimeter (Ti^{4+} using H_2O_2 and composition of $Fe(phen)_3]2^+$), complexometric titration using EDTA (calcium in Milk and Fe^{2+}/Fe^{3+} in a mixture), and Ion-Exchange chromatography (chloride and Bromide; Cadmium and zinc). Upon acquiring the required knowledge as well as practical skills, the students can extend it for the analysis of different metal ions in different samples including soil, environmental, pharmaceutical etc samples.

1. Nephelometric/turbidimetric determination of sulphate/phosphate in ground water samples.

2. Determination of calcium in milk powder using EDTA.

3. Separation and determination of chloride and bromide on an anion exchanger.

4. Cation exchange chromatographic separation of cadmium and zinc and their estimation by

EDTA titration.

5. Analysis of a mixture of iron(II) and iron(III) by EDTA titration using *p*H control.

6. Evaluation of the composition of Fe(II)–1,10-phenanthroline complex by spectrophotometry.

7. Colorimetric determination of Ti(IV) using H_2O_2.

Scheme of Examination:

1. Duration of Examination	:	4 hours
2. Experiment	:	35 marks
3. Viva-voce and Journal	:	05 marks
4. Internal assessment	:	10 marks
Total	:	50 marks

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E.B Sandell.
4. Analytical Chemistry–G.D Christian, 4th ed, Wiley, 1986.

Paper Code and Name	**PG75P302D: Lab course in Analytical Chemistry-II**

COURSE OUTCOMES

After carrying out the experiments mentioned in this paper, students will learn

The hands on experience inpaper& column chromatography (separation of amino acids and plant pigments), conductometric titrations, visual and potetiometric titrations (iron in razor blade and pharmaceuticals), complexometric titrations (Al and Mg inantacid) and precipitation titration (saccharin in Tablets). Such knowledge is helpful to students to analyse a variety of samples in quality control/ quality assurance.

Chromatography:

(i) Paper chromatography: Qualitative separation of amino acids in a given mixture
(ii) Column chromatography: Separation of plant pigments

2. **Conductometric titrations**:

(i) Sodium acetate with HCl
(ii) NH_4Cl with NaOH
(iii) HCl, CH_3COOH and $CuSO_4$

3. Estimation of iron in razor–blade by potentiometric & visual titration using sodium vanadate.

4. Assay of iron in pharmaceutical preparation by visual & potentiometric titration by $Ce(SO_4)_2$

5. Determination of aluminium and magnesium in antacids by EDTA titration.

6. Determination of saccharin in tablets by precipitation titration.

Scheme of Examination:

1. Duration of Examination : 4 hours
2. Experiment : 35 marks
3. Viva-voce and Journal : 05 marks
4. Internal assessment : 10 marks

Total : 50 marks

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E.B Sandell.
4. Analytical Chemistry–G.D Christian, 4th ed, Wiley, 1986.

Paper Code and Name	**PG75P303D: Lab course in Analytical Chemistry – III**

COURSE OUTCOMES

After carrying out the experiments mentioned in this paper, students will be exposed to operate various instruments such as

- Polarimeter used to study the optical isomers
- Potentiometer used to analyze the halide mixture and iron
- Conductometer used to analyze halide mixture and sulphate
- pH meter used to determine the strength of acids and bases
- spectrophotometer used to analyze the water sample

The above exposure makes the students to carry out project works involving a variety of problems related to analysis

1. **Polarimetry:** Determination of specific rotation of (i) cane Sugar solution (ii) cane sugar cane by inversion method (iii) cane sugar solution in presence of other sugar solution.
2. **Potentiometric Titrations:** (i) analysis of mixture of halides (ii) determination of iron using potassium dichromate.
3. **Conductometric Titrations:** (i) analysis of halides, (ii) determination of sulphates.
4. **pH Metric titrations:** (i) Determination of strength of acids (ii) determination of strength of

commercial phosphoric acid (H_3PO_4) by pH titration (iii) determination of soda ash in washing soda.

5. **Spectrophotometry:** Analysis of waste water for (i) phosphate by molybdenum blue method (ii) ammonia-nitrogen by Nessler's method OR nitrite-nitrogen by NEDA method.

Scheme of Examination:

1. Duration of Examination	:	4 hours
2. Experiment	:	35 marks
3. Viva-voce and Journal	:	05 marks
4. Internal assessment	:	10 marks
Total	:	50 marks

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E.B Sandell.
4. Analytical Chemistry–G.D Christian, 4th ed, Wiley, 1986.

