Course	Details				
Code	ICH3CR01				
Title	Inorganic Chemistry-1				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	2/III				
Type	Core				
Credits	4	Hrs /Week	5	Total Hours	90

Specific objectives	To explore the structure,bonding and applications of coordination compounds and organometallic compounds.Extraction and purification of different metals.
Course outcomes	• To understand the nomenclature and structure of coordination compounds and apply it in different fields. • To study Different types Non-aqueous solvents • To understand the chemistry of Interhalogen and Noble gases compounds • To understand the principles of qualitative and quantitative analysis.

Module	Course Description	Hrs
1.0	**Coordination Chemistry**	**54**
1.1	**Coordination Chemistry - I** Introduction of coordination compounds, Types of ligands – Anionic, cationic and neutral – IUPAC Nomenclature, Isomerism in coordination compounds –Structural isomerism and stereo isomerism. Chelates, chelate effect-Stability of complexes: Inert and labile complexes. Polynuclear complexes. Review of Werner's theory and Sidgwick's concept of coordination – EAN rule.	12
1.2	**Coordination Chemistry - II** Bonding theories: Valence bond theory - Geometries of coordination numbers 4 and 6 – Inner orbital and outer orbital complexes- Limitations of VBT. Crystal filed theory - Splitting of *d*- orbitals in octahedral, tetrahedral, tetragonal and square planar complexes - Jahn Teller Effect– Jahn –Teller distortion in Cu (II) complexes. Factors affecting crystal field splitting - CFSE of low spin and high spin octahedral complexes. Spectrochemical series - Explanation of geometry, magnetism and spectral properties - Merits and demerits of Crystal field theory. Qualitative aspect of Ligand field Theory Molecular orbital theory – evidence for metal ligand covalency- MO diagram for octahedral complexes (with sigma bonds only).	24
1.3	**Coordination Chemistry III** Spectral and magnetic properties of complexes – electronic absorption spectrum of $[Ti(H_2O)_6]^{3+}$, Calculation of magnetic moments – spin only formula. Reactivity of complexes - Ligand substitution reactions- SN_1 and SN_2 substitution reactions of square planar complexes- Trans effect and its applications. Application of coordination chemistry in qualitative and quantitative analysis of metal ions such as Cu^{2+}, Zn^{2+}, Ni^{2+} and Mg^{2+}. Reactions of metal complexes-labile &inert complexes.	18

2.0	**Acids and Bases and Non-aqueous Solvents**	**18**
2.1	Acid base concept in non aqueous media-HSAB concept, solvent effects, linear free energy relationship-mechanism and methods of determination	6
2.2	Reactions in non-aqueous solvents. Ammonia – solutions of metals in liquid ammonia. Protonic solvents: anhydrous sulfuric acid, hydrogen halides. Aprotic solvents: non-polar solvents, non-ionizable polar solvents, polar solvents undergoing autoionization, liquid halogens, interhalogen compounds, oxy halides, dinitrogen tetroxide, sulphur dioxide	12

3.0	**Inter-halogen and Nobe Gas Compounds**	**12**
3.1	**Inter-halogen and Noble Gas Compounds** Interhalogens - classification- general preparation- structures of AB, AB_3, AB_5 and AB_7 types. Reactivity (ClF, ICl_3, ClF_3, IF_5 and IF_7). Comparison of pseudohalogens with halogens. , Electropositive character of iodine. Separation of noble ga(charcoal adsorption method). Compounds of noble gases.	12
4	**Theoretical principles of qualitative and quantitative analysis**	**6**
4.1	Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (oxalate, fluoride, borate, phosphate, chromate, arsenite and arsenate). and need to remove them after Group II.	6

References

1. F.A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edition, Wiley India Pvt. Ltd., New Delhi, 2009 (Reprint).
2. J.E. Huheey, E.A. Keitler and R.L. Keitler, *Inorganic Chemistry– Principles ofStructure and Reactivity,* 4th Edition, Pearson Education, New Delhi, 2013.
3. D.F. Shriver and P. Atkins, *Inorganic Chemistry*, 5th Edition,Oxford University Press, New York, 2010.
4. B.R. Puri, L.R. Sharma and K.C. Kalia, *Principles of Inorganic Chemistry*, 31st Edition, Milestone Publishers and Distributors, New Delhi, 2013.
5. P.L. Soni and Mohan Katyal, *Textbook of Inorganic Chemistry*, 20th Edition, S. Chand and Sons, New Delhi, 2013.
6. Satya Prakash, *Advanced Inorganic Chemistry, Volume 2,* S. Chand and Sons, New Delhi, 2005.
7. J.D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Oxford University Press, New Delhi 2008.
8. R. Gopalan and V. Ramalingam, *Concise Coordination Chemistry,* 1st Edition, Vikas Publishing House, New Delhi, 2001.
9. Wahid U. Malik, G D. Tuli and R.D. Madan, Selected Topics in Inorganic Chemistry, S. Chand and Co., New Delhi, 2010 (Reprint)
10. Vogel 'A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis': (Third Ed.) (ELBS)
11. J.E. Huheey, E.A. Keiter, R.A. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn., Harper Collins College Pub., 1993.
12. H.J. Emeleus, A.G. Sharpe, Modern Aspects of Inorganic Chemistry, 4th Edn., ELBS, 1973.
13. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.

Course	Details				
Code	**ICH3CR02**				
Title	**Organic Chemistry - I**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	**2/III**				
Type	**Core**				
Credits	**3**	**Hrs/Week**	**4**	**Total Hours**	**72**

Specific objectives	To give a basic understanding on the basic principles of stereochemistry, isomerism and asymmetric synthesis.
Course outcomes	1. To introduce fundamental concepts of Organic Chemistry with emphasis on stereochemistry 2. To understand the concepts of isomerism and its classification. 3. To apply the concepts of conformation and configuration in organic chemistry. 4. To apply the principles of asymmetric synthesis.

Module	Course Description	Hrs
1	**Isomerism and geometrical isomerism**	**9**
1.1	Isomerism-classification. Structural isomerism – definition, classification, Stereoisomerism – definition, classification. Configuration and conformational stereoisomers. Introduction to Akamptisomerism.	3
1.2	Geometrical isomerism: Nomenclature: cis–trans, syn-anti and E/Z (upto two C=C systems) with C.I.P rules. Methods of distinguishing geometrical isomers. Interconversion of geometrical isomers.	4
1.3	Projection formulae: Wedge formula, Newman, Sawhorse and Fischer projection formulae and their interconversion.	2
2	**Optical isomerism**	**18**
2.1	Optical isomerism: Optical activity, specific rotation, concept of chirality.	1
2.2	Center of chirality: Molecules with C, N, S based chiral centers, absolute configuration, enantiomers, racemic modifications and methods of resolution. D and L nomenclature. R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral center and Cn, molecules with more than one center of chirality, diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules. Erythro and threo nomenclature.	7
2.3	Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes.	5

2.4	Topicity and prostereoisomerism, homotopic, enantiotopic and diastereotopic atoms, groups and faces (including Pro-R, Pro-S, and Re/Si stereodescriptors) and their nomenclature, Chirotopicity and stereogenicity.	5
3	**Conformational Analysis**	**9**
3.1	Conformational descriptors: Factors affecting conformational stability of molecules.	3
3.2	Conformational analysis of substituted ethanes, Origin of ring strain in cyclic systems: Baeyer's strain theory, Sache-Mohr theory of strain- less rings. Conformational analysis of cyclohexane and its derivatives, decalins, adamantane, congressane, bicyclic systems, sucrose, lactose.	6
4	**Dynamic Stereochemistry**	**18**
4.1	Effect of conformation on reactivity of E2 elimination-dehalogenation, dehydrohalogenation, semipinacolic deamination and syn eliminations. Saytzeff and Hofmann eliminations.	10
4.2	Substitution and oxidation of 2° alcohols. Nucleophilic addition to carbonyl compounds (Cram's Rule). Chemical consequence of conformational equilibrium - Curtin Hammett principle.	8
5	**Asymmetric Synthesis**	**9**
5.1	Fundamental Aspects: Specific rotation, optical purity (enantiomeric excess), racemization (through cationic, anionic and radical intermediates); methods of asymmetric induction – auxiliary control, substrate control, reagent control, and solvent control; chemical and enzymatic resolution, kinetic resolution and dynamic kinetic resolution; desymmetrization – chemical and enzymatic.	9
6	**Problems based on the above topics**	**9**

References

1. I.L. Finar, Organic Chemistry, Vol. 2: Stereochemistry and the Chemistry Natural Products, 5th ed., Pearson Education India, 2002.
2. D. Nasipuri, Stereochemistry of Organic Compounds: Principle and Applications, 4th ed., New Age International Pvt. Ltd., 2020.
3. D.G. Morris, Stereochemistry, RSC, 2001.
4. E.L. Eliel, S.H. Wilen, Stereochemistry of Organic Compounds, John Wiley & Sons, 1994.
5. P.S. Kalsi, Stereochemistry: Conformation and Mechanism, 10th ed., New Age International Pvt. Ltd., 2019.
6. D.K. Mandal, Stereochemistry and Organic Reactions: Conformation, Configuration, Stereoelectronic Effects and Asymmetric Synthesis, Academic Press Inc., 2021.
7. M. North, Principles and Applications of Stereochemistry, Stanley Thornes (Publishers) Ltd., 1998.
8. V.K. Ahluwalia, Stereochemistry of Organic Compounds, Springer Nature Switzerland, 2022.

Course	Details				
Code	ICH3CR03				
Title	Physical Chemistry - I				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	2/III				
Type	Core				
Credits	3	Hrs/Week	4	Total Hours	72

Specific objectives	To provide an insight in to all types of energy transformations that accompanies physical and chemical processes.
Course outcomes	1. To understand the Laws of thermodynamics and its applications 2. To enable the students to predict the direction of a chemical reaction in equilibrium

Module	Course Description	Hrs
1	**Classical Thermodynamics**	**60**
1.1	Basic concepts- system, surroundings, types of systems. Extensive and intensive properties, macroscopic properties. State functions and path functions. Types of Processes. Zeroth law of thermodynamics. Definition of internal energy and enthalpy. Heat capacities at constant volume (C_v) and at constant pressure (C_p), relationship between C_p and C_v.	**4**
1.2	First law of thermodynamics –Mathematical statement of first law. Reversible process and maximum work. Calculation of work, heat, internal energy change and enthalpy change for the expansion of an ideal gas under reversible isothermal and adiabatic condition. The Joule-Thomson effect – derivation of the expression for Joule-Thomson coefficient. Sign and magnitude of Joule-Thomson coefficient, inversion temperature. Liquefaction of gases.	**10**

1.3	Thermochemistry – standard states. Enthalpies of formation, combustion and neutralization. Integral and differential enthalpies of solution. Hess's law and its applications. Kirchoff's equation.	**5**
1.4	Second law: Limitations of first law – Different statements of IInd law, Thermodynamic scale of temperature. Carnot cycle and its efficiency, Carnot theorem. Concept of entropy – Definition and physical significance. Entropy as a function of volume and temperature, Entropy as a function of pressure and temperature. Entropy as criteria of spontaneity and equilibrium. Gibbs and Helmholtz free energies and their significances- criteria of equilibrium and spontaneity. Gibbs-Helmholtz equation, dependence of Gibbs free energy change on temperature, volume and pressure. Maxwell's relations and different types of deductions using these relations	**12**
1.5	Partial molar quantities, chemical potential and Gibbs-Duhem equations, variation of chemical potential with temperature and pressure, determination of partial molar volume and enthalpy . Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. Activity, dependence of activity on temperature and pressure.	**12**
1.6	Thermodynamics of mixing, Gibbs-Duhem-Margules equation, applications of Gibbs-Duhem- Margules equation- Konovalov's first and second laws, excess thermodynamic functions-free energy, enthalpy, entropy and volume, determination of excess enthalpy and volume.	**12**
1.7	Third law of thermodynamics-statement and determination of absolute entropies of substances. Experimental verification of the third law of thermodynamics.	**5**
2	**Chemical and Ionic Equilibria**	**12**
2.1	Chemical affinity and thermodynamic functions, effect of temperature and pressure on chemical equilibrium- Van't Hoff reaction isochore and isotherm.	4

2.2	Ionic Equilibria: Introduction – Concepts of acids and bases, Dissociation constants – acids, bases, and polyprotic acids. Ostwald's dilution law. Degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Buffer solutions – Mechanism of buffer action, Henderson equation. Hydrolysis of salts – degree of hydrolysis and hydrolysis constant, determination of degree of hydrolysis, pH of salt solutions	**8**

References

1. Irving M. Klotz, Robert M. Rosenberg, Chemical Thermodynamics, John Wiley & Sons, INC Publication ,2008
2. R.P. Rastogi, R.R.Misra, An Introduction to Chemical Thermodynamics, 6thedn., Vikas Pub. Pvt. Ltd. (2003).
3. J. Rajaram, J.C. Kuriakose, Thermodynamics, S Chand and Co., 1999.
4. S. Glasstone, Thermodynamics for Chemists, Affiliated East West Publishers.
5. M.W. Zemansky, R.H. Dittman, Heat and Thermodynamics, Tata McGraw Hill, 1981.
6. P. Atkins and J Paula, The elements of Physical chemistry, 7th edn., Oxford University Press.

SEMESTER III

ICH3CP06 QUALITATIVE INORGANIC ANALYSIS- I

Credit – 2 (36 Hrs.)

1. Study of the reactions of the following radicals with a view to their identification and confirmation. Ag^{+}, Pb^{2+}, Bi^{2+}, Cd^{2+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^{+}, Na^{+}, K^{+}, NH_4^{+}, CO_3^{2-}, SO_4^{2-}, NO_3^{-}, Cl^{-} and CH_3COO^{-}.

2. Systematic qualitative analysis of mixtures containing two acid and two basic radicals from the above list by Semi- micro method only. (Minimum of 4 mixtures to be analyzed)

References

1. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 1966.
2. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
3. V.V. Ramanujam, Inorganic Semi Micro Qualitative Analysis, The National Pub.Co., 1974.
4. I. M. Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.

