M.Sc. IV-SEMESTER

Semester No.	Category	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of SEE (Hrs)
			IA	SEE	Total	L	T	P		
FOURTH	HCT41	Natural Products	20	80	100	4	-	-	4	3
	HCT42	Spectroscopy and Chromatography	20	80	100	4	-	-	4	3
	HCT43	Advanced Concepts in Physical Chemistry	20	80	100	4	-	-	4	3
	SCT41	Selected Topics in Inorganic Chemistry	20	80	100	4	-	-	4	3
	SCT42	Inorganic industrial materials	20	80	100	4	-	-	4	3
	SCT43	Energy and Industrial Inorganic Chemistry	20	80	100	4	-	-	4	3
	HCP41	Spectral data interpretation	10	40	50	-	-	4	2	4
	HCRP42	Research project/Internship	20	80	100	-	-	8	4	4
Total Marks for IV Semester					**550**				**22**	

M.SC. CHEMISTRY FOURTH SEMESTER

Course Title: NATURAL PRODUCTS	**Course Code: HCT41**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand the properties and composition of natural products
2.	To gain knowledge and importance of natural products.
3	To acquire knowledge on properties of natural products

Unit	Description	Hours
01	**CHEMISTRY OF NATURAL PRODUCTS-I:** **Carbohydrates:** Classification of carbohydrates, D,L-notations, configuration and conformations of carbohydrates. redox reactions of monosaccharides, osazone formation, chain elongation (Kiliani-Fischer synthesis), chain shortening (Ruff degradation), cyclic structure of monosaccharides (hemiacetal formartion), stability of glucose, acylation and alkylation of monosaccharides, formation of glycosides, anomeric effect, reducing and non-reducing sugars. Disaccharides- structural elucidation of sucrose, cellobiose, maltose and lactose, Polysaccharides- structural elucidation of cellulose, starch (amylose and amylopectin) and glycogen.	15hrs
02	**Amino acids and Proteins: Amino acids:** Classification and nomenclature of amino acids, general properties and reactions of amino acids, configuration of amino acids. General methods of synthesis of amino acids – Amination of α-haloacids, Gabriel's phthalimide synthesis, Strecker synthesis, Malonic ester synthesis, Darapsky synthesis, Azlactone synthesis. **Proteins:** Structure and nomenclature of peptides and proteins, automated solid phase peptide synthesis (Bruce-Merrifield synthesis), cleavage of disulphide linkages, determination of amino acid composition, sequencing the peptide from N-terminus (Edman degradation) and C-terminus, determination of structure of proteins (primary, secondary and tertiary structures). **Nucleic acids:** Classification of nucleic acids, structure of nucleosides and nucleosides containing pyrimidine and purine bases, sequence of nucleic	15hrs

	acids, Crick-Watson model of DNA, structure of RNA (m-RNA, t-RNA and r-RNA), genetic code – salient features.	
03	**Chemistry of natural products – II** **Alkaloids**: Introduction, occurrence, nomenclature, classification, isolation, properties determination of molecular structure. Synthesis and structural elucidation of Papaverine and Reserpine. Synthesis of ephedrine, hygrine, nicotine and nicotinic acid. **Terpenoids:** Introduction, occurrence, classification, isolation, general characteristics, isoprene rule. Synthesis and structural elucidation of Citral and α-Pinene. **Vitamins:** Classification, nomenclature, biological functions, isolation, structure, biological importance and co-enzymes of Vitamin-B_1, B_2, B_3, B_6, B_{12}, Folic acid (Folate), Vitamin-A., A_1, A_2, Vitamin-E, Vitamin-C, Nicotinic acid and Nicotinamide.	15hrs
04	**Lipids:** Introduction, simple lipids (fats, oils, waxes), compound lipids, phospholipids (Lecithins, Cephalins, Plasmalogens, Sphingomyelins), glycolipids, galactolipids. **Steroids:** Introduction, Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon, Sterols – Cholesterol, Lanosterol, Ergosterol, Stigmasterol (elementary account). Structural analysis of Cholesterol (structure of nucleus, position of double bond and hydroxyl group, nature and position of side chain, position of angular methyl group). Stereochemistry and structural elucidation of Androsterone, Testosterone, Estrone, Progestrone, Aldosterone.	15hrs

