BERHAMPUR UNIVERSITY

Course Curriculum & Syllabus: 2023-24

(M. Sc. Chemistry)

P. G. Department of Chemistry
BERHAMPUR UNIVERSITY
Bhanja Bihar
Berhampur-760007, Odisha

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(P. G. Department of Chemistry)

About the department: P. G. Department of Chemistry Berhampur University was established in 1972. The Department offers a two-year Master's degree course (M. Sc.) in Chemistry. Choice Based Credit System (CBCS) has been introduced from 2015 to keep the Students up-to-date with development of higher education in India and abroad. The Post-Graduate curricula is recently undergone major orientation congruent with the development and trends in the subject to help the students to seek a career in different thrust areas of the subject like Synthetic Organic Chemistry, Organic Synthesis, Natural Product Synthesis, Drug Discovery, Inorganic & Organometallic chemistry, Physical Chemistry, Nano-Chemistry and Environmental Chemistry etc. In order to gain competency in research, IV-semester Student has to take up research project in different areas of Chemistry. The Department of Chemistry offers Ph. D. degree in the subject. The Ph. D. programs offered broad areas of Chemistry such as Organic Chemistry, Drug discovery & Medicinal chemistry, Inorganic Chemistry, Bio–inorganic Chemistry, Water Treatments, Catalysis and Nanoparticles. By cultivating both strong academic relations between our students and faculty, and successful connection between course and research programmes, students at Berhampur University can succeed at the frontiers of research in chemistry and chemical biology.

Core Research Areas

The faculty members of the department work on all contemporary topics in chemistry, ranging from Synthetic organic chemistry, Drug Design, Medicinal chemistry, Chemical Biology, Materials Chemistry, Surface and Interface Science, Nanochemistry, Molecular Spectroscopy, Organometallic chemistry, and environmental chemistry.

Programme Outcome

Berhampur University has consistently maintained its position among the top chemistry departments in world rankings over the past decade. The department focuses on top-quality research in specific current areas such as Synthetic Organic chemistry, chemical biology of drugs, and Nanochemistry with a particular aim on disease control and cure. To make the department a flourishing center of excellence in teaching, curriculum development, cutting-edge research and popularizing Chemistry in society, attempts are being made to make international collaborations for students and faculty mobility and research cooperation. The department would like to attain worldwide recognition in Chemistry research and teaching. Additionally, the department also strives to contribute to industry and address problems of societal importance. The department also aims at Chemistry outreach in the form of books, online courses, and other chemistry education activities that showcase the role of "Chemistry as a central science." **The department aims to produce high-quality M. Sc. and Ph. D. students with application-oriented skills in industry and academia.**

Faculty members:

Dr. Satyanarayan Sahoo Ph. D: IIT-Madras	Asst. Professor (III)	Inorganic Chemistry
Dr. Ganngam Phaomei Ph. D: Manipur University	Asst. Professor (III)	Physical Chemistry
Dr. Laxmidhar Rout Ph. D: IIT-Guwahati, Postdoc: USA, Germany, France	UGC-Asst. Professor	Synthetic Organic Chemistry
Dr. Bibhuti Bhusan Parida Ph. D: CSIR-IICT, Postdoc: WSU (USA), France	Asst. Professor (II)	Synthetic Organic Chemistry

Facilities: IR, UV, Fluroscence, Polarimeter, Cryocooler, Gouy’s magnetic balance, Fumehood, Laminar fume hood, Rotavapour, centrifuge, Ice- flake machine and other necessary equipments.

Programs offered: M. Sc., Ph. D.

General Course Framework & Structure (M. Sc. Chemistry) 2023-24

SEMESTER- I: Total Credits/Total core/electives (22/05/00); Total marks: 500

Course Number	Coursed Name	Mark		Credit	Exam Time	
		Mid sem	End sem		Mid sem	End sem
CHEM C101	Organic Chemistry-I	20	80	4	1h	3h
CHEM C102	Inorganic Chemistry-I	20	80	4	1h	3h
CHEM C103	Physical Chemistry-I	20	80	4	1h	3h
CHEM C104	Molecular Spectroscopy	20	80	4	1h	3h
CHEM P105	Physical Practical	100		6	6h	

SEMESTER-II: Total Credits/Total core/electives (22/05/00); Total marks: 500

Course Number	Coursed Name	Mark		Credit	Exam Time	
		Mid sem	End sem		Mid sem	End sem
CHEM C201	Organic Chemistry-II	20	80	4	1h	3h
CHEM C202	Inorganic Chemistry-II	20	80	4	1h	3h
CHEM C203	Physical Chemistry-II	20	80	4	1h	3h
CHEM C204	Organic Spectroscopy	20	80	4	1h	3h
CHEM P205	Organic Practical	100		6	6h	
CHEM VAC1	Materials Characterization	100		NC	3h	