Course	Details				
Code	ICH4CR02				
Title	Analytical Chemistry				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	2/IV				
Type	Core				
Credits	3	Hrs /Week	4	Total Hours	72

Specific objectives	To analyse and apply various instrumental methods and analytical procedures to molecular systems.
Course outcomes	1. To understand errors, hypothesis testing and use of spreadsheets 2. To undertand the procedures for sampling 3. To apply the analytical techniques for environmental monitoring 4. To evaluate the different instrumental methods available for analysis

Module	Course Description	Hrs.
1.0	**Data Analysis (9 Hrs)**	9
1.1	1.1 Systematic and random errors, distribution of experimental results, statistical treatment- standard deviation, variance, confidence limits, application of statistics to data treatment and evaluation, student-t and F tests, detection of gross errors, rejection of a result- Q test, estimation of detection limits.	4
1.2	Least square method, correlation coefficient and its determination.	2

1.3	Hypothesis testing using statistical analysis	1
1.4	Use of spread sheets for plotting calibration curves, quality assurance and control charts	2
2.0	**Sampling**	**18**
2.1	Basis and procedure of sampling, sampling statistics, sampling and physical state, crushing and grinding, gross sampling, size of the gross sample, sampling liquids, gas and solids (metals and alloys), preparation of a laboratory sample, moisture in samples-essential and non-essential water, absorbed and occluded water, determination of water (direct and indirect methods).	9
2.2	Decomposition and dissolution, reagents for decomposition and dissolution like HCl, H_2SO_4, HNO_3, $HClO_4$, HF, microwave decompositions, combustion methods, use of fluxes like Na_2CO_3, Na_2O_2, KNO_3, NaOH, $K_2S_2O_7$, B_2O_3 and lithium meta borate. Elimination of interference from samples-separation by precipitation, electrolytic precipitation, extraction and ion exchange, distribution ratio and completeness of multiple extractions, types of extraction procedures.	9
3.0	**Environmental Analysis**	**18**
3.1	Analytical procedures involved in environmental monitoring. Water quality BOD, COD, DO, nitrite, nitrate, iron, fluoride.	2
3.2	Soil/Sediment analysis: Brief idea of chemistry of soil, trace element analysis in soil - B, Cd, Cu, Fe, Mn, Mo, Zn, Pb. Pesticides and pollution-classification and degradation of pesticides, methods of pesticide analysis. Sampling of soil, aquatic sediments, pH, electrical conductivity, redox potential, alkalinity, inorganic and organic contents.	5
3.3	Air pollution monitoring sampling, collection of air pollutants-SO_2, NO_2, NH_3, O_3 and SPM.	2
3.4	Analysis of metals, alloys and minerals: Analysis of brass, steel and limestone. Corrosion analysis.	4

3.5	Toxicology of Cd, Pb, Hg, As, Se, Pu, oxides of nitrogen and sulphur, benzene, halogenated hydrocarbons, aromatic amino compounds, benzopyrene and related compounds, treatment of hazardous waste and their disposal.	5
4.0	**Instrumental Method of analysis**	**18**
4.1	Introduction to optical atomic spectroscopy, components of optical instruments, general design -sources, monochromators, detectors, transistors - FET, MOSFET, ICs, OPAM, transducers and sensors, criteria for selecting instrumental methods –precision, sensitivity, selectivity and detection limit. Types of optical instruments-colorimeter, spectrophotometer, spectrofluorometer. Atomic emission and atomic absorption phenomena- comparison of relative merits and drawbacks	7
4.2	Atomic Absorption Spectroscopy- Instrumentation details of AAS: Atomisation methods-flame, electro thermal and plasma techniques, glow discharge and laser ablation, sources- HCl, EDL-TGL, wavelength choice detectors, use in qualitative and quantitative analysis, interferences in AAS-chemical, spectral and instrumental background correction techniques	6
4.3	Atomic emission spectroscopy: Instrumentation details of AES-flame, arc, spark, plasma emissions (ICP and DCP), details of wave selection-detection systems, applications.	3
4.4	Atomic Fluorescence Spectroscopy: Instrumentation-dispersive and non dispersive instruments.	2
5.0	**Thermal and Radiochemical Methods**	**9**
5.1	Thermogravimetry (TG), differential thermal analysis (DTA) and differential scanning calorimetry (DSC) and their instrumentation. Thermometric titrations.	5
5.2	Measurement of alpha, beta, and gamma radiations, neutron activation analysis and its applications. Principle and applications of isotope dilution methods	4

References

1. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, 8th Edn., Saunders College Pub.,2007.
2. J.H. Kennedy, Analytical Chemistry: Principles, Saunders College, Pub.,1990.
3. S.E. Manahan, Environmental chemistry, 9th Edn., CRC Press,2010
4. G.D. Christian, J.E. O'Reilly, Instrumental Analysis, Allyn& Bacon,1986.
5. D.C. Harris, Quantitative Chemical Analysis, 7th Edn., W.H. Freeman & Co., 2011
6. F.W. Fifield, D. Kealey, Principles and Practice of Analytical Chemistry,
7. Blackwell Science, 2000.
8. D. A. Skoog, F.T. Holler, T.A. Nieman, Principles of Instrumental Analysis, 5thEdition.
9. H.H. Willard, L.L. Merritt, J.A. Dean, Instrumental Methods of Analysis, 5th Edn., Van Nostrand,1974
10. F.A. Settle, Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall PTR,1997
11. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Text Book of Quantitative Chemical Analysis, 5th Edn., John Wiley&sons,1989.
12. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974
13. H.A. Laitinen, W.E. Harris, Chemical Analysis, McGrawHill,1975
14. J. A. Nathanson, Basic Environmental Technology, 5th Edn., Pearson Prentice Hall, 2007
15. C.S. Rao, Environmental Pollution Control Engineering, New Age International, 1995.
16. C.L. Wilson, D.W. Wilson, Comprehensive Analytical Chemistry, Elsevier,1982

Course	Details				
Code	ICH4CR03				
Title	Green Chemistry				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	2/IV				
Type	Core				
Credits	3	Hrs/Week	4	Total Hours	72

Specific objectives	To provide an insight into the green route of synthesis
Course outcomes	1. To understand the importance of green chemistry 2. To recognize twelve principles of green chemistry 3. To familiarize the basic concepts in green chemistry 4. To evaluate and identify the adverse effects of chemicals to environment and select safer green methods for synthesis

Module	Course Description	Hrs
1	**Introduction to Green chemistry**	**9**
1.1	Introduction to Green Chemistry: What is Green Chemistry? Need for Green Chemistry, Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Introduction of Green protocol**:** Rules -Rio declaration- Montreal protocol, Kyoto protocol.	3
1.2	Twelve principles of Green Chemistry with their explanations and special emphasis on the following with examples: Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.	6
2	**Prevention & minimization of toxic materials (Green alternatives)**	**18**
2.1	Prevention/ minimization of hazardous/ toxic products: reducing toxicity risk (function) hazard exposure; waste or pollution prevention hierarchy. Source of waste, cost of waste, Waste minimization technique, waste treatment, reuse and recycling.	4

2.2	Energy requirements for reactions-alternative sources of energy: use of microwaves and ultrasonic energy. Selection of starting materials; avoidance of unnecessary derivatization-careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.	8
2.3	Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD, greener alternative to Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.	6
3	**Green synthesis**	**21**
3.1	Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorousbiphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.	4
3.2	Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis), Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction, Ultrasound assisted reactions: sono chemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) Surfactants for Carbon Dioxide- replacing smog producing and ozone depleting solvents with $C0_2$ for precision cleaning and drycleaning of garments. Right fit pigment: synthetic azopigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils.	17
4	**Green Industrial Processes**	**18**
4.1	Pollution statistics from various industries, polymer industry, textile industry, greener approach of dyeing, eco-friendly pesticides, pharmaceutical industry, wastewater treatment.	3

4,2	Water and Biodegradation: Analysis of water and water quality parameters and standards-Monitoring Techniques and Methodology: pH, measurement of acidity, alkalinity, specific conductance, Total hardness (Ca & Mg) ,residual chlorine, chlorides, DO, BOD, COD, Total nitrite and nitrate, fluoride, sulphide and Ammonia	6
4.3	Design for energy efficiency**:** principle of microwave oven, microwave assisted organic syntheses, simple examples-renewable feedstock-biodiesel, preparation, advantages, catalysis, greencatalysts- inherently saferchemistry for accident prevention. Green chemistry practices in research, educational and commercial laboratories – lab safety signs-introduction to microscale experiments as green method.	9
5	**Future Trends in Green Chemistry**	**6**
5.1	Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2 S3); Green chemistry in sustainable development.	6

References

1. Paul Anastas, ,John C. Warner,; Green Chemistry: Theory and Practice New Ed Edition; Oxford University press,USA,2000
2. Lancaster, M, "Green Chemistry; An Introductory Text",Royal Society of Chemistry; Cambridge, UK, 2003
3. Rashmi Sanghi and M.MSrivastava, "Green Chemistry Environment Friendly Alternatives", Narosa Publishing House,2006
4. S.K. Banerji, "Environmental Chemistry".
5. Anil K. De "Environmental Chemistry - An introduction"
6. B. K. Sharma "Air Pollution".
7. V. K. Ahluwalia "Environmental Chemistry" 5. G.W. vanLoon and S. J. Duffy "Environmental Chemistry: A global perspective"
8. S.K.Mohanty, Environment and Pollution Laws, Universal Law Publishing Co. Pvt Ltd
9. C.N Sawyer, P.L McCarty and G.F Parkin, Chemistry for Environmental Engineering and Science, 5th ed. Tata McGraw-Hill, 2003
10. Das, A. K. Environmental Chemistry with Green Chemistry, Books and allied (P) Ltd.
11. Ahluwalia, V.K. Green Chemistry: Environmentally Benign Reactions, Ane Books India, New Delhi, 2006.
12. Anastas, P.T and Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press,1998
13. Kirchoff, M. and Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC, 2002

14. Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC, 2002
15. Lancaster, Mike Green Chemistry: An introductory text: 2nd Ed. RSC publishing, ISBN 978-1-84755-873-2

SEMESTER IV

ICH4CP06 QUALITATIVE INORGANIC ANALYSIS -II

Credit – 2 (36 Hrs.)

1. Elimination of interfering anions such as F^-, BO_2^-, $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$ and PO_4^{3-}.
2. Systematic qualitative analysis of mixtures containing two acid and two basic radicals from the following with one interfering radical by Semi- micro method only.
   Ag^+, Pb^{2+}, Bi^{2+}, Cd^{2+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^+, Na^+, K^+, NH_4^+, CO_3^{2-}, SO_4^{2-}, NO_3^-, F^-, Cl^-, BO_2^-, $C_2O_4^{2-}$, $C_4H_4O_6^{2-}$, CH_3COO^- and PO_4^{3-}.

(Minimum of 5 mixtures to be analyzed)

References

1. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 1966.
2. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
3. V.V. Ramanujam, Inorganic Semi Micro Qualitative Analysis, The National Pub.Co., 1974.
4. J. Singh, R. K. P. Singh, J. Singh, LDS Yadav, I. R. Siddiqui, J. Shrivastava, Advanced Practical Chemistry, Pragati Prakashan, 7th Edn., 2017.

Course	Details				
Code	ICH5CR01				
Title	Environmental Studies and Human Rights				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core				
Credits	4	Hrs/Week	5	Total Hours	90

Specific objectives	To provide an insight into the environmental issues and human rights
Course outcomes	1.To understand the scope and importance of environmental studies 2.To realize the need for public awareness 3.To familiarize with the main issues and pollution 4.To understand the need for human rights.

Module	Course Description	Hrs
1	**Multidisciplinary Nature of Environmental Studies**	18
1.1	Definition, scope and importance. Need for public awareness. Natural resources: Renewable and non-renewable resources, forest resources - use and over-exploitation, deforestation.	3
1.2	Water resources - use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems. Mineral resources - use and exploitation, environmental effects of extracting and using mineral resources.	5
1.3	Food resources - World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems. Energy resources - growing energy needs, renewable and non renewable energy sources, use of alternate energy sources.	5
1.4	Land resources - land as a resource, land degradation, man induced landslides, soil erosion and desertification	5
2	**Ecosystems**	12
2.1	Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers. Energy flow in the ecosystem. Ecological succession.	4
2.2	Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the given ecosystem:- Forest ecosystem.	8
3	**Social Issues and the Environment**	15

3.1	Urban problems related to energy. Water conservation, rain water harvesting, water shed management. Resettlement and rehabilitation of people: its problems and concerns.	6
3.2	Environmental ethics: Issues and possible solutions. Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, Public awareness.	9
4	**Air, Water and Soil Pollution**	**15**
4.1	***Air pollution***: Causes, effects and control measures. Acid rain, smog, green house effect, Global warming, ozone depletion – causes and consequences. Introduction to noise pollution, hazards of noise pollution.	5
4,2	***Water pollution*:** Causes- organic, inorganic and macroscopic contaminants, effects of pesticides, insecticides and detergents on water pollution. Marine pollution, eutrophication, biomagnification ,water quality parameters-DO, BOD, COD.	5
4.3	***Soil pollution***: Causes and effects: Agrochemicals, industrial wastes, petroleum wastes, electronic wastes, landfill and dumping. Genetically modified plants.	5
5	**Toxicology and Toxicological Effects**	**6**
5.1	Toxic chemicals in the environment, impact of toxic chemicals on enzymes, biochemical effects of As, Cd, Pb, Hg, CO, Oxides of Nitrogen and Sulphur.	6
6	**Environmental Aspects of Nuclear Chemistry**	**12**
6.1	Nuclear particles, size of the nucleus - nuclear forces - nuclear stability – N/P ratio – packing fraction – mass defect – binding energy - magic numbers. Nuclear models – shell model and liquid drop model.	3
6.2	Natural radioactivity. Modes of decay- group displacement law — rate of decay – decay constant – half-life period – Gieger-Nuttall rule – disintegration series – transmutation reactions using protons, deutrons, α-particles and neutrons. Artificial radioactivity – positron emission and K electron capture – trans uranic elements, spallation reactions .	4
6.3	Applications of radioactivity: Radio carbon dating – rock dating – isotopes as tracers – study of reaction mechanism (ester hydrolysis). Application of radioactive isotopes in medicine. Nuclear fission - atom bomb - nuclear reactors – fast breeder reactors. Nuclear fusion and hydrogen bomb. Nuclear waste and its impact on environment – nuclear waste management	5
7	**Introduction to Human Rights**	**12**
7.1	An Introduction to Human Rights, meaning, concept and development. Three generations of human rights (civil and political rights; economic, social and cultural rights).	3

7.2	Human Rights and United Nations – contributions, main human rights related organs - UNESCO,UNICEF, WHO, ILO, Declarations for women and children, Universal Declaration of Human Rights. Human Rights in India: Fundamental rights and Indian Constitution, Rights for children and women, Scheduled Castes, Scheduled Tribes, Other Backward Castes and Minorities.	5
7.3	Environment and Human Rights - right to clean environment and public safety. Issues of industrial pollution, prevention, rehabilitation and safety aspect	4

References

1. Bharucha Erach, Text Book of Environmental Studies for undergraduate Courses. University Press, IInd Edition 2013 (TB)
2. Clark.R.S., Marine Pollution, Clanderson Press Oxford (Ref)
3. Cunningham, W.P.Cooper, T.H.Gorhani, E & Hepworth, M.T.2001 Environmental Encyclopedia, Jaico Publ. House. Mumbai. 1196p .(Ref)
4. Dc A.K.Enviornmental Chemistry, Wiley Eastern Ltd.(Ref)
5. Down to Earth, Centre for Science and Environment (Ref)
6. Heywood, V.H & Watson, R.T. 1995. Global Biodiversity Assessment, Cambridge University Press 1140pb (Ref)
7. Jadhav.H & Bhosale.V.M. 1995. Environmental Protection and Laws. Himalaya Pub. House, Delhi 284p (Ref)
8. Mekinney, M.L & Schock.R.M. 1996 Environmental Science Systems & Solutions. Web enhanced edition 639p (Ref)
9. Miller T.G. Jr., Environmental Science, Wadsworth Publishing Co. (TB)

10. Odum.E.P 1971. Fundamentals of Ecology. W.B. Saunders Co. USA 574p (Ref)
11. Rao.M.N & Datta.A.K. 1987 Waste Water treatment Oxford & IBII Publication Co.Pvt.Ltd.345p (Ref)
12. Rajagopalan. R, Environmental Studies from crisis and cure, Oxford University Press, Published: 2016 (TB)
13. Sharma B.K., 2001. Environmental Chemistry. Geol Publ. House, Meerut (Ref)
14. Townsend C., Harper J, and Michael Begon, Essentials of Ecology, Blackwell Science (Ref)
15. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II, Enviro Media (Ref)
16. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (Ref)
17. Wanger K.D., 1998 Environmental Management. W.B. Saunders Co. Philadelphia, USA 499p (Ref)
18. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition, New Age International (P) Ltd., New Delhi, 1995 (Reprint 2005).
19. S. Glasstone, Source Book on Atomic Energy, 3rd Edition, East-West Press Pvt. Ltd., New Delhi, 1967.
20. U.N. Dash, Nuclear Chemistry, Sultan Chand and Sons (1991).