References:

1. **Organic Chemistry,** Solomons, Fryhle, 8th Edition (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India 2004.
2. **Organic Chemistry**, G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.
3. **Organic Chemistry,** R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
4. **Organic Chemistry**, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2004.
5. **Organic Chemistry**, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.
6. **Organic Chemistry**, M. Jones, Jr., 2nd Edition, W.W. Norton and Company, New York, 2000.
7. **Organic Chemistry,** Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
8. **Organic Chemistry,** I.L. Finar, 5th Edition (Volume-2), Pearson Education, New Delhi,

India, 2009.
9. O**rganic Chemistry of Natural products**, Gurudeep R. Chatwal, (Edited by M. Arora), Vol. 2, Himalaya Publishing House, Mumbai, India, 2008.
10. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. I, GOEL Publishing House, Meerut, India, 2003.
11. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. II, GOEL Publishing House, Meerut, India, 2004.
12. Introduction to Alkaloids – G.A. Swan
13. The Alkaloids - K.W. Bently
14. Steroids – L. Fiescher and M. Fischer
15. Steroids – Shoppe
16. Chemistry of Natural Products by Sujata V. Bhat, Bhimsen A. Nagasampagi, Meenakshi Sivakumar
17. Organic Chemistry 2nd Edition, Nick Greeves), Stuart Warren , Jonathan Clayden

Course outcomes:

1.	Able to comment on natural products
2.	Predict the properties and applications of natural products

Course Title: SPECTROSCOPY AND CHROMATOGRAPHY	**Course Code: HCT42**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand the concept of advanced spectroscopic techniques
2.	To gain knowledge and applications of spectroscopic techniques applied to inorganic chemistry.
3.	To gain theoretical knowledge abt spectroscopic techniques

Unit	Description	Hours
01	**Mossbauer Spectroscopy:** Basic principle, spectral parameters, spectral display. Doppler Effect, Zeeman splitting, isomer shift, Quadrupole splitting, magnetic interaction. Mossbauer spectrometers, components. Applications of Mossbauer techniques to the studies of (i) Bonding and Structure of Fe+2 and Fe+3 compounds (ii) Detection of oxidation states. **NQR Spectroscopy**: Consequence of nuclear spin larger than ½, prolate and oblate nucleus, nuclear Quadra polar charge distribution-theory and instrumentation, relationship between electric field gradients and molecular structure, applications and interaction of eQq data. Effect of crystal lattice on the magnitude of eQq. Structural information from NQR spectra. **Electron Spin Resonance Spectroscopy:** Basic principles, zero field splitting, Kramer's degeneracy, factors affecting g-values. Interpretation of g-values. Isotopic and anisotropic hyperfine coupling constants. Spin Hamiltonian, spin densities and Mc Connel relationship. Measurement techniques. ESR spin – orbit coupling and significance of g tensors application to first row transition metal complexes.	15hrs
02	**Turbidimetry and Nephelometry:** Tyndall, Rayleigh and Raman Scattering,Factors Influencing Turbidity Measurements, Particle size distribution and shape, Effect of temperature, pH, and sample composition Principles, Instrumentation and Turbidity and nephelometry in assessing water quality, Quality control in beverage and pharmaceutical industries, Monitoring suspended solids in industrial processes. **Fluorimetery and Phosphorimetry:** Principles, laws governing; Instrumentation, quantitative analysis, application in real sample analysis (e.g. in environment, biology, medicine, rock, minerals, etc.) Fluorescent	15hrs