SEMESTER- III: Total Credits/Total core/electives (22/02/03*); Total marks: 500

Course Number	Coursed Name	Mark		Credit	Exam Time	
		Mid sem	End sem		Mid sem	End sem
CHEM C301	Physical Organic Chemistry	20	80	4	1h	3h
CHEM E302	Advanced Organic Synthesis	20	80	4	1h	3h
CHEM E303	Organometallic Chemistry	20	80	4	1h	3h
CHEM E304	Analytical Chemistry	20	80	4	1h	3h
CHEM E305	Nanochemistry	20	80	4	1h	3h
CHEM CT300	Environmental Chemistry	20	80	4	1h	3h
CHEM P306	Inorganic Practical	100		6	6h	
CHEM VAC2	Chemistry and Society	100		NC	3h	

SEMESTER-IV: Total Credits/Total core/electives (22/02/03); Total marks: 500**

Course Number	Coursed Name	Mark		Credit	Exam Time	
		Mid sem	End sem		Mid sem	End sem
CHEM C401	Physical Chemistry-III	20	80	4	1h	3h
CHEM E402	Bio-organic Chemistry	20	80	4	1h	3h
CHEM E403	Bio-inorganic & Supramolecular Chemistry	20	80	4	1h	3h
CHEM E404	Asymmetric Synthesis	20	80	4	1h	3h
CHEM E405	Polymer Chemistry	20	80	4	1h	3h
CHEM E406	Industrial Chemistry	20	80	4	1h	3h
CHEM E407	Organic Synthesis in medicines	20	80	4	1h	3h
CHEM D408	Dissertation	100		6		
VAC3	Cultural Heritage of South Odisha			NC		

*3rd semester students can opt for two elective courses out of four (CHEM E302, 303, 304 and 305) and one course in other department. Other department students can opt for CHEM CT300.

** 4th semester students can opt for three elective courses from six (CHEM E402, 403, 404, 405, 406, 407).

(CHEM: Chemistry, C: Core, E: Elective; P: Practical (Core paper), VAC: Value Added Course & D: Dissertation (Core paper).

SEMESTER-I

Course No. CHEM C101	Course Name: **Organic Chemistry-I**	
Semester: I	Credits: 4	**Core Course**
Pre-requisites: B.Sc. (Hons.) Organic Chemistry		
Course Outcome: This course gives the basics of organic chemistry with an in-depth understanding of a broad range of basic organic reactions and rearrangements, fundamental prospective such as idea of reaction intermediates, drawing reaction mechanism, name reactions-rearrangement, stereochemistry of products.		

Course details

Unit	**Contents**	Hours/ Semester
1	**Basics in Organic Chemistry** Huckel's rule, Aromaticity: aromatic, non-aromatic and anti-aromaticnature of compounds;Brief idea on pKa of organic molecules;Brief on Regioselective, Stereospecific, Stereoselective and Chemoselective reactions;HSAB principle; NGP, Classical and non-classical carbocations; Bredt's rule; Various Elimination reactions: Pyrolytic elimination,Cope Elimination, Hoffmann Elimination,Chugaev elimination;Various substitutions reactions:Sandmeyer Reaction, Von Richter, Sommelet-hauser, and Smilesrearrangements.	10
2	**Stereochemistry** Configurational and conformational isomerism in acyclic and cyclic compounds, Conformational analysis of cycloalkanes, decalins, Conformations of sugar, *D, L*-notation, *R, S*- notation, *Syn* pentane interaction, Allylic strain (A1,2 and A1,3), *anti*-periplanar, *syn*-periplanar orientation, chirality of molecules with more than one chiral center, threo and erythro isomers, meso compounds, Chirality (centre, axial, planar & helical), Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), Optical purity, specific rotation, enantiomeric excess (ee), diastereomeric ratio, Zimmerman– Traxler model in Aldol reaction, Crams's rule and Felkin-Ahn model.	10
3	**Reactive Intermediates&Fragmentations:** **Carbenes**: Generation, Property and structure of carbene, Carbene Insertion in C=C Bond. carbene Insertion into C-H Bond, Carbene Insertion into O-H Bond and various reactions where carbene involved as intermediate; **Nitrenes**: Generation,Property and structure of Nitrenes, reactions of nitrenes and allied reactions; **Ketenes:** Generation, Property and structure of Ketene, reactions of Ketenes and allied reactions; **Fragmentation:**Eschenmoser Fragmentation, Grob Fragmentationand Wharton Fragmentation.	10
4	**Name Reactions& Rearrangement:** Gattemann-Koch, Reformatsky,Perkin,Houben-Hoeschon, Vilsmeier-Haack, Prins, Pinner, Appel, Mannich, Michael addition,Stork-Enamine,Robinson annulation, Baylis–Hillman, Knoevenagel, Claisencondensation, Stobbe condensation, Clasien-Schmidt, Shapiro, Bamford-Stevens,Hunsdiecker,Wittig, Horner-Wardsworth-Emmons (HWE),Aldol, Nazarov Cyclisation, Benzoin, Kulinkovichcyclopropanation, Mitsunobu, Nef, Chichibabin, Arndt-Eistert, Ritter,Barton-McCombiedeoxygenation, Barton decarboxylation. Baeyer-Villiger,Favorskii,Dienone-Phenol, Pinacol-Pinacolone, Wagner-Merrwein, Benzidine, Benzilic Acid,Overman, Payne,Neber, Beckmann, Hoffmann, Curtius, Schmidt, Loosen, Cope, Claisen, Fries, Stevens, Pummerer, Brook, Stieglitz, Carrol.	15
Total		45