Course	Details				
Code	ICH5CR02				
Title	INORGANIC CHEMISTRY II				
Degree	Integrated M.Sc. in Basic Sciences - Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core				
Credits	3	Hrs/Week	4	TotalHours	72

Specific objectives	To understand the metallurgical processes, bioinorganic compounds and nuclear chemistry
Courseoutcomes	• To understand the general principles of isolation of elements • To understand and apply the basic metallurgical operations • To study about the importance and applications of bioinorganic compounds • To understand the various types of nuclear reactions and its applications

Module	CourseDescription	Hrs.
1.0	**General Principles of Isolation of elements**	12
1.1	Methods of concentration of an ore- Gravity separation, Froth floatation, Magnetic separation, Leaching, electrostatic separation, automated ore sorting and dewatering. Preliminary processes- calcination and roasting. Methods of extracting metal from concentrated ore	4

1.2	Electrometallurgy- Metallurgy of Aluminium, Sodium Pyrometallugy. Metallurgy of iron and zinc. Aluminothermy, auto-reduction and hydrometallurgy metallurgy of silver and gold.	3
1.3	Purification of crude metal- Distillation, Liquation, Zone refining, Electro refining Chromatographic techniques, oxidative refining and Vapour phase refining (Mond's process and Van Arkel process)	5
2.0	**Basic metallurgical operations**	**15**
2.1	Thermodynamics of the oxidation of metals to metal oxides, Ellingham diagrams. Pulverisation, calcination, roasting refining. Physicochemical principle of extraction of iron, copper, silver, sodium, aluminium, magnesium, zinc, uranium and titanium.	4
2.2	Classification of steel, heat treatment of steel, passivity, different theories of rusting of iron and its prevention.	2
2.3	Corrosion: Introduction, Dry or Chemical Corrosion, Wet or electrochemical corrosion. Mechanism of Electrochemical Corrosion, Factors Influencing Corrosion.	4
2.4	Corrosion Control, Proper designing, Using pure metal, Using metal alloys, Cathodic protection. Chemical conversion, Coating, Phosphating, Chromising, Treatment of metal surfaces hot dipping, Use of inhibitors.	5
3.0	**Bioinorganic Compounds**	**18**
3.1	Essential and trace elements in biological systems, toxic effects of metals (Cd, Hg, Cr, Pb and As), structure and functions of biological membranes, mechanism of ion transport across membranes, sodium pump, ionophores, valinomycin. Phosphate esters in biology, Redox metalloenzymes, cytochromes-cytochrome P450.	4

3.2	Oxygen carriers and oxygen transport proteins: Structure and functions of haemoglobins and myoglobin, oxygen transport mechanism, cooperativity, Bohr effect. Structure and functions of haemerythrins and haemocyanin.	3
3.3	Biochemistry of zinc and copper: Structure and functions of carbonic anhydrase, carboxypeptidase A and superoxide dismutase.	3
3.4	Other important metal containing biomolecules: Vitamin B_{12} and the vitamin B_{12} coenzymes, photosynthesis-chlorophyll a, PS I and PS II.	4
3.5	Role of calcium in muscle contraction, blood clotting mechanism and biological calcification. Metals in medicine-therapeutic applications of cis-platin, radioisotopes and MRI agents.	4
4.0	**Nuclear Chemistry**	**27**
4.1	Nuclear particles, nuclear forces, nuclear size, nuclear density, stability of nucleus, binding energy, magic numbers, packing fraction, n/p ratio. Nuclear models – liquid drop model and shell model.	3
4.2	Natural radioactivity, modes of decay, decay constant, half-life period, average life, radioactive equilibrium, Geiger-Nuttal rule, units of radioactivity, radiation dosage. Induced radioactivity, nuclear reactions induced by charged projectiles, neutrons and γ rays, spallation reactions, preparation of transuranic elements, Fertile and fissile isotopes, chain reaction, stellar energy.	5
4.3	Nuclear Reactions: Q value and reaction threshold, reaction cross section, cross section and reaction rate, neutron capture cross section-variation of neutron capture cross section with energy (1/V law). Nuclear fission - fission fragments and mass distribution, fission yields, fission energy, fission cross section and threshold fission neutrons, nuclear fusion reactions and their applications.	6
4.4	Principles of counting technique: G.M. counter, proportional, ionization and scintillation counters, cloud chamber.	3

4.5	Synthesis of transuranic elements: Neptunium, Plutonium, Curium, Berkelium, Einsteinium, Mendelevium, Nobelium, Lawrencium	3
4.6	Analytical applications of radioisotopes-radiometric titrations, kinetics of exchange reactions, measurement of physical constants including diffusion constants, Radioanalysis, Neutron Activation Analysis, Prompt Gama Neutron Activation Analysis and Neutron Absorptiometry.	4
4.7	Radiation chemistry of water and aqueous solutions. Measurement of radiation doses. Relevance of radiation chemistry in biology, organic compounds and radiation polymerization.	3

References

1. Herbash, Principles of extractive metallurgyVol.1and 2
2. Volskky, E. Sergievskaya, Theory of metallurgical process
3. R. Baiky, Clays,H .Ries, Textbook of Metallurgy, John Wiley and sons
4. Fillipoy, Theory of metallurgical process, MIR Publications
5. Pchlke, Unit processes of extractive metallurgy, Elsevier publication
6. R. M. Roat-Malone, Bioinorganic Chemistry, A Short Course, Wiley Inter science, 2007.
7. Robert R. Crichton, Biological Inorganic Chemistry, A New Introduction to Molecular Structure and Function, Elsevier, 2012.
8. H.J. Arnikar, Essentials of Nuclear Chemistry, Wiley Eastern, 1982.
9. S.N. Goshal, Nuclear Physics, S. Chand and Company, 2006.

Course	Details				
Code	ICH5CR03				
Title	Organic Chemistry-II				
Degree	Integrated M.Sc.in Basic Sciences- Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core				
Credits	3	Hrs /Week	4	Total Hours	72

Specific objectives	To provide an insight into the environmental issues and human rights
Course outcomes	1. To understand different functional groups in Organic Chemistry and the reactions of them 2. To familiarise active methylene compounds, carbohydrates and their reactions

Module	Course Description	Hrs
1	**Nitrogen containing Compounds**	**18**
1.1	**Nitro compounds** (aliphatic and aromatic): Preparation of nitroalkanes and aromatic nitro compounds. Tautomerism of nitro compounds. Reduction of nitrobenzene in acidic, neutral and alkaline media. Electrolytic reduction. Selective reduction of aromatic polynitro compounds. Reactions of nitromethane. Charge transfer complexes of aromatic nitro compounds.	6

1.2	**Amines**: Preparation of amines: Reduction of nitro compounds and nitriles, reductive amination of aldehydes and ketones, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (with mechanisms). Reactions: Schotten – Baumann reaction, Hinsberg reaction(with mechanisms), Separation of a mixture of 1°, 2° and 3° amines using Hinsberg reagent. Stereochemistry of amines. Basicity of aliphatic and aromatic amines. Electrophilic substitution reactions of aniline: Halogenation, nitration and sulphonation. Quaternary ammonium salts as phase-transfer catalysts.	7
1.3	**Diazonium Salts :** Preparation: From aromatic amines. Reactions: Structure and stability of benzene diazonium salts. Conversion to benzene, phenol, chloro, bromo, iodo and fluoro benzenes, nitro benzene and azo dyes. Mechanisms of Sandmeyer and Gatterman reactions. Schiemann and Gomberg reactions. Preparation, structure and uses of Phenyl hydrazine, Diazomethane and Diazoacetic ester. Arndt –Eistert synthesis	5
2	**Carbohydrates**	**12**
2.1	Classification of carbohydrates. Reducing and non-reducing sugars. General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Cyclic structure of ribose. Chain lengthening and chain shortening of aldoses - Kiliani-Fischer synthesis and Wohl degradation. Interconversion of aldoses and ketoses. Glycosidic Linkage. Structure of sucrose, maltose and cellobiose (excluding their structure elucidation). Reactions and uses of sucrose. Structure of the polysaccharides -starch and cellulose (excluding their structure elucidation). Industrial applications of cellulose Artificial sugars (sweeteners) – sucralose.	12
3	**Carboxylic Acids, Sulphonic Acids and their Derivatives**	**27**

3.1	Carboxylic acids (aliphatic and aromatic) :Preparation - Oxidation of alcohols and aldehydes, hydrolysis of nitriles, side chain oxidation and carbonylation of Grignard reagents. Acidic and alkaline hydrolysis of esters (with mechanisms) Acidity of carboxylic acids, effect of substituents on acid strength. Reactions- Reduction and decarboxylation reactions. Reactions carboxylic acids with PCl_5, PCl_3, $SOCl_2$, ammonia, alcohol and diazomethane. Hell – Volhard - Zelinsky reaction (with mechanism). Ascent and descent of acid series.	9
3.2	Carboxylic acid derivatives: Preparation of acid chlorides, anhydrides, esters and amides from acids. Comparative study of nucleophilicity of acid derivatives. Reactions of acid chloride with alcohol and amine. Reactions of acetic anhydride with alcohol and amine. Transesterification, Perkin condensation and Reformatsky reaction (with mechanisms).	7
3.3	Dicarboxylic acids, hydroxy acids and unsaturated acids :Methods of formation, important reactions and uses of dicarboxylic acids, hydroxy acids and unsaturated acids like oxalic acid, malonic acid, adipic acid, phthalic acid, citric acid, salicylic acid, cinnamic acid, anthranilic acid, acrylic acid, maleic acid and fumaric acid	7
3.4	Sulphonic acids and their derivatives:Preparation, reactions and uses of benzene sulphonic acid, benzene sulphonyl chloride and ortho- and para- toluene sulphonyl chlorides	4
4	**Active Methylene Compounds**	**6**
4.1	Acidity of active methylene compounds. Keto-enol tautomerism. Preparation of ethyl acetoacetate by Claisen ester condensation. Reactions and synthetic uses of ethylacetoacetate, diethyl malonate and ethyl cyanoacetate.	6
5	**Ethers, Epoxides and Thioethers**	**9**

5.1	Methods of preparation of ethers. Reactions of ethers. Zeisel's method of estimation of alkoxy groups. Methods of preparation of epoxides, Stereospecificity in alkene epoxidation reactions. Reactions of epoxides with alcohols, alkoxides, ammonia derivatives and $LiAlH_4$. Regioselectivity in epoxide opening.	5
5.2	Structure, methods of preparations and properties of thiols.	2
5.3	Structure and reactions of thioethers. Mustard gas.	2

References

01. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, Academic Press, 2002.

02. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edn., Springer, 2007.

03. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 2005.

04. J. March, M.B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edn., Wiley, 2007.

05. R.T. Morrison, R.N. Boyd, S.K. Bhatacharjee, Organic Chemistry, 7th Edn., Pearson, 2011.

06. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.

Course	Details				
Code	**ICH5CR04**				
Title	**Physical Chemistry - II**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core				
Credits	**3**	Hrs/Week	**4**	Total Hours	**72**

Specific objectives	To study the interactions of various types of radiation with matter and to have a knowledge of the basics of photochemistry
Course outcomes	1. To understand the techniques used for the structural elucidation of molecules. 2. To understand the basics and applications of photochemistry.

Module	Course Description	Hrs
1	**Foundations of Spectroscopic Techniques**	**54**
1.1	Origin of spectra: origin of different spectra and the regions of the electromagnetic spectrum, intensity of absorption, influencing factors, signal to noise ratio, natural line width, contributing factors, Doppler broadening, Lamb dip spectrum, Born Oppenheimer approximation, energy dissipation from excited states (radiative and nonradiative processes), relaxation time.	4
1.2	Microwave spectroscopy: principal moments of inertia and Classification (linear, symmetric tops, spherical tops and asymmetric tops), selection rules, intensity of rotational lines, relative population of Energy levels, derivation of J_{max}, effect of isotopic substitution, calculation of intermolecular distance, spectrum of non rigid rotors, rotational spectra of polyatomic molecules, linear and symmetric top molecules, Stark effect and its application, nuclear spin and electron spin interaction, chemical analysis by microwave spectroscopy.	10

1.3	Infrared spectroscopy: Morse potential energy diagram, fundamentals,overtonesand hot bands, determination of force constants, diatomic vibrating rotator, break down of the Born-Oppenheimer approximation, effect of nuclear spin, vibrational spectra of polyatomic molecules, normal modes of vibrations, combination and difference bands, Fermi resonance, fingerprint region and group vibrations, effect of H-bonding on group frequency, disadvantages of dispersive IR, introduction to FT spectroscopy, FTIR.	10
1.4	Raman spectroscopy: scattering of light, polarizability and classical theory of Raman spectrum, rotational and vibrational Raman spectrum, complementarities of Raman and IR spectra, mutual exclusion principle, polarized and depolarized Raman lines, resonance Raman scattering and resonance fluorescence.	10
1.5	Electronic spectroscopy: term symbols of diatomic molecules, electronic spectra of diatomic molecules, selection rules, vibrational coarse structure and rotational fine structure of electronic spectrum, Franck-Condon principle, predissociation, calculation of heat of dissociation, electronic spectra of poly atomic molecules	10
1.6	Nuclear Magnetic Resonance spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling. Electron Spin Resonance (ESR) spectroscopy: Principle, hyperfine structure, ESR of simple radical - methyl radical.	10
2	**Photochemistry**	**18**
2.1	Laws of photochemistry-Grothus-Draper law, Stark-Einstein law. Quantum yield, examples of low and high quantum yields, chemical actinometry, excimers and exciplexes, Jablonski diagram. Qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing). Chemiluminescence, bioluminescence. Chemistry of the environment. Green house effect, ozone layer in atmosphere	18

References

1. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn., Tata McGraw Hill, 1994.

2. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India, 2001.
3. D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Brooks Cole, 2000.
4. R.S. Drago, Physical Methods in Inorganic Chemistry, Van Nonstrand Reinhold,1965.
5. F A Alberty and R J Silby, Physical Chemistry, John Wiley.
6. P. W. Atkins, The elements of Physical chemistry, 8thedn, Oxford University Press.
7. Gurdeep Raj, Photochemistry, 6thEdn, Goel Publishing House, 2014
8. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International (P) Ltd.
9. Puri, Sharma & Pathania, Priniciples of Physical Chemistry, Vishal Publishing Co.
10. N. J. Turro, Modern Molecular Photochemistry, 4th Edition University Science Books,Sausalito, 1991.
10. H. Gunther, NMR Spectroscopy, Wiley, 1995.
11. D.A. McQuarrie, J.D. Simon, Physical Chemistry: A Molecular Approach, University ScienceBooks, 1997.
12. D.N. Sathyanarayan, Electronic Absorption Spectroscopy and Related Techniques, UniversitiesPress, 2001.
13. D.N. Sathyanarayana, Vibrational Spectroscopy: Theory and Applications, New AgeInternational, 2007
14. D.N. Sathyanarayana, Introduction To Magnetic Resonance Spectroscopy ESR,NMR,NQR, IKInternational, 2009.