	Probes and Labels, Fluorescence Lifetime and Quantum Yield, Quenching and Stern-Volmer Equation, **Chemiluminesescence Methods:** Principle, Apparatus, Quantitative, Chemiluminescence - Gas phase and liquid phase chemiluminescent analysis andtitrations. **Optical Rotator Dispersion and Circular Dichroism**: Rotatory dispersion, instrumentation for ORD and CD, Cotton effect, Anomalous ORD curves, Octant rule, applications of Octant rule, applications of ORD and CD.	
03	**Ultracentrifugation:** Principle, sedimentation constant, sedimentation equilibrium, sedimentation velocity, methodology and applications. **Electrophoresis:** Overview, types, the basic of electrophoretic separations, migration rates and plate heights, electro osmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isolectrophoresis, capillary isoelectric focusing. **Capillary Electrochromatography:** Packed column Electrochromatography, micellar electro kinetic electro chromatography, capillary electro chromatography and applications. **Supercritical fluid chromatography:** Properties of supercritical fluids, instrumentation and operating variables, comparison of supercritical to other types of chromatography, applications. **Supercritical fluid extraction:** Advantages of supercritical fluid extraction, instrumentation, supercritical fluid choice, off-line and on-line extractions, typical application of supercritical fluid extraction.	15hrs
04	**X-ray Absorption Spectroscopy (XAS):** X-ray production and measurement, Principle of XAS, Instrumentation and applications. **X-ray diffraction:** Crystal systems, crystallographic axes and angles, nomenclature and point groups. Space lattice, Reciprocal lattice, Bravis lattice, Unit cell, Weiss indices, Miller indices, Bragg's equation, Single crystal rotation methods, Powder methods analytical procedures for powder diffraction analysis, structure factor. Fourier series, Fourier refinement. Phase problem. **Electron diffraction:** Introduction, Scattering intensity versus scattering angle, Wierl's equation, Radial distribution function, Refinement radial distribution function, Rotation sector method. **Neutron diffraction:** Introduction, Scattering of neutrons by solids and liquids. Difference between neutron and X-ray diffraction. **Photoelectron Spectroscopy**: Basic principles, photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules, chemical information from ESCA, instrumentation and applications. Auger electron spectroscopy principles, instrumentation and applications.	15hrs
References:		

1. Standard Methods of chemical Analysis. A. J. Welcher (part B), Robert E.Kriegor Publishing Co. USA, 1975.
2. Qualitative inorganic analysis by A. I. Vogel.
3. Chemical analysis of terms and nonferrous and foundry materials. Westword and Mayar.
4. Chemical methods of analysis. Snell and Snell.
5. A text book of inorganic analysis. A.I.Vogel.
6. Laboratory manual for Environmental chemistry. SunitaHooda&Sumanjeet Kaur.
7. Analytical Chemistry. Dr. ALKA L. GUPTA apragati edition.
8. Applied Chemistry theory and practice second edition. O. P. Vermani. A. K. Narula.
9. Principles of Photoelectron Spectroscopy" by R.M. Silverstein and G.C. Bassler
10. "Introduction to Surface Chemistry and Catalysis" by Gabor A. Somorjai
11. "Modern Photoelectron Spectroscopy" by J.C. Hance and J.P. Desvergne
12. "Electron Spectroscopy: Theory, Techniques, and Applications" by Petr Carsky and Karel Tsuji
13. "Photoelectron and Auger Spectroscopy" by J. H. D. Eland
14. "Introduction to Modern X-ray Spectrometry" by Ron Jenkins
15. "Introduction to Synchrotron Radiation" by Philip Willmott and Clemens Heske
16. "Electron Spectroscopies Applied to Low-Dimensional Structures" by Claudio L. Bianchi and P. Rudolf
17. "Angle-Resolved Photoemission Spectroscopy on High-Temperature Superconductors: Studies of Bi2212 and Single-Layer FeSe Film Grown on SrTiO3 Substrate" by Takayoshi Yokoya
18. "Handbook of X-ray Photoelectron Spectroscopy" by John F. Moulder, William F. Stickle, and Peter E. Sobol.
19. Fundamentals of Molecular Spectroscopy- CN Banwell& Mc Cash

Course outcomes:

1.	Apply spectroscopic techniques for qualitative and quantitative analysis
2.	Predict the structure and properties
3.	Apply for structural characterization

Course Title: ADVANCED CONCEPTS IN PHYSICAL CHEMISTRY	Course Code: HCT 43
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	Understand the advanced concepts of electrochemistry and photochemistry
2.	Gain knowledge in applied aspects of nanomaterials and polymers
3.	Acquint with the theoretical aspects of spectroscopy