Reference &Textbooks:

1. Organic Chemistry: Clayden, Greeves and Warren, Oxford Univ. Press, 2nd Ed (2012).

2. Modern Organic Reactions: H. O. House, W.A. Benjamin. 2nd Ed.(1972)
3. Principles of Organic Synthesis: R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).

4. Stereochemistry of Organic Compounds, E. L. Eliel, S. H. Wilen, L.N. Mander, John Wiley & Sons, Inc.,New York, NY. (1994).
5. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
6. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part-A and B Springer, 5th Ed (2005)
7. Walsh, P. J., Kozlowski, M. C. Fundamentals of Asymmetric Catalysis, University Science Book, 2009.
8. Ojima, I. Catalysis in Asymmetric Synthesis, Wiley-VCH, 2004.
9. Carreira, E., Kvaermo, L. Classics in Stereoselective Synthesis, Wiley-VCH, 2009.
10. Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh, McMillan,3rd Ed (2009)
11. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
12. Stereochemistry: Conformation and Mechanism, P. S. Kalsi, New Age International Publishers.
13. Name reactions and Reagents in Organic Synthesis 2nd Ed, B. P Munday, M. G. Ellerd and F. G. Favaloro, Wiley

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM C102	Course Name: **Inorganic Chemistry-I**	
Semester: I	Credits: 4	**Core Course**
Pre-requisites: B.Sc. (Hons.) Inorganic Chemistry		
Course Outcome: This course gives an in-depth understanding of a broad range of basics of inorganic chemistry. The student will learn regarding type of bonding nature in the molecule and metal complex. The course will give an overall understanding of bonding theory such as VBT, MOT; Π-acceptor ligands; Rings, Cages and Metal Clusters; Chemistry of main group elements.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Valence bond Theory**: Qualitative discussion on valence bond theory-formation of hydrogen molecule, VSEPR theory, shapes of simple molecules and ions, Hybridization and wave mechanical description for sp, sp^2 and sp^3 hybrid orbitals, qualitative idea about dsp^2,dsp^3 and d^2sp^3 hybrid orbitals, Linnet's double quartet theory and spectra of simple molecules. **Molecular Orbital Theory**: Qualitative discussion on molecular orbital theory, bonding and antibonding orbitals, energy distribution and stability, MO energy level diagrams of simple diatomic and polyatomic molecules, Walsh diagram.	12
2	**Metal Π-Complexes**: Chemistry of metal carbonyls, 18-electron rule, Constitution of metal carbonyls: mononuclear, poly nuclear clusters with terminal and bridge carbon monoxide ligand units, Carbonylate anions, Carbonyl hydrides and Carbonyl halides. Metal nitrosyl and other types of metal nitric oxide complexes, Cyanonitrosyl complexes of metals, Brown ring compounds, dinitrogen complexes.	12
3	**Rings, Cages and Metal Clusters**: Inorganic catenation and hetero catenation; Synthesis, structure and reactivity of borazines, phosphazenes, borides, carbides, silicones, silicates, boron nitride; boranes, carboranes, metallaboranes and metallacarboranes, Isolobal analogs of p-block and d-block clusters; low and high nuclearity carbonyl clusters; compounds with metal-metal multiple bonds.	12
4	**Chemistry of Main Group elements:** General characteristics, Structure and Reactions of simple and industrially important compounds: Hydrides, Oxides and Oxoacids of pnictogens (N, P), chalcogens (S, Se &Te) and halogens, Chemistry of noble gases, Pseudo halogens and Interhalogen compounds, Allotropes of carbon, phosphorous and sulphur, Acid-base concepts and principles (Lewis, Brønsted, HSAB and acid-base catalysis)	12
Total		48

Reference &Textbooks:

1. Advanced Inorganic Chemistry: F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, John Wiley and Sons Press, 3rd Ed. (1995).
2. Inorganic Chemistry-Principles of Structure and Reactivity: J. E. Huheey, E. A. Keiter, R. L. Keiter, Harper-Collins, NY, 4th Ed. (1993).
3. Inorganic Chemistry: G. L. Missler and D. A. Tarr, Prentice Hall, 3rd Ed. (2003).
4. Inorganic Chemistry: D. F. Shriver, and P. W. Atkins, Oxford University, Oxford, 3rd Ed. (1999).
5. Chemistry of the Elements. N. N. Greenwood, and A. Earnshaw, Elsevier, 2nd Ed. (1997).

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM C103	Course Name: **Physical Chemistry-I**	
Semester: I	Credits: 4	**Core Course**
Pre-requisites: B.Sc. (Hons.) Physical Chemistry		
Course Outcome: This course will provide the basic concept of the structure, behaviour of molecule and chemical phenomena at the microscopic level.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Symmetry and group theory:** Symmetry elements and Symmetry operations, Mathematical requirements for a point group, Group, Subgroup and classes, matrix representation for the E, C_n, σ_v, S_n, Matrix representation of point groups (C_{2v}, C_{3v} C_{4v}), Transformation matrices, Irreducible representation, Construction of character table (C_{2v}, C_{3v}, C_{4v},C_{2h}, D_2, D_{2d}), Mulliken symbolism rules for IR_S, Standard reduction, Direct product.	12
2	**Application of group Theory:** Symmetry of Normal modes of Molecules: Infrared and Raman activity for C_{2v} and C_{3v}, Linear combination of atomic orbitals (LCAO) theory: Hybridization scheme for σ and π bonding: D_{4h}, T_d, O_h; projection operator and the ligand group orbitals, Hybrid orbital as linear combination of atomic orbitals, Molecular orbitals theory of coordination compounds: σ and π-bonding in octahedral complexes, Formation of LGOs, Formation of MOs, Construction of MO energy level diagram.	12
3	**Quantum chemistry:** Black Body radiation, photoelectric and Compton effects, wave-matter duality, Postulates of quantum mechanics, Operator: Linear operator and Hermitian operator, set up quantum mechanics operators (Momentum, Hamiltian and Angular momentum operator); Translational motion: Particle in one and three dimensional boxes, Tunnelling; Vibrational motion of a particle; Rotational motion: particle in a ring, sphere, Rigid rotator.	12
4	**Atomic and Molecular structure:** Hydrogen atom and hydrogen like atoms, Shapes of *s, p* and *d*-orbitals.Approximation methods: The variation method, Perturbation method (first order, second order), Application of variation methods and perturbation method to Helium atom, The ground and excited states of Helium, Huckel theory of conjugated systems, Bond order and charge density calculation, Application to ethylene, butadiene, cyclopropenyl radical.	12
Total		48

Reference &Textbooks:

1. K. Veera Reddy, Symmetry and Spectroscopy of Molecules, New Age International, Delhi
2. Mark Ladd, Symmetry and group theory in chemistry, Horwood Publishing Chichester, England.
3. Arthur M. Lesk, Introduction to Symmetry and Group Theory for Chemists, Kluwer Academic Publishers, London.

4. Kieran C Molloy, Group Theory for Chemists: Fundamental Theory and Applications**,** Woodhead Publishing, Oxford.
5. F. A. Cotton, Chemical Applications of Group Theory, Wiley, India.
6. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ. Inc., New Delhi.
7. R.K. Prasad," Quantum Chemistry", New Age International, New Delhi
8. John P. Lowe & Kirk A. Peterson, Quantum Chemistry, Elsevier/Academic Press
9. Peter Atkins & Ronald Friedman, Molecular Quantum Mechanics, , Oxford Press.
10. Michael Mueller, Fundamentals of Quantum Chemistry, Kluwer Academic Publishers New York.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, mock test, assignment, doubt clearing class, Assignments.