Paper Code and Name	**PG75T401D: Pollution and Analysis**

COURSE OUTCOMES (COs)

After studying this paper , students will learn

- causes for different types of pollution (soil, air, water, radiation and noise)and their hazardous effects on life and solutions for minimization of pollution.
- Different methods of analysis to understand extent of pollution by determining pH organic matter and trace metals in soil; hardness, fluoride and dissolved oxygen in water; measurement of noise and analysis of radionuclides.
- Analysis of pollutants present in soil, water & air, and radioactive substances.
- Determination of Chemical Oxygen Demand(COD) and Biological Oxygen Demand(BOD) using laboratory techniques.

This training makes the students analyze air, water and soil samples by linking theory to practicals. They can also suggest suitable remedies to the concerned.

UNIT–I

Soil pollution and Analysis:

Soil pollution: Acidification, salinisation, sodification, agrochemical pollution, urban and industrial pollution, effects of soil pollution and solutions for soil pollution.

Soil analysis: Preparation of laboratory sample, measurement of pH and conductivity, acidic and alkaline soil. Analysis of major constituents: Organic matter, nitrogen, sulphur, sodium, potassium and calcium. Analysis of trace elements: Copper, molybdenum, zinc and boron.

(12 Hours)

UNIT–II

Air Pollution and Analysis:

Air pollutants: Classification and properties of air pollutants, emission sources, major emissions from global sources. Behaviour and fate of air pollutants, wet precipitation, dry deposition, interaction at the earth's surface, chemical reactions in the atmosphere, photochemical smog, effects of air pollution on human health, vegetation and materials.

Air pollution sampling and measurement: Ambient air sampling, collection of gaseous and particulate air pollutants. Analysis of air pollutants: SO_2–ambient air measurements, stack gas measurement chemiluminescent techniques, CO–NDIR, amperometric, FID & catalytic oxidation methods, Coulometric & chemiluminescent methods. Hydrocarbon measurement: Total and individual hydrocarbons by chromatographic methods, particulates optical & mass measurement methods.

(12 Hours)

UNIT–III

Water Pollution and Analysis:

Sources of water pollution, classification of water pollutants: Organic, inorganic, sediment, thermal and radioactive materials, effects and solutions. Analysis of water parameters: Hardness, carbonate, bicarbonate, chloride, sulphate, fluoride, sodium, potassium, iron, chromium, manganese, chlorine demand, dissolved oxygen, ciochemical oxygen demand and chemical oxygen demand.

(12 Hours)

UNIT–IV

Noise and Radiation Pollution and analysis:

Noise pollution: Concept of sound, noise and hearing problems, measurement of noise, sources of noise, effects of noise pollution. Regulation and control rules 2000 for noise pollution.

Radiation Pollution: Sources, effects, protection from radiation pollution, disposal of radioactive waste. Analysis of radionuclides.

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Environmental Chemistry, S.E. Manahan, CRC Press/ Lewis Publishers, 1994
2. Environmental Chemistry with Green Chemistry, A.K. Das, Books and Allied (P) Ltd, (2012)

3. Environmental Chemistry, A.K.Dey, New Age International,(P) Ltd, Publishers, New Delhi
4. Environmental Chemistry, B.K.Sharma, Goel Publishing House.
5. Environmental Science and Technology, S.E. Manahan, Lewis Publishers, New York
6. Environmental pollution analysis, S.M.Khopkar, New Age International,(P) Ltd, Publishers, New Delhi

Paper Code and Name	**PG75T402D: Quality control, Analysis of Food, Beverages and Pharmaceuticals**

COURSE OUTCOMES

After studying this paper , students will learn

- Basic concepts of quality control and quality assurance
- Importance of quality control in drugs, pharmaceuticals and raw materials
- Law related case studies of quality control section in various industries
- Classification and analysis of beverages, food preservative, adulterants, drugs, pharmaceuticals, dairy products and edible oils.

This knowledge is very useful to students seeking jobs in industries in Quality assurance and quality control. The knowledge on analysis in clinical studies is useful to diagnose the ailments or deficiencies.

UNIT–I

Quality Control:

An introduction to quality control and quality assurance: Basic concepts, quality assurance, aspects of specification and tolerance, quality acceptance, sampling, reliability, cost aspects of quality decisions. Importance of quality control: Drugs and pharmaceuticals. Sources of impurities in pharmaceutical chemicals. Quality control in raw materials, production (in process), finished product. Current trends in quality control, ISO–9000 and ISO–14000 series. Laws related to quality control. Case studies of quality control in various industries such as plastics and polymers, fertilizers, agrochemicals, petrochemicals, dyes and pharmaceuticals.

(12 Hours)

UNIT–II

Analysis of Beverages, Food Preservatives and Adulterants:

Introduction: Soft drinks, alcoholic drinks, tea, coffee and fruit juices. Analysis of Caffeine in coffee and tannin in tea, detection of chicory in coffee, chloral hydrate in toddy. Estimation of methyl alcohol in alcoholic beverages, poisonous materials derived from containers. Food preservatives like sodium benzoate, sodium propionate, sodium sulphate, potassium metabiosulphate (qualitative and quantitative analysis).