Unit	Description	Hours
01	**Electrochemistry and Photochemistry:** Ion-solvent interaction, Born model, solvation number and their determination, over voltage, Decomposition potential, Butler-Volmer equation, Taffel equation, Factors important in elucidating electrode reaction and some electrochemical systems of technological importance, Electroplating. Electrochemical energy systems: Introduction, fundamentals of batteries, primary and secondary batteries, fuel cells, types of fuel cells, Interaction of radiation with matter, review of laws of photochemistry, Jablonski's diagram, radiative and non-radiative processes. Stern – Volmer equation, photophysical kinetics of uni and bimolecular processes. Photolysis of water. Theories of Fluorescence, Phosphoroscence and Bioluminescence.	
02	**Chemistry of nanomaterials**: General introduction to nanomaterials,synthesis and applications of nanoparticles of gold, silver, rhodium, palladium and platinum,synthesis and applications of metal oxides of transition and non-transition elements-SiO_2, TiO_2, ZnO, Al_2O_3, iron oxides and mixed metal oxide nanomaterials, non-oxide inorganic naomaterials, porous silicon nanomaterials- fabrication and chemical and biological sensing applications. **Characterization of Nanomaterials**: UV-visible, Raman, XRD, SEM, TEM and AFM techniques.	
03	**Molecular Spectroscopy:** Characterization of electromagnetic radiation, quantization of energy levels, rotational spectroscopy, classification of molecules based on their moment of inertia, rotation of rigid diatomic molecules and non rigid diatomic molecules and rotational energy levels. Infrared Spectra: Vibration of diatomic molecule, simple harmonic oscillator model, vibrational energy levels and vibrational spectra, The	

	anharmonic oscillator model, fundamental bands, overtones and hot bands. Vibrational and rotational spectra of diatomic and polyatomic molecules and its applications to CO, CO_2 and H_2O molecules. Overtones and combination frequencies PQR branches, Born-Oppenheimer approximation. Electronic spectra of diatomic molecules, Electron transition in diatomic molecule V` and V`` progressions. Frank-Condon principle, rotational fine structure of electronic vibrations Fortrate diagrams and pre dissociation. Raman Spectroscopy: Introduction, stokes and anti stokes lines, classical and quantum theory of Raman Effect, Raman activity of vibration, rotational and vibrational Raman spectra, mutual exclusion principle, Resonance Raman Spectroscopy.	
04	**Polymer Science and Technology:** Determination of molecular weight by end group analysis and GPC method, determination of chain dimension from light scattering technique. Understanding of thermo mechanical behavior from TMA and DMA techniques.Physical properties v/s applications: plastic, fibers, elastomers, and additives. Swelling of polymers, stress strain behavior, viscoelastic behavior and elastomers. Conduction polymers: synthesis through chemical oxidation understanding of structure and properties of polyaniline, polypyrrole and polythiophene,	

References:

1. Modern aspects of electrochemistry Vol-I & Vol-II- J.O.M.Bockris & A.K.N Reddy
2. Electrochemistry by Glasstone
3. Heterogeneous catalysis- G.C.Bond
4. The basic applications of heterogeneous catalysis- Michael Bowker.
5. Fundamentals of Molecular Spectroscopy- CN Banwell & Mc Cash
6. Introduction to molecular Spectroscopy- G.M.barrow
7. Polymer Chemistry- Billayer
8. Polymer Chemistry- P.J.Flory
9. Physical chemistry of macromolecules by D.D.Deshpande
10. Polymer Science- Gowarikar
11. Physical chemistry- P.W. Atkins
12. Chemical Kinetics- Laidler

Course outcomes:

1.	Skilled with applied aspects of electrochemical systems
2.	Apply the advanced aspects of physical chemistry
3.	Apply theoretical knowledge of spectroscopy and nanomaterials

Course Title: SELECTED TOPICS IN INORGANIC CHEMISTRY	**Course Code: SCT41**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To gain information on biological processes, solid state chemistry, photochemistry.
2.	To understand the advanced concepts of inorganic chemistry
	To understand te biological processes