Course No. CHEM C104	Course Name: **Physical Spectroscopy**	
Semester: I	Credits: 4	**Core Course**
Pre-requisites: B. Sc. (Hons.) Chemistry		
Course Outcome: This course gives an in-depth understanding of a broad range of basics of molecular spectroscopy. The student will learn about microwave, vibrational, Raman, and photoelectron spectroscopy. In addition student will learn the application of EPR and Mossbauer spectroscopy.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Microwave spectroscopy***:* Classification of molecules, Rigid rotator model, Effect of isotopic substitution on transition frequencies, Non- rigid rotator., Stark effect, Applications. **Atomic spectroscopy:** Electronic configuration, Russell-Saunders terms and coupling schemes, Franck-Condon principle, magnetic effects: spin-orbit coupling and Zeeman splitting,	12
2	**Vibrational Spectroscopy***:* Vibrational energy of diatomic molecules, zero point energy, force constant and bond strength, Morse potential energy diagram, vibrational-rotational spectroscopy, P,Q,R branches, break – down of Oppenheimer approximation, vibration of polyatomic molecules, Selection rules, Normal mode of vibration, Group frequencies, Overtones, Hot bands, Factors affecting the band positions and intensities for IR- region.	12
3	**Raman Spectroscopy***:* Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-rotational Raman spectra, selection rules, Mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS). **Photo electron spectroscopy***:* Basic principles, Photoelectric effect, Ionisation process, Koopmans's thermo photoelectron spectra of simple molecules, ESCA, Chemical information from ESCA, Auger electron spectroscopy.	12
4	**EPR Spectroscopy***:* Electron spin resonance spectroscopy : Basic principles , Zero- field splitting and Kramer's degeneracy, lande splitting factor g-value, Measurement techniques, Application (H, CH_3, AlH_3, Pirazine, benzyl, $(OMe)CH_2$, TEMPO, Cu(II), V(III), Ti (II), Mn(V) radicals). **Mossbauer spectroscopy***:* Basic principles, Spectral parameters and spectral display, Application of the techniques to study the bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spins.	12
Total		48

Reference &Textbooks:

1. Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler

3. Spectroscopic methods in organic chemistry- D.H. Williams and I. Fleming
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Modern Spectroscopy, J.M.Hollas, John Wiley, 4th edition, 2004, Sussex.
6. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F. L. Ho, Wiley Inter science.
7. Physical Methods in Chemistry, R.S.Drago, Sauders College.
8. Introduction to Molecular Spectroscopy, G.M.Barrow, McGraw Hill
9. Electron Paramagnetic resonance of transition ions, A. Abraham and B. Bleaney, Clarendon Press, 1970, Oxford.
10. Introduction to magnetic resonance , A Carringtone and A D McLachalan, Harper & Row
11. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley
12. Molecular Spectrocopy, P.S. Sindhu, Tata McGraw Hill , 1985, New Delhi.
13. Symmetry ans Spectroscopy of Molecules, , K.V. Reddy, New Age International (P) Ltd., Ist edition, 1998, New Delhi

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM P105	Course Name: **Physical Practical**	
Semester: I	Credits: 6	**Core Course**
Pre-requisites: B. Sc. (Hons.) Physical Practical		
Course Outcome: The student will learn practical knowledge of physical and analytical chemistry		

Course Details

Unit	**Contents**	Hours/ Semester
1	Determination of surface excess of alcohols and the critical Micelle Concentration (CMC) of surfactant from the measurement of surface tension. Determination of the Molecular weight of a polymer and Isoelectric point of gelatine by viscosity measurement	20
2	Determination of critical solution temperature (CST) and study of phase diagram of three-component liquid (ternary) system at room temperature. Determination of activation energy from the Kinetic measurement of hydrolysis of ester and determination of rate constant of inversion of sucrose by polarimeter and also verification of the effect of catalyst on the rate constant.	20
3	Determination of dissociation constant of acid and determination of hydrolytic constant (K_h) pH-metrically. Determination of iron content in the given ferrous ammonium sulphate solution by Colorimetry and determination the composition and stability constant of Fe(III) salicylic acid complex colorimetrically by Job‘s method of continuous variation. Determination of Λ_o and K_a of weak electrolyte at a definite temperature by Debye Huckel Onsagar equation, determine the stoichoimetric ratio in the complexometric titration of $HgCl_2$ against potassium iodide conductometrically and Determine the strength of HCL and acetic acid (AcOH) from the mixture of acids by strong alkali (NaOH) conductometrically.	32

4	Determination of total cation concentration in natural water and To estimate the amount of Na^+ ion in a given sample using ionisation resin column. Potentiometric estimation of Mohr salt solution with standard potassium dichromate solution and also determination of formal potential (reduction) of ferric-ferrous system, determination of activity solubility product of silver chloride by emf measurement, potentiometric titration of a weak acid with caustic soda solution and determination of the dissociation constant of the acid using quinhydrone electrode at room temperature.	24
Total		96

Reference &Text books:

1. Experimental Physical Chemistry by R.C. Das and B. Behera
2. Text book of Quantitative Inorganic Analysis by A.I. Vogel, ELBS(1978)
3. Experimental Physical chemistry by J B Yadav, Goel Pub. House,(1981)
4. Senior Practical Physical Chemistry by B. C. Kosla, Simla Printers New Delhi (1987).
5. Experimental Physical Chemistry by Daniel et al., McGraw Hill, New York (1962).
6. Practical Physical Chemistry by A.M James and P. E. Pritchard, Longman‘s Group Ltd (1968)

Assessment and Expectations from Class: Tutorial, Quiz, Endsem-100, attendance, Punctuality, doubt clearing class.