Food Adulterants: Artificial sweeteners like saccharin and dulcin, coal tar dyes and non−permitted colours and trace metals, detection and estimation.

(12 Hours)

UNIT−III

Drugs and Pharmaceutical Analysis:

Antibiotics: Introduction, classification, structure elucidation, stereochemistry and reaction mechanism of pencillins, tetracycline and chloramphenical.

Analysis of common drugs:
Analgesics: Aspirin and paracetamol. Antihelmentics: Mebendazole. Antiallergies: Chlorpheneramine malleate. Anti−inflammatory agents: Oxyphenbutazone. Antimalarials: primaquine phosphate. Antituberculosists: Isoniazid(INH). Narcotics: Nicotine, morphine. Sedatives: Diazepam. Vitamins: A, B_1, B_2, B_6, C & folic acid.

(12 Hours)

UNIT−IV

Analysis of dairy products and edible oils:

Chemistry, principles and analysis of liquids (edible): (i) general composition of edible oils, qualitative tests to purity, rancidity of fats and oil, estimation of rancidity, hydrogenated fat, tests for common edible oils like groundnut oil, castor oil, cottonseed oil & mustard oil. Tests for adulterants like argemoss oil & mineral oils and (ii) analytical principles in the analysis of dairy products composition of milk and milk products, alcohol test, fermentation, dye reduction. Methylene blue and resaturin tests. Tests to distinguish between buffed olemargarine, phosphate tests for efficacy of pasteurization. Analysis of fat content, mineral in milk and butter. Estimation of added water in milk.

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Analysis of Foods, H.E.Cox
2. Chemical Analysis of Foods, H.E.Cox
3. Foods: Facts and Principles; N. Shakuntala Many and S. Swamy, 4th Edtn., New Age International (1998)
4. Pharmaceutical analysis : Ed. By T.Higuchi and E.B. Hanssen, Wiley New York
5. Quantitative analysis of drugs: D.C.Garratt, Chappman and Hall, New York
6. Drugs and Pharmaceutical sciences Series; Marcel Dekkar, Vol. II, INC. New York

Paper Code and Name	PG75T403D: Selected Topics in Analytical Chemistry – II

COURSE OUTCOMES

After studying this paper , students will learn

- Analysis of various biomedical samples, ores, minerals, fertilizers, metals, alloys and cement.
- Types, composition and purification methods of crude oil.
- Analysis of products and residues producedbin refinery process of crude oil
- Usage of various analytical techniques in the evaluation of crude oil and its product.

The students will realise the importance of analysis and also the possible adulteration.

UNIT– I

Analysis of Biomedical samples:

Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease. Sample collection and preservation of physiological fluids, analytical methods for the constituents of physiological fluids (blood, serum,urine). Blood–estimation of glucose, cholesterol, urea, haemoglobin and bilirubin. Urine: Urea, uric acid, creatinine, calcium phosphate, sodium, potassium and chloride. Biological significance, analysis and assay of enzymes (pepsin, monoaminoxide,tyrosinase), vitamins (thiamine, ascorbic acid, vitamin–A) and harmones (progesterone,oxytocin, insulin). Chemical, instrumental and biological assays to be discussed wherever necessary. Estimation of poisonous materials such as lead, mercury and arsenic in biological materials.

(12 Hours)

UNIT–II

Analysis of Ores, Minerals and Fertilizers:

Composition, properties and analysis of minerals and ores: Heamatite, pyrolusite, dolomite, chromate, bauxite, limestone, zillmenite, gypsum and epsom.

Fertilizer analysis: Types, analysis of nitrogenous fertilizers, organic nitrogenous, phosphatic and potassic fertilizers.

Pesticide and insecticide analysis: introduction, classification and analysis of DDT, gammexane, endosulphon, zinaf, ziram, malathian, thiram, thiometon, simazine & chloridane.

(12 Hours)

UNIT–III

Metals, Alloys and Cement Analysis:

Steel, Cu–Ni alloy, solder, bronze. brass, aluminum alloy, ferroalloys of silicon, molybdenum, chromium, titanium and vanadium. Analysis of structural materials: Cement and glass. Analysis of refractory materials: Fire clay, fluorspar. Analysis of cement

(12 Hours)

UNIT–IV

Analytical procedures in refineries:

Types of crude oil (sweet and sour), composition of crude cil, causes for corrosion in refinery (sulfidic & naphthenic acid) crude oil refining, fractional distillation (atmospheric and vacuum distillation). Purification processes (merox, alkylation, reformulation, hydrotreating, cracking etc.). Products of refinery (naphtha, gasoline, diesel, furnace oil, lube oil etc.), residues of refining processes (sulfur, pet coke). Specifications of gasoline, jet fuel and diesel in India and abroad. Paraffins, iso–paraffins, olefins, naphthenes, aromatics.