Course	Details				
Code	**ICH5CR05**				
Title	**Physical Chemistry - III**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core				
Credits	**3**	Hrs/Week	**4**	Total Hours	**72**

Specific objectives	To apply the concepts of quantum mechanics to atoms and molecules and understand the basics of group theory
Course outcomes	1. To enable the students to solve the simple quantum mechanical models such as simpleharmonic oscillator, rigid rotor, H atom etc. 2. To understand the quantum mechanical aspect of angular momentum and spin. 3. Enable the students to predict the point group of important molecules. 4. To understand the idea of crystal symmetry

Module	Course Description	Hrs
1	**Quantum mechanics – Applications to systems**	**36**
1.1	3 dimensional box problem – concept of degeneracy and application to real systems.	3
1.2	Vibrational motion: One-dimensional harmonic oscillator (complete treatment), Hermite equation(solving by method of power series), Hermite polynomials, recursion relation, wave functions and energies-important features, harmonic oscillator model and molecular vibrations.	7
1.3	Rotational motion: Co-ordinate systems, cartesian, cylindrical polar and spherical polar coordinates and their relationships. The wave equation in spherical polar coordinates-particle on a ring, the phi equation and its solution, wave functions in the real form. Non-planar rigid rotor (or particle on a sphere),separation of variables, the phi and the theta equations and their solutions, Legendre and associated Legendre equations, Legendre and associated Legendre polynomials. Spherical harmonics (imaginary and real	7

	forms), polar diagrams of spherical harmonics.	
1.4	Quantization of angular momentum, quantum mechanical operators corresponding to angular momenta (L_x, L_y, L_z and L^2), commutation relations between these operators. Spherical harmonics as eigen functions of angular momentum operators L_z and L^2. Ladder operator method for angular momentum, space quantization.	6
1.5	Quantum Mechanics of Hydrogen-like Atoms: Potential energy of hydrogen-like systems. The wave equation in spherical polar coordinates: separation of variables-r, theta and phi equations and their solutions, wave functions and energies of hydrogen- like atoms. Orbitals: Radial functions, radial distribution functions, angular functions and their plots. Dirac's relativistic equation for hydrogen atom (Elementary idea only).	9
1.6	Spin orbitals: Construction of spin orbitals from orbitals and spin functions,spin orbitals for many electron atoms, symmetric and antisymmetric wave functions. Pauli's exclusion principle, slater determinants.	4
2	**Group theory**	**36**
2.1	Matrices: addition and multiplication of matrices, inverse and orthogonalmatrices, character of a matrix.	3
2.2	Mathematical groups: Properties, Abelian groups, cyclic groups, subgroups. Group multiplication tables (GMTs)- C_{2v}, C_{3v} and C_{2h}, isomorphicgroups.	6
2.3	Matrix representation of elements like E, Cn, Sn, I, σ-matrix representation of pointgroupslikeC_{2v}, C_{3v}, C_{2h}, C_{4v}-trace/character. Block diagonalisation, block factored matrices. Reducible and irreducible representation.	6
2.4	Representation using vectors as basis, representation generatedby cartesian coordinates positioned on the H_2O molecule (C_{2v} point group)	4
2.5	Great Orthogonality theorem (Statement) and its consequences. Standard reduction formula, Character table, construction of character tables for C_{2v}, C_{2h}, C_{3v} and C_{4v}.Direct product of representations.	12
2.6	Symmetry in crystals: 32 crystallographic point groups (no derivation), Hermann-Mauguin symbols. Screw axis- pitch and fold of screw axis, glide planes, space groups (elementary idea only)	5

References

1. I.N. Levine, Quantum Chemistry, 7thEdn., Pearson Education Inc., 2016.
2. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4th Edn., Oxford University Press, 2005.
3. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
4. J.P. Lowe, K. Peterson, Quantum Chemistry,3rd Edn., Academic Press, 2006.
5. R.K. Prasad, Quantum Chemistry, 3rd Edn., New Age International, 2006.
6. F.A. Cotton, Chemical Applications of Group Theory, 3rdEdn.,Wiley Eastern, 1990.
7. L.H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill, 1969
8. V. Ramakrishnan, M.S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1992.
9. S. Swarnalakshmi, T. Saroja, R.M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.
10. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2010
11. K. Veera Reddy, Symmetry and Spectroscopy of molecules, New Age International (P) Ltd, 1999.

SEMESTER V

ICH5CP06 Gravimetric Analysis

Credit – 2 (36 Hrs.)

1. Estimation of Barium as barium sulphate
2. Estimation of iron as Fe2O3
3. Estimation of sulphate as barium sulphate
4. Estimation of copper as cuprous thiocyanate
5. Estimation of nickel as nickel dimethyl glyoxime.

References

1. J. Mendham. R.C. Denney, J.D. Barnes and M. Thomas, *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Edition, Pearson Education, Noida, 2013.
2. D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, *Fundamentals of Analytical Chemistry*, 8th Edition, Brooks/Cole, Thomson Learning, Inc., USA, 2004.
3. G. D. Christian, Analytical Chemistry, JohnWiley and Sons.
4. R. D. Day, A. L. Uderwood, Quantitative analysis,

SEMESTER V

ICH5CP07: ORGANIC ANALYSIS

Credits-2 **Total Hours: 36**

1. Determination of physical constants of solids and liquids – melting and boiling points.
2. Tests for elements: Nitrogen, Halogens and Sulphur
3. Tests for unsaturation.
4. Tests for aromatic character.
5. Study of the reactions of the following functional groups: carboxylic acid, 1,2-dicarboxylic acid, phenol, aldehyde, ketone, ester, reducing and nonreducing sugars, polynuclear hydrocarbon, primary, secondary and tertiary amines, amides, diamide, nitro and halogen compounds.
6. Systematic analysis and preparation of solid derivative of the following organic compounds: carboxylic acid, 1,2-dicarboxylic acid, unsaturated acids, phenol, hydroxy acids, aldehyde, ketone, ester, reducing and nonreducing sugars, polynuclear hydrocarbon, primary, secondary and tertiary amines, amide, diamide, nitro and halogen compounds. (Minimum eight compounds to be analysed)
7. Microanalysis Procedures to analyse the organic compounds.

References

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 5th ed., Pearson Education, 2005.
2. Mann,F.G.; Saunders, B.C. Practical Organic Chemistry, 4th ed., Pearson Education, 2009.
3. Ahluwalia, V.K.; Dhingra, S. Comprehensive Practical Organic Chemistry – Qualitative Analysis, Universities Press, 2000.
4. Vishnoi, N.K. Advanced Practical Organic Chemistry, 3rd ed., Vikas Publishing House, New Delhi, 2010

Course	Details				
Code	ICH6CR01				
Title	Inorganic chemistry- III				
Degree	Integrated M.Sc. in Basic Sciences-Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/ VI				
Type	Core				
Credits	3	Hrs. /Week	4	Total Hours	72

Specific objectives	To improve the level of understanding of the chemistry of organometallic compounds.
Course outcomes	1. To inculcate interest in understanding transition metal organometallic chemistry. 2. To understand the classification, properties and applications of organometallic compounds. 3. To study the methods of preparation and bonding in metal carbonyls. 4. To understand the properties, structure and bonding of metal clusters. 5. To understand the reactions of organometallic compounds.

Module	Course Description	Hrs.
1.0	**Organometallic Compounds - Synthesis, Structure and Bonding**	**27**
1.1	Definition – Classification based on the nature of metal-carbon bond and on the basis of hapticity, The 18- electron rule and stability. Hapto nomenclature of organometallic compounds, organometallic compounds with linear pi donor ligands-olefins, acetylenes, dienes and allyl complexes- synthesis, structure and bonding. Synthesis and structure of complexes with cyclic pi donors-metallocenes and cyclicarene complexes, bonding in ferrocene and dibenzene chromium, carbine and carbine complexes.	12

1.2	Metal carbonyls: CO as a π-bonding ligand, synergism, preparation, properties, structure and bonding of simple mono and binuclear metal carbonyls, metal nitrosyls, metalcyanides and dinitrogen complexes. Polynuclear metal carbonyls with and without bridging.Carbonyl clusters-LNCCS and HNCCS, Isoelectronic and isolobal analogy, Wade-Mingosrules,clustervalenceelectrons.IRspectralstudiesofbridgingandnon-bridgingCOligands. Structure and bonding in carbonyls- $Mo(CO)_6$, $Fe(CO)_5$, $Ni(CO)_4$, $Mn_2(CO)_{10}$ and $Fe_2(CO)_9$. EAN of metals in metal carbonyls – indication of metal-metal bonding. - Quadruple bond – structure of $Re_2Cl_8^{2}$	15
2.0	**Reactions of Organometallic Compounds**	**12**
2.1	Substitution reactions-nucleophilic ligand substitution, nucleophilic and electrophilic attack on coordinated ligands.	3
2.2	Addition and elimination reactions-1,2 additions to double bonds, carbonylation anddecarbonylation. Oxidative addition- concerted addition, S_N^2, radical and ionic mechanisms. Reductive elimination-binuclear reductive elimination and σ-bond metathesis. Oxidative coupling and reductive decoupling. Insertion (migration) and elimination reactions–insertions of CO and alkenes, insertion into M−H versus M−R, α,β,γ and δ eliminations.	6
2.3	Redistribution reactions, fluxional isomerism of allyl, cyclo pentadienyl and allene systems.	**3**
3.0	**Catalysis by Organometallic Compounds**	**18**
3.1	Homogeneous and heterogeneous organometallic catalysis- Tolman catalytic loops, alkene hydrogenation using Wilkinson catalyst. Reactions of carbon monoxide and hydrogen-the water gas shift reaction, the Fischer-Tropsch reaction (synthesis of gasoline). Hydro formylation of olefins using cobalt and rhodium catalysts.	9
3.2	Polymerization by organometallic initiators and templates for chain propagation- Ziegler Natta catalysts, polymerization by metallocene catalysts. Carbonylation reactions: Monsanto acetic acid process, olefin hydro formylation- oxoprocess, carbonylation of alkenes and alkynes in the presence of a nucleophile- the Reppe reaction. Carbonylation of aryl halides in the presence of a nucleophile, Olefin metathesis-synthesis gas based reactions, photo dehydrogenation catalyst (“PlatinumPop”). Oxidation of olefins: Palladium catalyzed oxidation of ethylene-the Wacker process, epoxidation of olefins, hydroxylation by metal-oxo complexes.	9
4.0	**Palladium Catalyzed C-C and C-N Cross Coupling Reactions of Organometallic Compounds**	**15**

4.1	Discovery of Palladium based cross coupling reactions, Industrial applications of cross coupling reactions. The cross coupling catalyst. The Heck reaction, Suzuki- Miyaura coupling, Sonogashira coupling, Stille coupling, Kumada coupling, Negishi coupling, Hiyama coupling, Buchwald-Hatwig C-N cross coupling.	12
4.2	Cross coupling reactions of organohalides with non- organometallic and non-heteroatom based reagents	3

References

1. J.E. Huheey, E.A. Keiter, R.L. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Harper Collins College Publishers,1993.
2. F.A. Cotton, G Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, 6th edition, Wiley-Interscience, 1999.
3. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
4. P. Powell, Principles of Organometallic Chemistry, 2nd Edn., Chapman and Hall, 1988.
5. B.E. Douglas, D.H. McDaniel, J. J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
6. B.D. Guptha, A.J Elias, Basic Organometallic Chemistry, Universities Press, 2010.
7. R.W. Hay, Bio Inorganic Chemistry, Ellis Horwood, 1984.
8. SumitBhaduri, DobleMukesh, Homogeneous Catalysis: Mechanism and Industrial Applications, Wiley Interscience, 2000.
9. Astruc, D.; Organometallic Chemistry and Catalysis, Springer Verlag, 2007.
10. Robert H. Crabtree, The Organometallic Chemistry of the Transition Metals, 4th Edn., Wiley Interscience, 2005.

Course	Details				
Code	ICH6CR02				
Title	Organic chemistry- III				
Degree	Integrated M.Sc. in Basic Sciences-Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/ VI				
Type	Core				
Credits	3	Hrs. /Week	4	Total Hours	72

Specific objectives	To enable the student to use spectroscopy for structural elucidation of organic molecules
Course outcomes	1. To apply the concepts of spectroscopy in analysis. 2. To apply the different spectroscopic methods to solve problems based on it, spectral data for explaining important organic reactions and functional transformations.

Module	Course Description	Hrs.
1	**Ultraviolet-Visible and Chiro-optical Spectroscopy**	9
1.1	Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules. Classification of UV absorption bands, examples of UV chromophores.	3
1.2	Influence of substituent, ring size and strain on spectral characteristics. Solvent effect, Stereochemical effect, non-conjugated interactions. Chiro-optical properties-ORD, CD, octant rule, axial haloketone rule, Cotton effect-applications.	3
1.3	Problems based on the above topics.	3
2	**Infrared Spectroscopy**	9
2.1	Fundamental vibrations, characteristic regions of the spectrum (fingerprint and functional group regions), influence of substituent, ring size, hydrogen bonding, vibrational coupling and field effect on frequency, determination of stereochemistry by IR technique.	2
2.2	IR spectra of C=C bonds (olefins and arenes) and C=O (carbonyls).	4
2.3	Problems based on IR spectral data.	3
3	**Nuclear Magnetic Resonance Spectroscopy**	18
3.1	Magnetic nuclei with special reference to ^{1}H and ^{13}C nuclei. Chemical shift and shielding/ deshielding, factors affecting chemical shift, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic	3

	shielding and magnetic anisotropy. ^{1}H and ^{13}C NMR scales.	
3.2	Spin-spin splitting: AX, AX_2, AX_3, A_2X_3, AB, ABC, AMX typecoupling, first order and non-first order spectra, Pascal's triangle, coupling constant, mechanism of coupling- Dirac model. Karplus curve, quadrupole broadening and decoupling, homotopic, enantiotopic and diastereotopic protons, virtual coupling, long range coupling. NOE and cross polarization.	4
3.3	Simplification non-first order spectra to first order spectra: shift reagents, spin decoupling and double resonance, off resonance decoupling. Chemical shifts and homonuclear/heteronuclear couplings. Basis of heteronuclear decoupling.	3
3.4	2D NMR and COSY, HOMOCOSY and HETEROCOR.	3
3.5	Polarization transfer, selective population inversion, DEPT, sensitivity enhancement and spectral editing, MRI.	2
3.6	Problems on spectral interpretation with examples.	3
4	**Mass Spectrometry**	**9**
4.1	Molecular ion: Ion production methods (EI). Soft ionization methods: SIMS, FAB, CA, MALDI-TOF, PD, field desorption electrospray ionization, fragmentation patterns (polyenes, alkyl halides, alcohols, phenols, aldehydes and ketones, esters),nitrogen and ring rules, McLafferty rearrangement and its applications, HRMS, MS-MS, LC-MS, GC-MS.	6
4.2	Problems on spectral interpretation with examples.	3
5	**Structural Elucidation Using Spectroscopic Techniques**	**9**
5.1	Identification of structures of unknown organic compounds based on the data from UV-Vis, IR, ^{1}H NMR and ^{13}C NMR spectroscopy (HRMS data or Molar mass or molecular formula may be given).	3
5.2	Interpretation of the given UV-Vis, IR and NMR spectra.	3
5.3	Spectral analysis of the following reactions/functional transformations: 1. Pinacol-Pinacolone rearrangement. 2. Benzoin condensation. 3. (4+2) cycloaddition 4. Beckmann rearrangement. 5. Cis-trans isomerisation of azo compounds. 6. Benzil-benzilic acid rearrangement. 7. Fries rearrangement.	3
6	**Fluorescence Spectroscopy**	**18**
6.1	Introduction: Jablonski diagram, Stokes shift, delayed fluorescence, emission and excitation spectra, quantum yield; solvents and environmental effects; Instrumentation, fluorophores: intrinsic and extrinsic fluorophores, red and NIK fluorophores, Fluorescent organic and inorganic nanoparticles, lanthanides and metal complexes as fluorophore, Fluorescent Proteins, Miscellaneous Probes, time domain lifetime	9

	measurements.	
6.2	Introduction to fluorescent sensing, design and applications offluorescence sensing. Mechanism of sensing: sensing by collision quenching Energy-transfer sensing, aggregation-induced emission based sensing, PET probes, excimer-monomer based probes, probes with other sensing mechanisms, sensing with fluorescent nanomaterials, biosensors, Molecular Beacons, Introduction of Fluorophores into Living Cells, Bioimaging.	9

References:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, Introduction to Spectroscopy, 3rd Edn., Broos, Cole, 2000.
2. A.U. Rahman, M.I. Choudhary, Solving Problems with NMR Spectroscopy, Academic Press,1996.
3. L. D. Field, S. Sternhell, J. R. Kalman, Organic Structures from Spectra, 4th Edn., John Wiley &sons, 2007.
4. C.N. Banwell, E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edn., TataMcGraw Hill, 1994.
5. D.F. Taber, Organic Spectroscopic Structure Determination: A Problem Based Learning Approach, Oxford University Press, 2007.
6. H. Gunther, NMR Spectroscopy, 2nd Edn., Wiley, 1995.
7. R.M. Silverstein, G.C. Bassler, T.C. Morril, Spectroscopic Identification of Organic Compounds, 5th Edn., Wiley, 1991.
8. D.H. Williams, I. Fleming, Spectroscopic Methods in Organic Chemistry, 6th Edn., McGraw-Hill, 2008.
9. W. Kemp, Organic Spectroscopy, 2ndEdn., Macmillan, 1987.
10. F. Bernath, Spectra of Atoms and Molecules, 2nd Edn., Oxford University Press, 2005.
11. E.B. Wilson Jr., J.C. Decius, P.C. Cross, Molecular Vibrations: The Theory of Infrared and RamanVibrational Spectra, Dover Pub., 1980.
12. Online spectral databases including RIO-DB.
13. J. R. Lakowicz, Principle of Fluorescence Spectroscopy, 3rd Edition, Springer, 2006.
14. B. Valeur, Molecular Fluorescence: Principles and Applications, 2nd Edition, Wiley, 2012.
15. D. M. Jameson, Introduction to Fluorescence, 1st Edition, CRC Press, 2014.
16. J. R. Alhani, Principles and Applications of Fluorescence Spectroscopy 1st Edition, WileyBlackwell, 2007.
17. A Shama, S. G. Schulman, Introduction to Fluorescence Spectroscopy, 1st Edition. Wiley.1999

Course	Details				
Code	ICH6CR03				
Title	Organic chemistry- IV				
Degree	Integrated M.Sc. in Basic Sciences-Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/ VI				
Type	Core				
Credits	2	Hrs. /Week	4	Total Hours	72

Specific objectives	To ensure that the students understands heterocyclic chemistry and natural products
Course outcomes	1. To know about the most important simple ring systems containing heteroatom, nomenclature and discuss the synthesis and reactivity of five and six membered hetero aromatic compounds. 2. To understand the chemistry of colours, classification and synthesis of dyes. 3. To provide an overview of the field of natural product chemistry, identify different types of natural products, their occurrence, isolation, structure elucidation, synthesis and properties.