SEMESTER-II

Course No. CHEM C201	Course Name: **Organic Chemistry-II**	
Semester: II	Credits: 4	**Core Course**
Pre-requisites: B Sc. (Hons.) Organic Chemistry and **C101**		
Course Outcome: This course gives an in-depth understanding of a broad range of organic reactions from oxidation-reduction mechanism perspectives. It will give knowledge of interconversion of organic functional groups using different reagents. It gives in-depth knowledge and understanding on organic photochemistry, how the chemical transformations achievable through interaction of substrates with light and/ heat.		

Unit	Contents	Hours/ Semester
1	**Oxidation** Different oxidative processes of common functionalgroups using different reagents. Cr-based oxidation:CrO_3, Jones reagent, Collins reagent, PCC, PDC; DMSO (activated S-based) mediated oxidation: General mechanism of activated S-based oxidation, Swern oxidation,Pfitzner-Moffatt oxidation, Parikh-Doeringoxidation, Korey-Kim oxidation; Kornblum oxidation, Iodine-based oxidation: IBX, Dess-Martin-Periodinane (DMP) oxidation, BAIB-TEMPO, Ru-based Oxidation: RuO_4, TPAP;Sulfoniumylide oxidation; Oppenauer oxidation; MnO_2, Ag_2O-oxidtion; amines (N-Oxidation), *N*-Oxoammonium-mediated Oxidation; Alkene oxidation: mCPBA, (H_2O_2/OH^-), Dioxirane, Jacobsen epoxidation, OsO_4, SharplessAsymmtricEpoxidation (SAE), SharplessAsymmetric Dihydroxylation (SAD)(AD-mix-α and AD-mix-β); Wacker oxidation, Ozonolysis, Hydroboration-Oxidation (BH_3, and selectivity with 9-BBN, t-hexyl, Sia_2BH),Oxymercuration-demecruration,Pb $(OAc)_4$,SeO_2.	15
2	**Reduction** Different reductive processes, Dissolved metal reductions, Birch reduction;Catalyticreductions: hydrogenation using Pd, Ni, Pt, Adam's catalyst,Pearlman catalyst,Lindlar reduction, rosenmund reduction,Wilkinson reduction, Raney Nickel,hydrogenolysis; Hydride reduction: $LiAlH_4$, $LiAlH(Ot\text{-}Bu)_3$, $LiAlH(OEt)_3$, DIBAL, Red-Al,$NaBH_4$,Luche reduction, $NaBH_4/I_2$, $NaCNBH_3$, B_2H_6, $LiEt_3BH$,L-selectride, K-selectride; Wolf-Kishner, Clemmensen, diimide,Staudinger (PPh_3/H_2O), AIBN-Bu_3SnH,Chan reduction, Asmmetric Transfer Hydrogenation (ATH),Asymmetric reduction: CBS, Noyori, Baker-Yeast.	10
3	**Pericyclic Reaction:** Molecular orbital symmetry and overlapping:Symmetry and Frontier molecular orbitals of π-systems (1,3-butadiene, 1,3,5-hexatriene, allyliccation/anion/radicaλ), MO of cyclopropentylcation, anion and radical, MO of cycloheptadienyl (Tropylium) cation, anion and radical. Classification of pericyclic reactions, Conservation of orbital symmetry, Woodward-Hoffmann Correlation diagram, Frontier Molecular Orbital (FMO) theory;Electrocyclic reactions:conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems.Cycloadditions: antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, deMayoReaction, 1,3-dipolar cycloadditions and cheleotropic reactions;Sigmatropic rearrangements; suprafacial and antarafacial shifts of H, sigmatroic shifts involving carbon moieties, 1,3- and 3,3-sgmatopic rearrangements, Various Claisen rearrangement (Johnson, Ireland, Eschenmoser-Claisen,Overman, aromatic), Cope, and Aza-cope, Oxy-cope rearrangements;Ene/group transferand dyotropic reactions.	15
4	**Organic Photochemistry:** Electronic excitation, Jablonski diagram & Fluorescence-Phosphorescence, Photo isomerization of alkene, Photochemistry of vision process, Photo-Oxidation of alkenes,Photochemistry of carbonyl compounds–saturated, cyclic and acylic, β, γ-unsaturated and α, β- unsaturated compounds, Photo-dissociation of ketones- Norrish Type-I & II cleavage, Di-Pi-Methane Rearrangement,Paternò-BüchiReaction, Lumiketone Rearrangement, Photo-Fries Rearrangement, Barton Reaction, Hofmann-Loffler-Freytag (HLF) reaction.	10
Total		50