Analytical techniques used in crude oil and products evaluation: True boiling point distillation, spectroscopic evaluation (NIR & FTIR), density, viscosity, cloud point, pour point, PIONA analysis in gasoline, simulated distillation, GC–MS, HPLC, cetane number and octane number .

(12 Hours)

Total: 48 Hours

Recommended Books:

1. Technical methods of analysis: R.C.Griggin
2. Analytical Chemistry: Principles; J.H.Kennedy, 2nd Edn., Saunders, 1990
3. Principles of Instrumental methods of analysis: Skoog, Holler and Nieman, 5th Edn., Saunders 1998
4. Quantitative analysis: Day and Underwood, Prentice Hall, 1998
5. Fundamentals of petroleum refining: M.A.Fahim, T.A.Alsahhaf and Amal Elkilani, Elsevier Science, ISBN; 978–0–444–52785–1
6. Analytical methods in petroleum upstream applications. Etd., by Cesar Ovalles, Carl E. Rechsteiner Jr., CRC Press, Taylor and Francies Group
7. Industrial Chemistry: B.K.Sharma, Goel Publishing House
8. Quantitative analysis, An instrumental approach: Srivastava and Jain, S. Chand 1997
9. Biochemistry: The chemical reactions of living cells. D.E.Metzler, Academic Press.
10. Enzymes Chemistry: Impact and application Edn. Collin J.Suckling, Academic Press.

Paper Code and Name	PG75D404D: PROJECT WORK

COURSE OUTCOMES (COs)

During the project work, students will find new problems in the frontier areas of Research and work on them either in Industry/other educational instituions/R&D organization/parent institution by applying the theoretical and practical knowledge gained during their M.Sc Course. This is the platform wherein the student can make use of his novel ideas to implement for the betterment of the society

Paper Code and Name	PG75P401D: Instrumental Methods of Analysis.

COURSE OUTCOMES (COs)

1. Analysis of water for alkalinity and acidity by pH metric method
2. Determination of strength of commercial phosphoric acid by pH titration
3. Determination of ammonia in household cleaners by conductometric titrations.
4. Determination of sodium and potassium in soil by flame photometry
5. Determination of phosphate in domestic waste water by spectrophotometry.
6. Analysis of mercury/lead in industrial effluents by spectrophotometry
7. Determination of DO, BOD and COD of a waste water sample by titrimetry
8. Determination of fluoride by spectrophotometric method
9. Soil analysis

Scheme of practical examination:

1. Duration of practical examination : 4 hrs
2. Experiment : 35 marks
3. Viva voce and Journal : 05
4. Internal assessment : 05

Total : 50

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis – A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals – E.B Sandell.
4. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India

Paper Code and Name	PG75P402D: Instrumental Methods of Analysis.

COURSE OUTCOMES (COs)

1. Analysis of medicines: APC tablet, paracetomol, sulpha drugs by potentiometry/spectrophotometry/titrimetry
2. Assay of aspirin / caffeiene / phenacetin by spectrophoptmetry
3. Determination of vitamin A in vanaspathi by UV spectrophotometry.
4. Isolation of casein and lactose from milk
5. Food analysis: Determination of iron in mustard sugar, phosphorus in peas, ascorbic acid in tomato, benzoic acid in food products
6. Determination of iodine value of an oil sample
7. Saponification of an oil sample

Scheme of practical examination:

1. Duration of practical examination	:	4 hrs
2. Experiment	:	35 marks
3. Viva voce and Journal	:	05
4. Internal assessment	:	05
Total	:	50

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals–E.B Sandell.
4. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India

Paper Code and Name	PG75P403D: Instrumental Methods of Analysis.

COURSE OUTCOMES (COs)

1. Analysis of fertilizers: Urea, super phosphates
2. Analysis of pyrolusite ore
3. Analysis of alloys: cupronickel and bronze
4. Analysis of cement
5. Determination of (i) aluminium and magnesium in a mixture
6. Analysis of Stainless steel-Ni gravimetrically using DMG, Fe volumetrically using Ce(IV),

Cr volumetrically by persulphate oxidation,

7. Analysis of body fluids: Determination of cholesterol, glucose in blood; uric acid, creatinine in urine .

Scheme of practical examination:

1. Duration of practical examination	:	4 hrs
2. Experiment	:	35 marks
3. Viva voce and Journal	:	05
4. Internal assessment	:	05
Total	:	50

Recommended Books:

1. A text Book of Quantitative Inorganic Analysis–A.I Vogel
2. Vogel's Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
3. Colorimetric Determination of Traces of Metals – E.B Sandell.
4. Analytical Chemistry, G.D. Christian, 5th edition, 2001 John Wiley & Sons, Inc. India