Module	Course Description	Hrs
1	**Heterocyclic Compounds**	12
1.1	Classification and nomenclature. Structure and aromaticity of 5-numbered and 6-membered rings containing one heteroatom. Synthesis and reactions of: Furan, Thiophene, Pyrrole (PaalKnorr synthesis and Knorr pyrrole synthesis), Pyridine (Hantzsch synthesis), Indole (Fischer's indole synthesis), Quinoline (Skraup synthesis and Friedlander's synthesis) and Isoquinoline (Bischler-Napieralski reaction).	12
2	**Dyes**	8
2.1	Theories of colour and chemical constitution. Classification of dyes – according to chemical constitution and method of application. Natural and synthetic dyes. Synthesis and applications of: Azo dyes – Methyl orange; Triphenyl methane dyes - Malachite green and Rosaniline; Phthalein dyes – Phenolphthalein and Fluorescein; Indigoid dyes - Indigotin; Anthraquinoid dyes – Alizarin. Edible dyes (Food colours) with examples.	8

3	**Natural Products**	**9**
3.1	Terpenoids – Classification. Isoprene rule. Structure elucidation and uses of citral and geraniol. Natural rubber - structure, latex processing methods, vulcanisation, rubber compounding, mastication and uses. Alkaloids - General methods of isolation,classification,physiological action and medicinal importance. Structure elucidation and synthesis of coniine, nicotine and piperine.	9
4	**Lipids**	**9**
4.1	Introduction to lipids. Classification. Oils and fats: Biological functions. Extraction and refining. Common fatty acids present in oils and fats. Omega fatty acids. Trans fats and their effect. Hydrogenation, Rancidity. Acid value, Saponification value, Iodine value and RM value. Biological functions of waxes, phospholipids and glycolipids.	5
4.2	Soaps - Types of soaps. Cleansing action of soaps. Synthetic detergents - Classification. Detergent additives. Comparison between soaps and detergents. Environmental aspects. ABS and LAS detergents.	4
5	**Vitamins, Steroids and Hormones**	**9**
5.1	Vitamins – Classification. Structure, biological functions and deficiency diseases of vitamins A, B1, B2, B3, B5, B6, C and D. Steroids – Introduction. Diels' hydrocarbon. Structure and functions of cholesterol. Elementary idea of HDL and LDL.	5
5.2	Hormones – Introduction. Examples and biological functions of steroid hormones, peptide hormones and amine hormones (structure not required). Artificial hormones.	4
6	**Amino Acids, Peptides and Proteins**	**12**
6.1	Classification of amino acids. Synthesis, ionic properties and reactions of α-amino acids. Zwitterion structure and Isoelectric point. Polypeptides. Synthesis of simple peptides (upto tripeptides) by N-protecting (benzyloxycarbonyl and t-butyloxycarbonyl) & C-activating groups. DCC method. Merrifield's solid phase peptide synthesis.	6
6.2	Classification of proteins. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of proteins. Determination of N- Mahatma Gandhi University, Kottayam 47 terminal amino acid (by FDNB and Edman method) and C–terminal amino acid (by hydrazinolysis and with carboxypeptidase enzyme). Helical and sheet structures. Denaturation of proteins.	6

7	**Nucleic acids**	**9**
7.1	Components of Nucleic acids: Adenine, guanine, cytosine, thymine and uracil (structure only), other components of nucleic acids. Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson - Crick Model) and RNA. Biological functions of DNA and RNA - Replication and protein biosynthesis. Transcription and Translation. Genetic code.	9
8	**Enzymes**	4
8.1	Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (Including stereospecificity). Enzyme inhibitors and their importance. Uses of enzymes.	4

References

1. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, Wiley, 2014.
2. McMurry, J. Organic Chemistry, 7th ed. Cengage Learning, 2013.
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
4. Morrison, R.T., Boyd, R.N. & Bhattacharjee, S.K. Organic Chemistry, 7th ed., Dorling Kindersley (India) Pvt. Ltd (Pearson Education), 2011.
5. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry, 7 th ed., W. H. Freeman.
6. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.
7. Bhat S.V., Nagasampagi, B.A. & Sivakumar M. Chemistry of Natural Products, Narosa, 2005.
8. Jain, M.K. & Sharma, S.C. Modern Organic Chemistry, Vishal Publishing Co. 2010.
9. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
10. Tewari, K.S. & Vishnoi, N.K. Organic Chemistry, Vikas Publishing House, 2012.
11. Billmeyer, F.W. Textbook of Polymer Science, Wiley.

Course	Details				
Code	**ICH6CR04**				
Title	**Physical Chemistry - IV**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	3/VI				
Type	Core				
Credits	**2**	Hrs/Week	**4**	Total Hours	**72**

Specific objectives	To study the laws and principles of electrochemistry and solutions.
Course outcomes	1. To understand the underlying laws of electrochemistry 2. To apply these laws to cells, corrosion etc 3. To understand the concept of solutions.

Module	Course Description	Hrs
1	**Electrochemistry and Electromotive Force**	**54**
1.1	Introduction- Faraday's laws of electrolysis, electrochemical equivalent & chemical equivalent. Electrolytic conductivity, molar conductivity – Variation of molar conductivity with concentration. Kohlrausch's law – Applications.	6
1.2	Ionic mobility – relation with ion conductivity, influence of temperature on ion conductivity, ion conductivity and viscosity – Walden's rule. Abnormal ion conductivity of hydrogen and hydroxyl ions. Transference number and its experimental determination using Hittorf and Moving boundary methods.	7
1.3	Debye-Hückel theory of strong electrolytes – the concept of ionic atmosphere, Asymmetry and electrophoretic effect, Debye- Hückel-Onsager equation (no derivation). Activity, mean ionic activity and mean ionic activity coefficients of electrolytes. Ionic strength of a solution, Debye-Hückel limiting law (no derivation).	8
1.4	Applications of conductance measurements – Determinations of degree of dissociation of weak electrolytes, determination of solubility and solubility products of sparingly soluble salts, conductometric titrations involving strong acid- strong base, weak acid- strong base, mixture of a strong acid and weak acid against strong base and precipitation titrations.	8

1.5	Electrochemical cells and electrolytic cells, Galvanic cells, characteristics of reversible cells. Reversible electrodes – Different types, Reference electrodes – Standard Hydrogen Electrode, Calomel electrode, Electrode potential – Electrochemical series. Representation of cells, Electrode reactions and cell reactions	10
1.6	Derivation of Nernst equation for electrode potential and cell potential, Gibb's Helmholtz equation and EMF of a cell, calculation of ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells – Electrode concentration cell and electrolyte concentration cells. Types of electrolyte concentration cells – with transference and without transference, liquid junction potential and salt bridge. Applications of emf measurements – determination of solubility product, determination of pH using hydrogen electrode, quinhydrone electrode and glass electrode. Potentiometric titrations of acid-base and redox reaction, oxidation reduction indicators. Irreversible electrode processes – overvoltage. Corrosion of metals – forms of corrosion, corrosion monitoring and prevention methods. Pourbaix diagram and Evans diagrams.	15
2	**Solutions**	**18**
2.1	Raoult's law, Ideal and non ideal solutions, ΔG_{mix}, ΔV_{mix}, and ΔS_{mix} for ideal solutions vapour pressure- composition and temperature-composition curves of ideal and non-ideal binary liquid solutions, fractional distillation, deviation from Raoult's law, Azeotropic mixtures, partially miscible liquid system, critical solution temperature, Conjugate layers, example for upper, lower and upper cum lower CST	9
2.2	Colligative properties of dilute solutions – vapour pressure lowering, Boiling point elevation and freezing point depression (thermodynamic derivation).Molar mass determination-related problems – Osmotic pressure –laws of osmotic pressure – Reverse osmosis – purification of sea water. Abnormal molecular masses – van't Hoff factor – Degree of association and Degree of dissociation.	9

References

1. B. R. Puri, L. R. Sharma, M. S. Pathania, Elements of Physical chemistry, VishalPub. Co. Jalandhar.
2. K. L. Kapoor, A Textbook of Physical chemistry, Volume 4, Macmillan India Ltd.
3. Castellan, G.W. Physical Chemistry,4th Ed. Narosa (2004).
4. Glasstone S, An Introduction to Electrochemistry, East-West Press (Pvt.) Ltd. (2006).
5. Gurdeep Raj, Advanced Physical Chemistry, Goel publishing house.

6. Glasstone and Lewis, Elements of Physical Chemistry, Macmillan

7. K. L. Kapoor, A Textbook of Physical chemistry, Volumes 3, Macmillan India Ltd.

8. I.N. Levine, Physical Chemistry, Tata McGraw Hill

9. F A Alberty and R J Silby, Physical Chemistry, John Wiley.

10. P. W. Atkins, The elements of Physical chemistry, 8thedn, Oxford University Press.

11. D. A. McQuarrie, J. D. Simon, Physical Chemistry – A molecular Approach, Viva Books Pvt.Ltd.

12. S. H. Marron and J. B. Lando, Fundamentals of Physical Chemistry, Macmillan Ltd.

13. G. K. Vemulapalli, Physical Chemistry, Prentice-Hall of India Pvt. Ltd. (1997)

Course	Details				
Code	ICH6ELA1				
Title	Forensic Science				
Degree	Integrated M.Sc. in Basic Sciences - Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/VI				
Type	Elective				
Credits	4	Hrs/Week	5	Total Hours	90

Specific objectives	To understand the various aspects of crime detection in forensic science
Course outcomes	1. To understand the poisonsand diagnosis of poisons in the living and dead. 2. To understand the antidotes used for common poisons 3. To study about analysis of human bombs, metal detectors and security measures 4. To study about forgery and counterfeiting and use the knowledge in analyzing forged documents 5. To understand about traces and track analysis in forensic science 6. To understand and analyze natural fires and arson fires 7. To apply the knowledge in analysing the purity of gold and diamonds

Module	Course Description	Hrs
1.0	**Poisons**	**18**
1.1	Poisons- types and classification- diagnosis of poisons in the living and the dead– clinical symptoms-postmortem appearances. Heavy metal contamination (Hg, Pb, Cd) of seafoods. Use of neutron activation analysis in detecting Arsenic in human hair. Treatment in cases of poisoning- use of antidotes for common poisons.	18
2.0	**Crime Detection**	**18**

2.1	Accidental explosion during manufacture of matches and fireworks. Human bombs- possible explosives (gelatin sticks and RDX)–metal detector devices and other security measures for VVIP- composition of bullets and detecting powder burn. Analysis of incendiary and timed bombs–spill of toxic and corrosive chemicals from tankers.	18
3.0	**Forgery and Counterfeiting**	**18**
3.1	Documents- different types of forged signatures- simulated and traced forgeries– inherent signs of forgery methods– writing deliberately modified – uses of ultraviolet rays - comparison of typewritten letters – checking silver line watermark in currency notes – alloy analysis using AAS to detect counterfeit coins – detection of gold purity in 22 carat ornaments – detecting gold plated jewels – authenticity of diamond.	18
4.0	**Tracks and Traces**	**18**
4.1	Tracks and traces - small tracks and police dogs-foot prints –casting of footprints – Residue prints, walking pattern or tyre marks-miscellaneous traces and tracks – glass fracture – tool mark paints – fibres. Analysis of biological substances - blood, saliva, urine and hair- Cranial analysis (head and teeth) DNA Finger printing for tissue identification in dismembered bodies –Detecting steroid consumption in athletes and racehorses.	18
5.0	**Medical Aspects**	**18**
5.1	Aids- causes and prevention- misuse of scheduled drugs–burns and their treatment by plastic surgery. Metabolite analysis using mass spectrum– gas chromatography. Arson natural fires and arson-burning characteristics and chemistry of combustible materials - nature of combustion. Ballistics - classification – internal and terminal ballistics-small arms-laboratory examination of barrel washing and detection of powder residue by chemical tests.	18

References:

1. T.H. James, Forensic Sciences, StanleyThornes Ltd.

2. Richard, Criminalistics - An Introduction to Forensic Science (College Version), 8th Edition, Sofestein, Printice Hall.

Course	Details				
Code	ICH6ELA2				
Title	Polymer Science				
Degree	Integrated M.Sc. in Basic Sciences - Chemistry				
Branch(s)	Pure Chemistry				
Year/Semester	3/V				
Type	Core-Elective				
Credits	4	Hrs/Week	5	Total Hours	90

Specific objectives	To give an insight into the basics of polymer science
Course outcomes	1. To provide the fundamentals of polymer chemistry including the classification of polymers, methods of polymerization,their molecular weight and its determination, structure-property relationships and applications. 2. To give an insight to the various applications of polymers as plastics, synthetic fibers; agricultural chemicals, paints adhesives; and biomedical appliances.