Reference &Textbooks:

1. Organic Chemistry: Clayden, Greeves and Warren, Oxford Univ. Press, 2nd Ed (2012).
2. Modern Organic Reactions: H. O. House, W.A. Benjamin. 2nd Ed.(1972)
3. Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).
4. Physical Organic Chemistry: Isaacs, N. S. (Prentice Hall, 1996).
5. Stereolectronic Effects in Organic Chemistry: Deslongchamps, P. (Elsevier Science, 1983).
6. Advanced Organic Chemistry, Part A and B: Carey, F. A., Sundberg, R. J. (Springer, 2007).
7. Modern Molecular Photochemistry: Turro, N. J. (University Science Books, 1991).
8. Modern Physical Organic Chemistry: Anslyn, E. V., Dougherty, D. A. (University Science Books, 2005).
9. Woodward, R. B., Hoffmann, R. The Conservation of Orbital Symmetry, Verlag Chemie, 1970.
10. Orbital Symmetry: A Problem Solving Approach: Lehr, R. E., Marchand, A. P. (Academic Press, 1972).
11. Pericyclic Reactions: S. M. Mukherji, Macmillan, India.
12. Name reactions and Reagents in Organic Synthesis: Bradford P Munday, Michael G. Ellerd and Frank G. Favaloro, Jr. (Wiley Interscience, 2nd Ed)
13. Introductory Photochemistry: A. Cox and T. Camp. McGraw-Hill.
14. Fundamentals of Photochemistry: K. K. Rohtagi-Mukherji, Wilcy-Eastern
15. Organic Photochemistry: J. Coxon and B. Halton, Cambridge University Press

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM C202	Course Name: **Inorganic Chemistry-II**	
Semester: II	Credits: 4	**Core Course**
Pre-requisites: B Sc. (Hons.) Inorganic Chemistry and **C102**		
Course Outcome: The student will learn regarding Bonding in Co-ordination Compounds; Spectral and Magnetic Properties of Transition Metal Complexes, Metal-Ligand Equilibria in Solution; Reaction Mechanism of Transition Metal Complexes.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Bonding in Co-ordination Compounds:** Valence bond theory-strength and short comings, Crystal field theory-effect spin types, CFSE, Evidence for crystal stabilization energy in octahedral, tetrahedral, tetragonal, square pyramidal and square planner fields, Applications of Crystal Field Splitting, Jahn-Teller Theorem, Molecular orbital theory (qualitative), MO energy level diagrams, Sigma–pi bonding and their importance in co-ordination compounds	12
2	**Spectral and Magnetic Properties of Transition Metal Complexes:** Spectroscopic ground states, Correlation and Orgel diagrams for transition metal complexes (d^1-d^9 states), Tanabe-Sugano *diagrams,* Charge transfer spectra, Elementary idea about magneto chemistry of metal complexes, Diamagnetism, Para magnetism, Temperature independent paramagnetism, Magnetic susceptibility and its measurement, Paramagnetism applied to metal complexes, Ferromagnetism, Ferrimagnetism and Anti-ferromagnetism.	12
3	**Metal-Ligand Equilibria in Solution:** Stepwise and overall formation constants, Trends in stepwise constants, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Kinetics of octahedral substitution, Factors affecting stability of metal complexes with reference to the nature of metal ion and ligand, Chelate effect and its thermodynamic origin, Determination of binary formation constants by pH-metry and spectrophotometry.	12

4	**Reaction Mechanism of Transition Metal Complexes:** Acid hydrolysis, Factors affecting acid hydrolysis, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Anation reactions, Reactions without metal ligand bond cleavage, Substitution reactions in square planar complexes, Trans effect, Mechanism of one electron reactions, Outer-sphere type reactions, Marcus-Hush theory, Inner sphere type reactions.	12
Total		48

Reference & Textbooks :

1. Advanced Inorganic Chemistry: F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, John Wiley and Sons Press, 3rd Ed. (1995).
2. Inorganic Chemistry-Principles of Structure and Reactivity: J. E. Huheey, E. A. Keiter, R. L. Keiter, Harper-Collins, NY, 4th Ed. (1993).
3. Inorganic Chemistry: G. L. Missler and D. A. Tarr, Prentice Hall, 3rd Ed. (2003).
4. *Inorganic Chemistry:* D. F. Shriver, and P. W. Atkins, Oxford University, Oxford, 3rd Ed. (1999).
5. Mechanisms of Inorganic Reactions: F. Basolo and R. G. Pearson, John Wiley & Sons, 2nd Ed. (1967).
6. Inorganic Electronic Spectroscopy: A. B. P. Lever, Elsevier, 2nd Ed. (1984).
7. Magneto-chemistry: R. L. Carlin, Springer-Verlag, (1986).
8. Elements of Magnetochemistry, R. L. Dutta, A. Syamal, Affiliated East-West Press, 2nd Ed. (2004).