Unit	Description	Hours
01	**Bioinorganic Chemistry-II** Transport and storage of dioxygen, heme proteins, oxygen uptake, functions of haemoglobin, myoglobin, hemerythrin and hemocyanins, synthetic oxygen carriers. Metal storage and transport: Ferritin, transferrin and ceruloplasmin. Electron transfer proteins: Cytochromes, iron-sulphur proteins. Metalloproteins as enzymes: Carboxy peptidase, carbonic anhydrase, catalases, peroxidases, cytochrome P-450, cytochrome coxidase, superoxide dismutase, copper oxidases and vitamin B12 coenzyme. Biological nitrogen fixation, in vivo and in vitro nitrogen fixation	15hrs
02	**Photo inorganic chemistry:** Photochemical Reactions: Prompt and delayed reactions, quantum yield, laws of photochemistry, recapitulation of fluorescence and phosphorescence, d-d and charge transfer reactions. Excited states of metal complexes, energy transfer under conditions of weak interaction and strong interaction, exciplex formation. Conditions of the excited states to be useful as redox reactants: Photosubstitution, photooxidation, photoreduction and photochemical reactions of transition metal complexes including $[Ru(bipy)_3]^{2+}$ and $[Fe(bipy)_3]^{2+.}$ Application to photovoltaics: Water photolysis and carbon dioxide reduction. Solar energy conversion and storage.	15hrs
03	**Metal Clusters:** Metal π-acceptor complexes: Metal carbonyls, preparative methods, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, magnetic and X-ray evidences of structures, MO representation of bi and tri-nuclear carbonyls, reactions of metal carbonyls. Metal carbonylates and carbonyl halides: Preparation and important reactions. Chemistry of metal nitrosyls: Preparation, structure and bonding, dinitrogen and dioxygen complexes. Metal-metal bonding in	15hrs

	carbonyls and halides, evidences for M-M bonding, factors favouring M-M bond formation. Metal clusters: Bi-, tri-, tetra-, penta- and hexanuclear metal clusters and bonding in metal clusters.	
04	**Solid State Chemistry:** Crystal lattice: Unit Cell, Miller indices and planes, X-ray diffraction method, molecular solids, hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, determination simple structure, spinel and perosvskite structures. Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors. Perfect and imperfect crystals, intrinsic and extrinsic defects, point-, line- and plane- defects. Vacancy, Schottky and Frenkel defects. Schottky and Frenkel defect formation, colour centres, non-stoichiometry.	15hrs

References:

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

Course outcomes:

1.	Apply the advanced topics in various processes
2.	Predict the importance of biological processes and solid state chemistry in different fields.

Course Title: INORGANIC INDUSTRIAL MATERIALS	Course Code: SCT42
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To gain information on various inorganic materials used routinely.
2.	To understand the preparation and properties of these materials
3.	To learn the properties and applications of inorganic systems

Unit	Description	Hours
01	**Refractories and Allied Materials** Ceramics: Classification and general properties of ceramics, basic raw materials, chemical conversions, manufacturing process, white wares and porcelain – manufacturing process. Industrial carbon, Lampblack, carbon black, activated carbon, natural graphite, manufactured graphite and carbon, Industrial diamonds. Refractories: Classification, properties and manufacture of refractories, vitreous – enamel, raw materials, manufacture of enamel glass and application of enamel.	15hrs
02	**Glass and Cement** Glass: Commercial glass, composition of glass, Properties of glass, raw materials and met hods of manufacturing of some special glasses. Portland cement: Types, raw materials, manufacture and process of Portland cement, Setting and hardening of cement, Other cements, gypsum, calcium and magnesium compounds. Chlor-alkali Industries: Manufacture of soda ash, sodium bicarbonate, chlorine and caustic soda, Bleachng powder, calcium and sodium hypochlorites, sodium chlorite	15hrs
03	**Metallurgy of Cu, Fe and Steel** Copper– occurrence, extraction, hydrometallurgy and pyrometallurgical methods, refining of copper-electrolytic, alloys of copper – brass, German silver, bell metal and bronzes. Iron – Raw materials, manufacture of pig iron, cast iron and wrought iron. Steel – manufacture steel by different methods Extraction and refining of zinc and nickel, extraction of Magnesium.	15hrs
04	**Fuels and Petroleum Products** Fuels – essential requirements of fuels, modern concept of fuels, origin, classification and selection of solid, liquid and gaseous fuels. Coal – composition and carbonization of coal, proximate and ultimate analysis of coal – moisture, ash, crude, proteins, calcium, potassium,	15hrs

	sulphur and phosphorus. Analysis of petrol and petroleum products – flash point, fire point, cloud point, pour point, aniline point, viscosity, specific gravity and vapour pressure.Detection and estimation of lead an antiknock compound in gasoline and sulphur in petroleum products.	