Module	Course Description	Hrs
1	**Introduction to polymer science**	**9**
1.1	Brief history of macromolecular science, Nomenclature of polymers: Nomenclature based on source and structure (Non-IUPAC), IUPAC structure-based nomenclature system, trade names. Classification, the rise of macromolecular science,molecular forces and chemical bonding in polymers. Basic terms and definitions: Monomer, polymer, end groups, degree of polymerisation, homopolymers, heteropolymers, copolymers, average molecular weight and distribution, polymer morphology, thermoplastics, elastomers, plastics, fibres, thermosetting resin, polymer blends.	9
2	**Mechanisms of polymerization**	**18**
2.1	Methods of polymerization-bulk, suspension, emulsion, solution polymerization. Copolymers and copolymerization, blocks and graft copolymers.	3

2.2	Types of polymerizations- addition, condensation, ionic, co-ordination. Addition – polymerization – mechanism, initiation, propagation and termination processes, initiators, inhibitors. Mechanism of ionic polymerization. Mechanism of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerization. Mechanism of copolymerization. Mechanism of ring opening and group transfer polymerizations. Polymerization techniques: Bulk, solution, suspension and emulsion polymerizations. Melt, solution and interfacial polycondensation techniques.	15
3	**Polymer Synthesis and Applications**	**22**
3.1	Detailed study of the following thermoplastic polymers with respect to synthesis, chemistry, properties and applications. Polyolefins, polyethylenes- HDPE, LDP, LLDP, polyvinyl chloride-grades of PVC, Teflon, Polystyrene-homopolymers, copolymers such as SBR, ABS, SAN. Vinyl polymers- polyvinyl acetate and its modifications like PVA, PVB and polyacetals. Polyamides -nylon -6, nylon-66 and other nylons. Poly ethers and poly esters, terephthalates. Cellulosics such as esters, ethers, acetates, butyrates, nitrate, CMC; regenerated cellulose.	13
3.2	Detailed study of the following thermosetting polymers with respect to synthesis, chemistry, properties and applications. (a) phenol-formaldehyde resins (b) amino resins-urea- formaldehyde and melamine-formaldehyde resins (c) polyurethanes (d) epoxy resins- grades of epoxy resins, curing process and its importance with mechanism (e) poly carbonates, silicones.	9
4	**Reactions of Polymers**	**4**
4.1	Hydrolysis, hydrogenation, addition, substitution, crosslinking, vulcanisation and cyclisation reactions.	4
5	**Polymer degradation**	**8**
5.1	Polyisoprene, polybutadiene, neoprene. Rubber processing – Compounding and compounding ingredients, Milling (two-roll mill), Calendaring, Extrusion moulding (Basic idea only)	3

5.2	Basic idea of polymers used as adhesive and coatings, liquid crystalline polymers, conducting polymers, biopolymers, biodegradable polymers. Polymer for engineering and biomedical applications. Types of degradation. Thermal, mechanical, photo and oxidative degradations of polymers. Pollution due to polymers, recycling of polymers. Laminates	5
5	**Physical PropertiesofPolymers**	**18**
5.1	Crystallization and Crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.	3
5.2	Molecular weight and molecular weight distribution – number, weight and viscosity average molecular weights of polymers, methods of determining molecular weight- end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance Polydispersity Index. Introductory concepts of kinetics of polymerization and Carother's relation.	7
5.3	Glass Transition Temperature (T_g): Definition. Factors influencing glass transition temperature (T_g). T_g and molecular weight. T_g and melting point. Importance of T_g. Viscosity, solubility, optical properties, electrical properties, thermal properties, mechanical properties of polymers- Introduction to tensile, impact, tear, abrasion and flexural properties of polymers.	8
6	**Polymer Processing Techniques**	**4**
6.1	Polymer processing techniques: Compression moulding, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Die casting, Film casting, Rotational casting, Calendering and Spinning. vulcanization of elastomers.	4
7	**Specialty Polymers**	7
7.1	High temperature resistant and flame retardant polymers. Biomedical applications of polymers. Controlled drug delivery systems. Conducting polymers - polyacetylene, polyaniline, poly(p-phenylene sulphide), polypyrrole, polythiophene. Conduction mechanism and applications. Carbon nanotubes. Synthesis and applications (elementary idea only).	7

References:

1. F.W. Billmeyer, A text book of polymer science, John Wiley & Sons,1971.
2. V.R. Gowariker, N.V. Viswanathan and Sreedhar, Polymer Science, Wiley Easern Ltd.,New Delhi,1986.
3. Odian, G. Principles of Polymerization, 4th ed., Wiley,2004.
4. B.K. Sharma, Polymer Chemistry, Goel Publishing House,Meerut.
5. Maurice Morten, Rubber Technology, Van Nostrand, Reinold, NewYork.
6. Ghosh, P. Polymer Science & Technology, 2nd ed., Tata McGraw-Hill, New Delhi, 2002.
7. Lenz, R.W. Organic Chemistry of Synthetic High Polymers. IntersciencePublishers, New York,1967.
8. Joel R. Fried, Polymer Science and Technology, 3rd Edn., 2014.
9. Bahadur, R., Sastry, N.V. Principles of Polymer Science, Narosa, New Delhi,2003.

SEMESTER VI

ICH6CP05 – PHYSICAL CHEMISTRY EXPERIMENTS

Credits-2 **Total Hours: 36 Hrs**

1. Viscosity – percentage composition of a mixture.
2. Heat of neutralization
3. Conductometric titration – strong acid *vs.* strong base
4. Transition temperature of salt hydrates. (Sodium thiosulphate, sodium acetate)
5. Critical solution temperature of phenol-water system.
6. Effect of electrolytes on the CST of phenol-water system.
7. Molecular weight determination by Rast's method. (using naphthalene, camphor or biphenyl as solvent and acetanilide, p-dichlorobenzene etc. as solute.)
8. Potentiometric titration – Fe^{2+} *vs.* MnO^{4-}
9. Determination of equivalence point of potentiometric and conductometric titrations using spreadsheet programme.

References

1. W. G. Palmer: 'Experimental physical chemistry', Cambridge University Press.
2. J.B. Yadav: Advanced Practical Physical Chemistry Goel Publishing House.
3. R.C. Das and B. Behra; 'Experiments in Physical Chemistry , Tata McGraw hill.
4. K.K. Sharma : 'An Introduction of Practical Chemistry': Vikas Publishing House, New Delhi
5. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry,R. Chand & Co.: New Delhi (2011).

SEMESTER VI

ICH6CP06- PREPARATION AND PURIFICATION METHODS OF ORGANIC COMPOUNDS

Credits-2 **Total Hours: 36 Hrs**

A. Basic Laboratory Techniques

1. Crystallisation – Any four compounds using solvents - ethyl acetate, ethanol, and water - Record the yield of recovery.
2. Distillation - Separation of water and ethyl acetate-Record the yield of recovery.
3. Solvent extraction – aniline from water/ methyl benzoate from water - using ether
4. Quantitative dilution of solutions - Any two dilutions from their standard solutions)

B. Organic Preparations

Organic preparations involving:

1. Oxidation (benzaldehyde to benzoic acid).
2. Hydrolysis (methyl salicylate or ethyl benzoate to the acid).
3. Nitration (m-dinitrobenzene and picric acid).
4. Halogenation (p-bromoacetanilide from acetanilide).
5. Acylation (Benzoylation of aniline/ phenol/ β-naphthol).
6. Esterification (benzoic acid ester).
7. Iodoform from acetone or ethyl methyl ketone.
8. Side chain oxidation (benzyl chloride to benzoic acid).
9. Claisen – Schmidt reaction: Dibenzal acetone from benzaldehyde.

C. Chromatography

1. TLC - Separation and identification- Determination of R_f value of o-and pnitroanilines, o- and p-chloroanilines, p-chlorophenol and p-nitrophenol, p-chloroaniline and p– nitroaniline, benzil and o-nitroaniline or any two amino acids.
2. Column Chromatography Purification of o-nitro aniline, o-nitrophenol, benzil, m-dinitro benzene, benzene azo –β-naphthol (non–evaluative).

References

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V. Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, 5th ed., Pearson Education, 2005.
2. Mann,F.G.; Saunders, B.C. Practical Organic Chemistry, 4th ed., Pearson Education, 2009.

3. Ahluwalia, V.K.; Aggarwal, R. Comprehensive Practical Organic Chemistry – Preparation and Quantitative Analysis, Universities Press, 2000.
4. Vishnoi, N.K. Advanced Practical Organic Chemistry, 3rd ed., Vikas Publishing House, New Delhi, 2010

Course	Details				
Code	**ICH7CR01**				
Title	**Advanced Inorganic Chemistry -I**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	4/VII				
Type	Core				
Credits	**5**	Hrs/Week	**5**	Total Hours	**90**

Specific objectives	To explore the structure and bonding,spectral and magnetic properties ,kinetics and reaction mechanism of metal complexes.
Course outcomes	1. To understand the basics of coordination chemistry including coordination numbers, geometry, and chelate effect. 2. To describe the bonding theories VBT, CFT, and MOT in turn describe CFSE, High and low spin complexes, magnetic moment of coordination 3. compounds 4. To interpret the electronic spectra of coordination compounds explaining color, allowed and forbidden transitions through Orgel and Tanabe-Sugano diagrams. 5. To design reaction mechanism pathways like associative/dissociative, inner and outer sphere mechanisms including electron transfer pathways. 6. To demonstrate the basics, spectral and magnetic properties of Lanthanides and Actinides

Module	Course Description	Hrs.
1.0	**Structural Aspects and Bonding in Coordination Compounds**	**18**
1.1	Classification of complexes based on coordination numbers and possible geometries. Sigma and pi bonding ligands such as CO, NO, CN^-, R3P, and Ar3P. Stability of complexes, thermodynamic aspects of complex formation-Irving William order of stability, chelate effect.	9

1.2	Splitting of *d* orbitals in octahedral, tetrahedral, square planar, square pyramidal and triagonal bipyramidal fields, LFSE, *Dq* values, Jahn Teller (JT) effect, theoretical failure of crystal field theory, evidence of covalency in the metal ligand bond, nephelauxetic effect, ligand field theory, molecular orbital theory M.O energy level diagrams for octahedral and tetrahedral complexes without and with π-bonding, experimental evidences for pi-bonding.	9
2.0	**Spectral and Magnetic Properties of Metal Complexes**	**18**
2.1	Electronic Spectra of complexes-Term symbols of d^n system, Racah parameters, splitting of terms in weak and strong octahedral and tetrahedral fields. Correlation diagrams for d^n and d^{10-n} ions in octahedral and tetrahedral fields (qualitative approach), *d-d* transition, selection rules for electronic transition-effect of spin orbit coupling and vibronic coupling.	4
2.2	Interpretation of electronic spectra of complexes-Orgel diagrams, demerits of Orgel diagrams, Tanabe-Sugano diagrams, calculation of *Dq*, *B* and *β* (Nephelauxetic ratio) values, spectra of complexes with lower symmetries, charge transfer spectra, luminescence spectra.	5
2.3	Magnetic properties of complexes-paramagnetic and diamagnetic complexes, molar susceptibility, Gouy method for the determination of magnetic moment of complexes, spin only magnetic moment. Temperature dependence of magnetism Curie's law, Curie-Weiss law. Temperature Independent Paramagnetism (TIP), Spin state cross over, Antiferromagnetism-inter and intra molecular interaction. Anomalous magnetic moments	6
2.4	Elucidating the structure of metal complexes (cobalt and nickel complexes) using electronic spectra, IR spectra and magnetic moments.	3
3.0	**Kinetics and Mechanism of Reactions in Metal Complexes**	**18**

3.1	Thermodynamic and kinetic stability, kinetics and mechanism of nucleophilic substitution reactions in square planar complexes, *trans* effect-theory and applications.	6
3.2	Kinetics and mechanism of octahedral substitution- water exchange, dissociative and associative mechanisms, anation, aquation, base hydrolysis, racemization reactions, solvolytic reactions (acidic and basic). Inert and labile compounds, conjugate base mechanism.	8
3.3	Electron transfer reactions: outer sphere mechanism-Marcus theory, inner sphere mechanism-Taube mechanism.	4
4.0	**Stereochemistry of Coordination Compounds**	**9**
4.1	Geometrical and optical isomerism in octahedral complexes, resolution of optically active complexes, determination of absolute configuration of complexes by ORD and circular dichroism, stereoselectivity and conformation of chelate rings, asymmetric synthesis catalyzed by coordination compounds.	6
4.2	Linkage isomerism-electronic and steric factors affecting linkage isomerism. Symbiosis-hard and soft ligands, Prussian blue and related structures, Macrocycles-crown ethers.	3
5.0	**Coordination Chemistry of Lanthanides and Actinides**	**9**
5.1	General characteristics of lanthanides-Electronic configuration, Term symbols for lanthanide ions, Oxidation state, Lanthanide contraction. Factors that mitigate against the formation of lanthanide complexes. Electronic spectra and magnetic properties of lanthanide complexes. Lanthanide complexes as shift reagents.	5
5.2	General characteristics of actinides-difference between *4 f* and *5 f* orbitals, comparative account of coordination chemistry of lanthanides and actinides with special reference to electronic spectra and magnetic properties	4

6.0	**Applications of Organometallic Compounds**	**18**
6.1	Asymmetric catalysis- Asymmetric hydrogenation, isomerisation and epoxidation.	3
6.2	C-H activation and functionalization of alkanes and arenes: Radicaltype oxidation, hydroxylation, dehydrogenation, carbonylation and regioselective borylation of alkanes and cycloalkanes. Radicaltype reactions, electrophilic reactions, carbonylation and borylation of arenes. Insertion of alkenes and alkynes in the Ar-H bond.	8
6.3	Application of palladium catalysts in the formation of C-O and C-N bonds, oxidative coupling reactions of alkynes with other unsaturated fragments for the formation of cyclic and hetero cyclic compounds. The Dötz reaction.	7

References

01. F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry: A Comprehensive Text, 3rd Edn., Interscience,1972.
02. J.E. Huheey, E.A. Keiter, R.A. Keiter, Inorganic Chemistry Principles of Structure and Reactivity, 4th Edn., Pearson Education India, 2006.
03. K.F. Purcell, J.C. Kotz, Inorganic Chemistry, Holt-Saunders, 1977.
04. F. Basolo, R.G. Pearson, Mechanisms of Inorganic Reaction, John Wiley & Sons, 2006.
05. B.E. Douglas, D.H. McDaniel, J.J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn., Wiley-India, 2007.
06. R.S. Drago, Physical Methods in Chemistry, Saunders College, 1992.
07. B.N. Figgis, M.A. Hitchman, Ligand Field Theory and its Applications, WileyIndia, 2010.
08. J.D. Lee, Concise Inorganic Chemistry, 4th Edn., Wiley-India, 2008
09. S. Cotton, Lanthanide and Actinide Chemistry, John Wiley & Sons, 2007.
10. T. Moeller, International Review of Science: Inorganic Chemistry, Series I, Vol VII, Butterworth, 1972.

Course	Details				
Code	**ICH7CR02**				
Title	**Advanced Theoretical Chemistry & Computational Chemistry**				
Degree	**Integrated M.Sc.in Basic Sciences- Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	4/VII				
Type	Core				
Credits	**4**	Hrs/Week	**4**	Total Hours	**72**

Specific objectives	Enable students to know important approximation methods in quantum mechanics and to have a basic idea about computational chemistry calculations.
Course outcomes	1. To understand the requirement of approximation methods in quantum mechanics. 2. To gain an insight on valance bond theory, molecular orbital theory and the concept of hybridization. 3. To know the applications of group theory in chemical bonding. 4. To get an exposure to the emerging world of computational chemistry

Module	Course Description	Hrs
1	**Approximate methods**	**18**
1.1	Many-body problem and the need of approximation methods, independent particle model. Variation method: Variation theorem with proof, illustration of variation theorem using the trial function x(a-x) for particle in a 1D-box and using the trial function e-αr for the hydrogen atom, variation treatment for the ground state of helium atom.	6
1.2	Perturbation method, time-independent perturbation method (non-degenerate case only), first order correction to energy and wave function, illustration by application to particle in a 1D-box with slanted bottom, perturbation treatment of the ground state of the helium atom. Qualitative idea of Hellmann-Feynman theorem.	6
1.3	Hartree-Fock method, multi-electron atoms. Hartree-Fock equations (no derivation). The Fock operator, core hamiltonian, coulomb operator and exchange operator. Qualitative treatment of Hartree-Fock Self-Consistent	6

	Field (HFSCF) method. Roothan's concept of basis functions, Slater type orbitals (STO) and Gaussian type orbitals (GTO), sketches of STO and GTO.	
2	**Chemical Bonding**	**18**
2.1	Schrödinger equation for molecules. Born-Oppenheimer approximation, valencebond (VB) theory, VB theory of H_2 molecule, singlet and triplet state functions (spin orbitals) of H_2.	6
2.2	Molecular Orbital (MO) theory, MO theory of H_2^+ ion, MO theory of H_2 molecule, MO treatment of homonuclear diatomic molecules Li_2, Be_2, N_2, O_2 and F_2 and hetero nuclear diatomic molecules LiH, CO, NO and HF, bond order. Correlation diagrams, non-crossing rule, spectroscopic term symbols for diatomic molecules, comparison of MO and VB theories.	6
2.3	Hybridization, quantum mechanical treatment of sp, sp^2 and sp^3 hybridisation. Semiempirical MO treatment of planar conjugated molecules, Hückel Molecular Orbital (HMO) theory of ethene, allyl systems, butadiene and benzene. Calculation of charge distributions, bond orders and free valency.	6
3	**Group theory - Applications**	**18**
3.1	Vibrational mode analysis using group theory taking H_2O,NH_3 and trans-N_2F_2 as examples using symmetry coordinates and internal coordinates method, prediction of IR and Raman activity,-rule of mutual exclusion,-redundant modes , out of plane modes.	5
3.2	Application in uv-visible spectroscopy, transition moment integral, vanishing of integrals, selection rules, orbital selection rules, transitions between non-degenerate states, prediction of electronic transitions in C_{2v},C_{3v},C_{4v},C_{2h} and C_{4h} using direct product terms , spin selection rules, relaxation in selection rules and distortion. electronic transitions due to the carbonyl chromophore in formaldehyde	6
3.3	Application in hybridization, Projection operator, transformation properties of atomic orbitals, construction of symmetry adapted linear combination of atomic orbitals (SALCs) of C_{2v}, C_{3v},D_{3h} and C_{2h} molecules. determination	5

	of hybridization and hybrid functions in CH_4, BF_3 and PCl_5	
3.4	Group theory and optical activity (brief study)	2
4	**Computational Quantum Chemistry**	**18**
4.1	Introduction and scope of computational chemistry, potential energy surface, conformational search, global minimum, local minima, saddle points.	3
4.2	Abinitio methods: A review of Hartee-Fock method, self consistent field(SCF)procedure. Roothan concept basis functions. Basis sets and its classification: Slater type and Gaussian type basis sets, minimal basis set, Pople style basis sets .Hartree-Fock limit. Post Hartree-Fock methods - introduction to Møller Plesset perturbation theory, configuration interaction, coupled cluster and semiempirical methods.	4
4.3	Introduction to Density Functional Theory (DFT) methods: Hohenberg-Kohn theorems, Kohn-Sham orbitals, exchange correlation functional, local density approximation, generalized gradient approximation, hybrid functionals (only the basic principles and terms need to be introduced).	4
4.4	Comparison of abinitio, semiempirical and DFT methods.	1
4.5	Molecular geometry input: Cartesian coordinates and internal coordinates, Z matrix, Z-matrix of single atom, diatomic molecule, non-linear triatomic molecule, linear triatomic molecule, polyatomic molecules like ammonia, methane and ethane. General format of GAMESS / Firefly input file, single point energy calculation, geometry optimization, constrained optimization and frequency calculation. Koopmans' theorem.	3
4.6	Features of molecular mechanics force field-bond stretching, angle bending, torsional terms, non-bonded interactions and electrostatic interactions. Commonly used forcefields-AMBER and CHARMM.	2

References

1. N. Levine, Quantum Chemistry, 7thEdn., Pearson Education Inc., 2016.
2. P.W. Atkins, R.S. Friedman, Molecular Quantum Mechanics, 4th Edn., Oxford University Press, 2005.

3. D.A. McQuarrie, Quantum Chemistry, University Science Books, 2008.
4. J.P. Lowe, K Peterson, Quantum Chemistry, 3rd Edn., Academic Press, 2006.
5. R. Anatharaman, Fundamentals of Quantum Chemistry, Macmillan India, 2001.
6. R.K. Prasad, Quantum Chemistry, 3rd Edn., New Age International, 2006.
7. T. Engel, Quantum Chemistry and Spectroscopy, Pearson Education, 2006.
8. H. Metiu, Physical Chemistry: Quantum Mechanics, Taylor & Francis, 2006.
9. L. Pauling, E.B. Wilson, Introduction to Quantum Mechanics, McGraw-Hill, 1935.
10. M.S. Pathania, Quantum Chemistry and Spectroscopy (Problems & Solutions), Vishal Publications, 1984.
11. F.A. Cotton, Chemical Applications of Group Theory, 3rd Edn., Wiley Eastern, 1990.
12. L. H. Hall, Group Theory and Symmetry in Chemistry, McGraw Hill,1969
13. V. Ramakrishnan, M.S. Gopinathan, Group Theory in Chemistry, Vishal Publications, 1992.
14. S. Swarnalakshmi, T. Saroja, R.M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.
15. S.F.A. Kettle, Symmetry and Structure: Readable Group Theory for Chemists, 3rd Edn., Wiley, 2007.
16. A. Vincent, Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications, 2nd Edn., Wiley, 2000.
17. A.S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2010.
18. K.I. Ramachandran, G. Deepa, K. Namboori, Computational Chemistry and Molecular Modeling: Principles and Applications, Springer, 2008.
19. A. Hinchliffe, Molecular Modelling for Beginners, 2nd Edn., John Wiley & Sons, 2008.
20. C.J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Edn., John Wiley & Sons, 2004.
21. D.C. Young, Computational Chemistry: A Practical Guide for Applying Techniques to RealWorld Problems, John Wiley & Sons, 2001.

Softwares

A) Molecular Mechanics:
Arguslab, Tinker, NAMD, DL-POLY, CHARMM, AMBER

B) Ab initio, semiempirical and dft:
1. Firefly / PC GAMESS available from http://classic.chem.msu.su/gran/gamess/
2. WINGAMESS available from http://www.msg.ameslab.gov/gamess/

C) Graphical User Interface (GUI):
Gabedit available from http://gabedit.sourceforge.net/ 2.wxMacMolPlt available from http://www.scl.ameslab.gov/MacMolPlt

Course	Details				
Code	**ICH7CR03**				
Title	**Advanced Organic Chemistry-I**				
Degree	**Integrated M.Sc. in Basic Sciences-Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	**4/VII**				
Type	**Core**				
Credits	**4**	**Hrs/Week**	**4**	**Total Hours**	**72**

Specific objectives	To understand and learn the concepts of Organic reaction mechanisms involving reaction intermediates, photochemical reactions ,concerted reactions and also the Physical concepts of Organic Chemistry
Course outcomes	1. To understand the structure, stability and reactions of carbanions, carbocations, carbenes etc. 2. To understand the principles of photochemical and concerted reactions 3. To analyze the concepts of physical organic chemistry and apply them to reactions.

Module	Course Description	Hrs
1	**Chemistry of Carbanions**	**9**
1.1	Formation, structure and stability of carbanions. Reactions of carbanions: C-X bond (X = C, O, N) formations through the intermediary of carbanions. Chemistry of enolates and enamines. Kinetic and Thermodynamic enolates- lithium and boron enolates in Aldol and Michael reactions, alkylation and acylation of enolates.	4
1.2	Nucleophilic additions to carbonyls groups. Named reactions under carbanion chemistry-mechanism of Dieckmann, Stobbe, Darzen and Acyloin condensations, Shapiro reaction and Julia elimination. Favorski rearrangement.	3
1.3	Ylides: chemistry of phosphorous and sulphur ylides - Wittig and related reactions, Peterson olefination.	2
2	**Chemistry of Carbocations**	**8**

2.1	Formation, structure and stability of carbocations. Classical and non-classical carbocations.	3
2.2	C-X bond (X = C, O, N) formations through the intermediary of carbocations.- Molecular rearrangements including agner-Meerwein, Pinacol-pinacolone, semi-pinacol, and Dienone - phenol rearrangements, Noyori annulation, Prins reaction, Oxymercuration and halolactonisation.	5
3	**Carbenes, Carbenoids, Nitrenes and Aynes**	**9**
3.1	Structure of carbenes (singlet and triplet), generation of carbenes, addition and insertion reactions. Reactions of carbenes - Wolf rearrangement, Generation and reactions of ylides by carbenoid decomposition.	4
3.2	Structure, generation and reactions of nitrene and related electron deficient nitrene intermediates. Hoffmann, Curtius, Lossen, Schmidt and Beckmann rearrangement reactions.	3
3.3	Arynes: generation, structure, stability and reactions. Orientation effect- amination of haloarenes.	2
4	**Radical Reactions**	**9**
4.1	Generation of radical intermediates and its reactions - addition to alkenes, alkynes (inter and intramolecular) for C-C bond formation - Baldwin's rules- Fragmentation and rearrangements- Hydroperoxides: formation, rearrangement and reactions. Autooxidation.	6
4.2	Named reactions involving radical intermediates: Barton deoxygenation and decarboxylation, McMurry coupling.	3
5	**Physical Organic Chemistry**	**9**

5.1	Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples. Linear free energy relationships-Hammet equation, Taft equation.	4
5.2	Catalysis by acids, bases and nucleophiles with examples from acetal and cyanohydrin .Ester formation and hydrolysis reactions of esters- AAC^2, AAC^1, AAL^1, $BAC^2$and BAL^1 mechanisms. Hard and soft acids, bases - HSAB principle and its applications (organic reactions only)	5
6	**Organic Photochemistry**	**10**
6.1	Photoreactions of carbonyl compounds: Photofragmentation reactions- Norrish reactions of ketones. Photoreduction reactions. Photoaddition reactions -PatternoBuchi reaction. Photo-substitution reactions-Barton reaction(nitrite ester reaction), Photo-rearrangement reactions- Di-π-methane and Photo Fries rearrangements, Photochemistry of azo compounds , nitro compounds and conjugated dienes (butadiene only), photochemistry of vision.	10
7	**Concerted Reactions**	**18**
7.1	Classification : Electrocyclic, sigmatropic, cycloaddition, chelotropic, ene and dyotropic reactions. Woodward Hoffmann rules - Frontier orbital and orbital symmetry correlation approaches - PMO method (for electrocyclic and cycloaddition reactions only).	6
7.2	Highlighting pericyclic reactions in organic synthesis such as Claisen, Cope, Wittig, Mislow-Evans and Sommelet-Hauser rearrangements. Diels-Alder and Ene reactions (with stereochemical aspects)	5
7.3	Unimolecular pyrolytic elimination reactions: Cheletropic elimination, decomposition of cyclic azo compounds, β-eliminations involving cyclic transition states such as N-oxides (Cope reaction), Acetates and Xanthates (Chugaeve reaction).	5
7.4	Problems based on the above topics	2

References:

1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanism, Academic Press, 2002.
2. .F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th Edn., Springer, 2007.
3. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 2005.
4. J. March, M.B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edn., Wiley, 2007.
5. T.H. Lowry, K.S. Richardson, Mechanism and Theory in Organic Chemistry, 2ndEdn., Harper & Row, 1981
6. N.S. Isaacs, Physical Organic Chemistry, ELBS/Longman, 1987.
7. R.T. Morrison, R.N. Boyd, S.K. Bhatacharjee, Organic Chemistry, 7th Edn., Pearson, 2011.
8. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2004.
9. N.J. Turro, V. Ramamurthy, J.C. Scaiano, Principles of Molecular Photochemistry: An Introduction, University Science books, 2009.
10. N.J. Turro, Modern Molecular Photochemistry, Benjamin Cummings, 1978.
11. K.K.R. Mukherjee, Fundamentals of Photochemistry, New Age Pub., 1978.
12. A. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, 1976..
13. S. Sankararaman, Pericyclic Reactions-A Text Book, Wiley VCH, 2005.

Course	Details				
Code	**ICH7CR04**				
Title	**ADVANCED PHYSICAL CHEMISTRY - I**				
Degree	**Integrated M.Sc.in Basic Sciences - Chemistry**				
Branch(s)	**Pure Chemistry**				
Year/Semester	4/VII				
Type	Core				
Credits	**3**	Hrs/Week	**4**	Total Hours	**72**

Specific objectives	To provide an insight into the thermodynamic and statistical properties of the system
Course outcomes	1. To apply principles and laws of equilibrium thermodynamics to multicomponent systems, 2. To calculate thermodynamic properties of ideal gases and realgases using the principles and techniques of statistical thermodynamics.

Module	Course Description	Hrs
1	**Classical Thermodynamics**	**27**
1.1	Mathematical foundations for thermodynamics-variables of thermodynamics, extensive and intensive quantities, equation for total differential, conversion formulas, exact differentials-general formulation, reciprocity characteristics, homogeneous functions, Euler's theorem.(Non-evaluative)	5
1.2	Thermodynamic equations of state. Maxwell relations and significance, irreversible processes - Clausius inequality.	4
1.3	Free energy, thermodynamic equilibria and free energy functions, temperature dependence of free energy - Gibbs Helmholtz equation, applications of Gibbs Helmholtz equation.	5

1.4	Chemical affinity and thermodynamic functions, effect of temperature and pressure on chemical equilibrium- Vant Hoff reaction isochore and isotherm.	4
1.5	Third law of thermodynamics, Nernst heat theorem, determination of absolute entropies using third law.	4
1.6	Three component systems- graphical representation. Solid-liquid equilibria, ternary solutions with common ions, hydrate formation, compound formation. Liquid-liquid equilibria-one pair of partially miscible liquids, two pairs of partially miscible liquids, three pairs of partially miscible liquids	5
2	**Irreversible Thermodynamics**	**9**
2.1	Thermodynamics of irreversible processes with simple examples, general theory of non-equilibrium processes, entropy production, the phenomenological relations, the principle of microscopic reversibility, Onsager reciprocal relations, thermal osmosis and thermoelectric phenomena	5
2.2	Bioenergetics, coupled reactions, ATP and its role in bioenergetics, high energy bond, free energy and entropy change in ATP hydrolysis, thermodynamic aspects of metabolism and respiration, glycolysis, biological redox reactions	4
3	**Statistical Thermodynamics**	**36**
2.1	Brief history about the macroscopic and microscopic approach in science, permutation, probability, Stirling's approximation, macrostates and microstates, equal-apriori principle and thermodynamic probability, phase-space, ensemble, types of ensembles.	6
2.2	"Boltzmann distribution law, partition function and its physical significance, relation between molecular partition function and molar partition function, distinguishable and indistinguishable particles, partition function and thermodynamic functions, separation of partition function-translational, rotational, vibrational, and electronic partition functions, partition function for hydrogen. Thermal de-Broglie wavelength	9

2.3	Calculation of thermodynamic functions and equilibrium constants, thermodynamic probability and entropy, Sakur-Tetrode equation, statistical formulation of third law of thermodynamics, residual entropy, heat capacity of gases - classical and quantum theories.	6
2.4	Need for quantum statistics, Bosons and Fermions, Bose-Einstein statistics:, Bose-Einstein distribution law, Bose-Einstein condensation, first order and higher order phase transitions, liquid helium, Fermi-Dirac statistics:, Fermi- Dirac distribution law, application in electron gas, thermionic emission. Comparison of three statistics.	9
2.5	Heat capacity of solids- the vibrational properties of solids, Einstein's theory and its limitations, Debye theory and its limitations.	6

References

1. Irving M. Klotz, Robert M.Rosenberg, Chemical Thermodynamics,John Wiley &Sons, INC Publication, 2008
2. R.P. Rastogi, R.R. Misra, An Introduction to Chemical Thermodynamics, Vikas Publishing House, 1996.
3. J. Rajaram, J.C. Kuriakose, Thermodynamics, S Chand and Co., 1999.
4. M.W. Zemansky, R.H. Dittman, Heat and Thermodynamics, Tata McGraw Hill, 1981.
5. P.W. Atkins, Physical Chemistry, ELBS, 1994.
6. G.W. Castellan, Physical Chemistry, Addison-Wesley, 1983.
7. K.J. Laidler, J.H. Meiser, B.C. Sanctuary, Physical Chemistry, 4th Edn., Houghton Mifflin, 2003.
8. L.K. Nash, Elements of Classical and Statistical Mechanics, 2nd Edn., Addison Wesley, 1972.
9. D.A. McQuarrie, J.D. Simon, Physical Chemistry: A Molecular Approach, University Science Books, 1997.
10. P.W. Atkins, Physical Chemistry, 9th Edn, Oxford University press, 2010
11. F.W. Sears, G.L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Addison Wesley, 1975.
12. M.C. Gupta, Statistical Thermodynamics, New age international, 2007
13. J. Kestin, J.R. Dorfman, A Course in Statistical Thermodynamics, Academic Press, 1971.
14. C. Kalidas, M.V. Sangaranarayanan, Non-equilibrium Thermodynamics, Macmillan. India 2002.