References:

1. Industrial Chemistry – B.K. Sharma, Goel publishing House, Meerut, 2010
2. Standard Methods of Chemical Analysis – F.J. Welcher, 6th Edn. Vol.3, Part-B, D. Van Nostrand Company, Inc.,
3.Petrochemical Industries – A.V.C. Hann,
4. Roger's Manual of Industrial Chemistry Furnas, Vol. I & II.
5. Engineering Chemistry – P.C. Jain and M.Jain.
6. Shreve's Chemical Process Industries, George T Austin, 5th Ed., McGraw-Hill,

Course outcomes:

1.	Apply the knowledge in the synthesis and characterization of various routine materials
2.	Predict the properties and improve their characteristics

Course Title: ENERGY AND INDUSTRIAL INORGANIC CHEMISTRY	Course Code: SCT43
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To gain information on various inorganic materials in energy applications.
2.	To understand the properties of these materials and applications
3.	Make an attempt to know the importance of renewable energy systems

Unit	Description	Hours
01	**Renewable energy sources** Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India. Energy from Sun: Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Applications Solar Thermal Energy Collectors: Types of Solar Collectors, Configurations of Certain Practical Solar Thermal Collectors, Material Aspects of Solar Collectors, Concentrating Collectors, Parabolic Dish – Stirling Engine System, Working of Stirling or Brayton Heat Engine, Solar Collector Systems into Building Services, Solar Water Heating Systems, Passive Solar Water Heating Systems, Applications of Solar Water Heating Systems, Active Solar Space Cooling, Solar Air Heating, Solar Dryers, Crop Drying, Space Cooing, Solar Cookers, Solar pond.	15hrs
02	**High energy materials** High efficiency solar cells, PERL Si solar cell, high efficiency solar cells, GaAs solar cells, tandem and multi-junction solar cells, solar PV concentrator cells and systems, III-V, II-VI thin- film solar cells (GaAs, Cu(In,Ga)Se2, CdTe) Nano-, micro- and poly-crystalline Si for solar cells, mono-micro silicon composite structure, crystalline silicon deposition techniques, material and solar cell characterization, advanced solar cell concepts and technologies (Porous Si layer transfer, Metal induced crystallization, etc.). Basic of electrochemical energy devices; mechanism and materials for different types of batteries, supercapacitor and hybrid; fuel cells	15hrs

	(Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells.), electrochemical and photoelectrochemical water splitting. Details of Pb-acid Nickel-metal hydride (Ni-MH), NiCd-alkaline battery, Ni-iron, Li/Na-ion, Mg-ion, Li/Na-S batteries.	
03	**Electrometallurgy** Introduction to Electrometallurgy, Electrochemical principles and basic concepts,Important milestones in the development of electrometallurgy, Conductivity,Electrolytic conduction, Molar conductivity, Transport numbers, Chemical changesin electrolysis, Examples of electrolysis, Electrode reactions, Stoichiometry ofelectrolysis (Faraday's Laws), Technological applications; Leaching,Precipitation, Metal extraction and refining, Electrorefining and Electrowinning ofmetals, Fused salt electrolysis of aluminium and magnesium, Electroplating,Electroforming, Electrochemical polishing, Batteries, Fuel cells.	15hrs
04	**Fertilizer Industries** Production aspects of the following; Phosphate rock, superphosphate, phosphoric acid, phosphates, baking powders, fire retardant chemicals. Potassium chloride, sulphate, bisulphate, hydroxide, carbonate, acid tartarate, permanganate and dichromate.Synthetic ammonia, ammonium nitrate, sulphates, phosphates, urea, nitric acid, cyanamide.	15hrs

References:

1. . Lancaster, M. Green Chemistry: An Introductory Text, Third Edition; RSC Publishing; 2016. ISBN: 978-1-78262-294-9
2. Supramolecular Chemistry: from Molecules to Nanomaterials Eds. by P.A. Gale and J.W. Steed (2012).
3. Modern Supramolecular Chemistry by F. Diederich, P. J. Stang, R. T. Tykwinski (2008). . Page 20 of 21
4. Core Concepts in Supramolecular Chemistry and Nanochemistry by J. W. Steed, D. R. Turner, K. J. Wallace (2007).
5. Supramolecular Chemistry by J.W. Steed and J.L. Atwood (2011).
6. Supramolecular Chemistry: Concepts and Perspectives by J.-M. Lehn, Wiley VCH, Weinheim (1995).
7. Supramolecular Chemistry by V. Balzani (Editor), L. De Cola, Kluwer, Dordrecht (1992).
8. Introduction to Supramolecular Chemistry by H. Dodziuk, Kluwer Academic Publishers, The Netherlands (2002).
9. Supramolecular Assemblies Y. Murakami (Editor), Mita Press, Tokyo, (1990).
10. Advances in Supramolecular Chemistry, Vol 1 (1990), Vol 2 (1992), Vol 3 (1993) by G. W. Gokel (Editor), JAI Press, Greenwich.
11. Supramolecular Chemistry – Fundamentals and Applications. Advanced Textbook by T. Kunitake, K Ariga, Berlin: Springer-Verlag Heidelberg, 2006. 208 p. ISBN 978-3-54001298-6.
12. C. Brechignac, P. Houdy, M. Lahmani, "Nanomaterials and Nanochemistry", Springer publication 2007.
13. Kenneth J. Klabunde, "Nanscale materials in chemistry", Wiley Interscience Publications 2001.
14. C. N. Rao, A. Muller, A. K. Cheetham ,"Nanomaterials chemistry", Wiley-VCH 2007.

Course outcomes:

1.	Apply the knowledge in the s characterization and application to energy sector
2.	Predict the properties and improve their characteristics

Course Title: SPECTRAL DATA INTERPRETATION	**Course code: HCP41**
Total Contact Hours: 60	**Course Credits: 02**
Formative Assessment Marks: 10	**Duration of ESA/Exam: 4h**
Summative Assessment Marks: 40	

Course Objectives:

1.	Practical approach for the interpretation of spectra of organic and inorganic compounds**.**
2.	Train to predict the structure of compounds using spectral data

SL No	List of experiments	Hours
1	a. Preparation and Spectral analysis of few complexes and organic compounds (UV- Visible, IR, TGA). b. Interpretation of Spectral data (UV-Vis, IR, NMR,& Mass)	60

References:

1. Vogel's Qualitative analysis, G Svehla and Sivasankar, Pearson press, 7th Ed 2012
2. Vogel's Textbook of Quantitative Chemical analysis, Mendham, Denney, Barnes, Thomas, Sivasankar, 6th Ed, Pearson publishers, 2009
3. A text book of quantitative inorganic analysis- A.I.Vogel, 3rd edition, 1966.
4. Vogel's text book of quantitative chemical analysis – J.Basset, R.C.Denney, G. H. Jeffere and J. Mendhom, 5th edition, 1989.
5. Vogel's Qualitative Inorganic Analysis, revised, G. Svehla, Longman, 7th Ed, 1996.
6. Practical Inorganic Chemistry, Marr and Rocket, 1972.

Course outcomes:

1.	Able to interpret the spectral data which helps in the structural elucidation of compounds.
2.	It strengthens the spectral analytical knowledge for Research, Industrial and teaching assignments.

Course Title: RESEARCH PROJECT /INTERNSHIP	Course code: HCRP41
Total Contact Hours: 120	Course Credits: 04
Formative Assessment Marks: 20	Duration of ESA/Exam: 4 h
Summative Assessment Marks: 80	

Course Objectives:

1.	Students are exposed to research to motivate them for research career.
2.	Trained for undertaking chemistry project works

SL No	List of experiments	Hours
1	Project work either In-house or Research Institutes as Internship	120

Course Outcomes:

1.	Students gain expertise in research oriented work to develop the research knowledge in the concerned field.
2.	It helps them to work in group as well as develop skills.