SEMESTER VII

ICH7CP05 INORGANIC CHEMISTRY PRACTICALS -I

Credit: 2 **Contact Lab Hours: 72**

PART I

Separation and identification of a mixture of four cations (a mixture of two familiar ions such as Ag^{+} , Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+}, As^{3+}, Sn^{2+}, Sb^{3+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+} , Mn^{2+}, Co^{2+}, Ni^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mg^{2+}, Li^{+} , Na^{+} , K^{+} and NH_4^{+} and two less familiar metal ions such as Tl, W, Se, Mo, Ce, Th, Ti, Zr, V, U and Li). Anions which need elimination not to be given. Minimum eight mixtures to be given.

PART II

Preparation and characterization complexes using IR, NMR and electronic spectra.

a) Tris (thiourea)copper(I) complex
b) Potassium tris (oxalate) aluminate (III).
c) Hexammine cobalt (III) chloride.
d) Tetrammine copper (II) sulphate.
e) Schiff base complexes of various divalent metal ions.
f) Bis(dimethylglyoximato)nickel(II)
g) Prussian blue

References

1. A.I. Vogel, G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn., Longman,1996.
2. A.I. Vogel, A Text Book of Quantitative Inorganic Analysis, Longman, 1966.
3. I.M.Koltoff, E.B. Sandell, Text Book of Quantitative Inorganic analysis, 3rd Edn., McMillian, 1968.
4. V.V. Ramanujam, Inorganic Semimicro Qualitative Analysis, The National Pub.Co., 1974.

5. J. Singh, R. K. P. Singh, J. Singh, LDS Yadav, I. R. Siddiqui, J. Shrivastava, Advanced Practical Chemistry, PragatiPrakashan, 7thEdn., 2017.

SEMESTER VII

ICH7CP06-ORGANIC CHEMISTRY PRACTICALS-I

Credit: 2 **Lab Hours: 72**

PART I

General methods of separation and purification of organic compounds such as:

1. Solvent Extraction
2. Soxhlet Extraction
3. Fractional crystallization
4. TLC and Paper Chromatography
5. Column Chromatography
6. Membrane Dialysis

PART II

1. Separation of Organic binary mixtures by chemical/solvent separation methods

2. Quantitative separation of organic mixtures by column chromatography – Purity assessment of the components by TLC.

PART III

Drawing the reaction schemes (Based on Semester **7** theory) by ChemDraw, Symyx Draw and Chemsketch. Draw the structures and generate the IR and NMR spectra of the substrates and products in the following reactions:

1. Condensation
    (a) Dieckmann condensation
    (b) Claisen condensation
    (c) Darzen condensation

(d) Aldol condensation

2. Oxidation / Reduction
   (a) Ozonolysis
   (b) Baeyer Villiger oxidation
   (c) Cannizaro reaction
   (d) Clemmenson reduction
3. Rearrangement
   (a) Benzilic acid rearrangement
   (b) Pinacol – Pinacolone rearrangement
   (c) Dienone – Phenol rearrangement
   (d) Wagner – Meerwein rearrangement
4. Pericyclic reaction
   (a) Diels – Alder reaction
   (b) Cope rearrangement

References

1. A.I. Vogel, A Textbook of Practical Organic Chemistry, Longman, 1974.
2. A.I. Vogel, Elementary Practical Organic Chemistry, Longman, 1958.
3. F.G. Mann, B.C Saunders, Practical Organic Chemistry, 4th Edn., Pearson Education India, 2009.
4. R. Adams, J.R. Johnson, J.F. Wilcox, Laboratory Experiments in Organic Chemistry, Macmillan, 1979.

MATHEMATICS

COMPLEMENTARY COURSE TO INTEGRATED M. Sc IN BASIC SCIENCES-CHEMISTRY

THIRD SEMESTER

ICH3CM04: Partial Differential Equations, Abstract Algebra and Analytic Geometry

5 hours/week (Total Hrs : 90) **4 credits**

SYLLABUS

Text Books:

1. **George B. Thomas, Jr: Thomas' Calculus (Twelfth Edition), Pearson.**
2. **John B Fraleigh – A First course in Abstract Algebra (Seventh Edition).**
3. **S. S. Sastry- Introductory Methods of Numerical Analysis (Fifth Edition), PHI.**
4. **Ian N. Sneddon – Elements of Partial Differential Equations ,TataMcGraw Hill.**

Module I: Analytic Geometry
(25hrs)

Polar coordinates, Conic sections, Conics in Polar coordinates.

Text 1: Chapter 11 (Sections 11.3, 11.6 and 11.7)

Module II: Binary Operations andGroups **(25 hrs)**

Binary Operations, Groups,Subgroups, Cyclic groups, Groups of Permutations, Homomorphisms.

Text 2: Chapter 1Sections 2, 4, 5 and 6 (Proofs of Theorems/ Corollary 5.17, 6.3, 6.7, 6.10, 6.14, 6.16 are excluded), Chapter 2 Section 8 (Proofs of theorems 8.15 and 8.16 are excluded),Chapter 3 Sections 13.1, 13.2 and 13.3, 13.11, 13.12 only.

Module III: Solution of Algebraic and Transcendental Equations
(20hrs)

Introduction, Bisection Method, Method of false position, Iteration method, Newton-Raphson method.

Text 3: Chapter 2 Sections 2.1 to 2.5

Module IV: Partial Differential Equations **(20 hrs)**

Methods of solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Partial differential equations, Origin of first order partial differential equations, Linear equations of the first order , Lagrange's method(proof of theorem 2 and theorem 3 are excluded), Integral surfaces passing through a given curve.

Text 4: Chapter 1 Section 3, Chapter 2 Section 1, 2 and section 4 (no proof of theorem 2 and theorem 3) and section 5.

MSc Integrated Chemistry

Mathematics- Complementary Course

ICH4CM04 - Fourier Series, Laplace Transformations, Vector Functions and Complex analysis

Semester : Four
Hours /Week : 5 (Total Hours: 90)
Text :Erwin Kreyzig, Advanced Engineering Mathematics, 10th edition,John Wiley& Sons, Inc

Module I:Fourier Series (15 hours)

Periodic functions, Trigonometric series,Euler formulas, Functions with period 2π, functions with any period 2L, Even and Odd functions, Half range expansions

(Proofs of all theorem and formulas are excluded)

Sections: Relevant topics from 11.1,11.2

Module II: Laplace Transforms (15 hours)

Laplace transform, Inverse Laplace transform, Linearity, First shifting theorem, Laplace transform of derivatives, Laplace transform of integral, Differential equations with initial value problems

(Proofs of all theorem and formulas are excluded)

Sections: Relevant topics from 6.1, 6.2

Module III: Vector Functions (30 hours)

Gradient, Directional derivative, Applications, Divergence, Curl, Line Integrals, Workdone, Surface and surface integrals, flux Integrals, Greens theorem,Divergence theorem, Stokes theorem, simple problems based on the theorems

(Proofs of all theorem and formulas are excluded)

Sections: Relevant topics from 9.7,9.8,9.9.9, 10.1,10.4,10.5, 10.6, 10.7,10.9

Module IV: Complex Analysis (30 hours)

Complex numbers and their geometric representations, Polar form, Powers and roots, Derivative and Analytic function, Cauchy-Riemann equations, Laplace Equation, line integral in complex plane, Cauchy's integral theorem and Cauchy's integral formula, Derivatives of analytic functions,Morera's theorem, Cauchy's inequality and Liouvelli's Theorem

(Proofs of all theorem and formulas are excluded)

Sections: Relevant topics from 13.1, 13.2, 13.3, 13.4, 14.1, 14.2, 14.3, 14.4

Reference

1.George B Thomas,Thomas Calculus -Early transcendentals, 12th edition, Addison Wesly

2.B.S.Grewal, Higher Engineering Mathematics,42nd edition, Khanna Publishers

3. Brown and Churchill, Complex Variables and Applications, McGraw Hill,Higher Education Edition, 2008

COMPLEMENTARY PHYSICS

SEMESTER III

ICH3CM05 – PHYSICS III - MODERN PHYSICS, ELECTRODYNAMICS AND TRANSDUCERS

Credits: 3 (54 hours)

Module I

Atomic Physics (10 hours) Basic features of Bohr atom model-formula for energy-vector atom model - various quantum numbers - Coupling schemes - LS and JJ coupling - Pauli's exclusion principle - magnetic moment of orbital electrons, Atomic nucleus classification-basic properties of nucleus - charge, mass, spin, magnetic moment binding energy and packing fraction-nuclear forces salient features

Text Books:

1. Modern Physics- R. Murugeshan, Er. Kirthiga Sivaprasad . S Chand

Module II

Radioactivity (8 hours) Radioactivity- properties of alpha, beta and gamma- Soddy Fajan's displacement law, law of radioactive disintegration -decay constant-half life and mean life-radioactive equilibrium measurement of radioactivity- Radio carbon dating

Text Books:

1. Modern Physics- R. Murugeshan, Er. Kirthiga Sivaprasad . S Chand

Module III

Electrodynamics (18 hrs) Gauss' Law - electrostatic potential - Poisson's equation and Laplace's equation - Work and Energy in electrostatics. Biot-Savart law - divergence and curl of E and B - Ampere's law - Magnetic vector potential - work done to move a charge - Lorentz Force - continuity equation - Poynting's Theorem.

Electromotive force - motional emf - Faraday's law - electric displacement current - Maxwell's equations in free space and matter - Wave equations for E and B – Plane waves - Monochromatic plane waves in vacuum -– Energy and Momentum in EM waves -Propagation through linear media – Reflection and Transmission at normal Incidence - Modified wave equation in conductors - Electromagnetic waves in conductors.

Text Books:

1. An Introduction to Electrodynamics, D J Griffith, 3rd Edn., PHI.

2. Electricity and Magnetism – J. H. Fewkes & John Yarwood - University tutorial Press.

3. Fundamentals of Magnetism and Electricity D N Vasudeva - S chand. 4. Electricity

and Magnetism A S Mahajan and A A Rangwala –TMH.

5. Electromagnetic Fields and Waves, K D Prasad- Satya Prakashan.

References

1. Functional Electronics, Ramanan (Tata McGraw-Hill)

2. Electricity and magnetism - Brijlal and N. Subrahmanyam (S. Chand and Co.)

Module IV

Transducers (18 hours) Classification of transducers - electrical transducer - resistive transducer - strain gauges - piezo - electric and magnetostrictive transducers - Hall effect transducers - thermistor inductive transducer - photoelectric transducers - photo voltaic cell – semiconductor photo diode – Solar cells - thermo electric transducers– mechanical transducers – ionization transducers – digital transducers - electro chemical transducers – Actuators

Text Books:

1. Transducers and instrumentation, D.V.S. Murty, PHI(1995)
2. Electronic Instrumentation, H.S. Kalsi, TMH(1995)
3. Electronic Instrumentation, H.S. Kalsi, TMH (1995)
4. Modern electronic Instrumentation and Measurement Techniques, A.D. Helfric & W.D. Cooper,PHI, (1997)
5. Instrumentation-Devices and Systems 2nd Edn. C.S. Rangan, G.R. Sarma, V.S.V. Mani, TMH, (1998)

SEMESTER IV

ICH4CM05– PHYSICS IV - OPTICS, DIELECTRICS AND SPECTROSCOPIC INSTRUMENTATION

Credits: 3 (54 hours)

Module I

Interference and Diffraction (20 hours) Light waves- phase difference and coherence, optical path and phase change, principle of superposition, Analytical treatment of interference-young's double slit experiment, conditions for interference, bandwidth - Interference in thin films-reflected system-colour of thin films fringes of equal inclination and equal thickness. Newton's rings-reflected system - measurement of wavelength.

Propagation of light- Fraunhofer diffraction. Theory of Plane transmission grating, determination of wavelength - dispersive power of grating. Prism and grating spectra, resolving power, Rayleigh criterion, resolving power of grating.

Module II

Polarization, Laser and Fiber Optics (15 hours) Polarization, types of polarization, Brewster's law, dichroism, birefringence – e-ray and o-ray, polarizer and analyser, Malu's law, optical activity.

Principle of operation of laser-population inversion, metastable states, optical resonator components of laser- active medium, pump, optical resonant cavity- principal pumping schemes- three level and four level- laser beam characteristics, applications of laser, Ruby laser and He-Ne laser.

Light propagation in optical fibers, acceptance angle, numerical aperture-step index fiber graded index fiber.

Module III

Dielectrics (7 hours) Dielectrics- polar and non-polar dielectrics- polarization- sources of polarization-Gauss's law in dielectrics- permittivity- dielectric displacement vector- dielectric constant, susceptibility ferro-electricity.

Module IV

Spectroscopic Instrumentation (12 hours)

X - Ray Diffraction, UV – Visible spectroscopy, Fourier Transform Infrared Spectroscopy and Raman Spectroscopy.

References:

1. Optics - Brijlal and N. Subrahmanyam - S Chand-2015
2. Electricity and Magnetism , D C Tayal
3. A text book of Applied Physics – A .K Jha
4. Electricity and Magnetism – R. Murugeshan (S Chand & Co.)

5. Lasers – theory & applications- Thyagarajan & Ghatak
6. Instrumental methods of analysis – Willard, Merritt, Dean, Settle – CBS
7. Principles of Instrumental Analysis - Holler,Skoog,Crouch-CENGAGE

ICH3CMP07,ICH4CMP07- COMPLEMENTARY PHYSICS PRACTICAL - II

(A minimum of 12 experiments has to be done)

Credits: 2 (72 hours)

1. Asymmetric Compound Pendulum- Determination of moment of inertia and Acceleration due to gravity (g)
2. Torsion pendulum (Equal mass method) - Rigidity modulus and Moment of Inertia
3. Spectrometer – Cauchy's constants
4. Characteristics of Zener diode- ac and dc resistance
5. Characteristics of LED – V- I characteristic for different colors
6. Potentiometer-Calibration of low range ammeter **OR** voltmeter
7. Construction of full wave rectifier (center-tap **OR** bridge) with and without filter – Ripple factor
8. Construction of regulated power supply using Zener diode- line and load regulation
9. Laser diffraction- width of single slit **OR** thickness of wire
10. Static Torsion - Rigidity modulus
11. Deflection and Vibration Magnetometer-m & Bh
12. Searle's Vibration Magnetometer - magnetic moment
13. Gates – AND, OR, NOT- verification of truth tables
14. Liquid lens - Refractive Index of glass using a liquid of known refractive

index 15. Characteristics of solar cell / photodiode – V- I characteristics

16. Determination of Dielectric constant of a thin sheet/ a liquid
17. Thermal conductivity of bad conductor – Lee's disc
18. Thermal conductivity of rubber.
19. Thermistor: Resistance - Temperature characteristics and temperature co- efficient of resistance.
20. Analysis of XRD pattern of samples. (cubic, tetragonal)
21. Analysis of FTIR of samples (organic and inorganic samples)

References

1. Practical Physics – C L Arora- S Chand
2. Properties of Matter -D.S. Mathur
3. Optics –Subrahmanyam & Brijlal
4. Electricity &Magnetism - Sreevastava
5. Electronics Lab Manual (Vol.1) - K. A. Navas
6. Laboratory manual for electronic devices and circuits-David A Bell
7. Practical Physics- Joseph Ittiavirah, Premnath and Abraham