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

<table>
<tr><td>Course No. CHEM C203</td><td colspan="2">Course Name: Physical Chemistry-II</td></tr>
<tr><td>Semester: II</td><td>Credits: 4</td><td>Core Course</td></tr>
<tr><td colspan="3">Pre-requisites: B Sc. (Hons.) Physical Chemistry and C103</td></tr>
<tr><td colspan="3">Course Outcome: This course will provide the knowledge of thermodynamics and its relation to microscopic physical laws. The last part of this course gives the understanding of mechanism of chemical processes.</td></tr>
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Course Details

Unit	**Contents**	Hours/ Semester
1	**Classical thermodynamics:** Brief resume of the concept of internal energy, enthalpy, entropy, free energy, Adiabatic and isothermal processes; laws of thermodynamics: first law, second law, third law; Effect of temperature and pressure on thermodynamics quantities: free energy, entropy, equilibrium constant, The principle of le Chatelier, Partial molar properties, Chemical potential, Determination of partial molar properties by: (1) Direct Method, (ii) Method of intercept; Phase equilibria: Conditions for equilibrium between phases, The phase rule, Systems of one component-water,Thermodynamics of non ideal solution: Concept of fugacity and its determination by (i) Graphical method, (ii) From equation of state (iii) Approximation method.	12
2	**Statistical thermodynamics:** Thermodynamic probability and entropy, Maxwell-Boltzmann statistics, Partition function (translational, vibrational, rotational and electronic) for diatomic molecules, relationship between partition and thermodynamic function (internal energy, enthalpy, entropy and free energy), Calculation of equilibrium constant, Fermi-Dirac statistics, Bose-Einstein statistics, Distribution law and its application to metal.	12
3	**Non-equilibrium thermodynamics:** Thermodynamic criteria for non-equilibrium states, Entropy production: heat flow and chemical reaction; Transformation of the generalized fluxes and forces, Non-equilibrium stationary state, Microscopic reversibility, Onsager's reciprocity relation, Electrokinetic phenomena.	12

4	**Chemical Dynamics:** Collision theory of reaction rate, Activated complex theory, Arrhenius equation, Ionic reaction, Kinetic salt effect, Steady state kinetics, Photochemical reaction (Hydrogen-Bromine and Hydrogen-Chlorine reactions), Oscillatory reactions (Belousov-Zhabotinsky reaction), Homogeneous catalysis, General features of fast reaction, Study of fast reaction by flow method and relaxation method. Dynamics of Unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus theories)	12
Total		48

Reference & Textbooks :

1. Walter J. Moore, Physical Chemistry , Orient Longman, London 1972..
2. Thermodynamics, Gurdeep Raj, Goel Publishing House, Meerut.India
3. P. W. Atkins, Physical Chemistry, Seventh Edition (2002), Oxford University Press, New York.
4. I.N. Levine, Physical Chemistry, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
5. Andrew Maczek, Statistical Thermodynamics, (1998) Oxford University Press Inc., New York
6. K. J. Laidler, Chemical Kinetics, Third Edition (1987), Harper & Row, New York
7. Paul L. Houston, Chemical Kinetics and Reaction Dynamics, Dover Publications, New York.
8. J. Raja Ram and J.C. Kuriacose, Kinetics and Mechanism of Chemical Transformations (1993), MacMillan Indian Ltd., New Delhi.
9. PK. Nag. Basic and applied thermodynamics, Tata McGraw Hill Pub. Co. Ltd., New Delhi.
10. S.R. De Groot and P. Mazur, Non-equilibrium thermodynamics, Dover Publications, Inc. New York
11. Donald A. McQuarrie and John D. Simon, Physical Chemistry A Molecular Approach, USA.
12. Thomas Engel and Philip Reid, Physical Chemistry, Pearson, New York.
13. Andrew Cooksy, Physical Chemistry, Thermodynamics, Statistical Mechanics, & Kinetics, Pearson, New York.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, mock test, assignment, doubt clearing class, Assignments.

Course No. CHEM C204	Course Name: **Organic Spectroscopy**	
Semester: II	Credits: 4	**Core Course**
Pre-requisites**: B. Sc. Organic Chemistry, CHEM C101**		
Course Outcome: The student will learn how to identify and characterize organic molecule through organic spectroscopy. The student should be able to know application of spectroscopy for unknown compoundidentification, structural elucidation by Combined UV, IR, Mass and NMR spectroscopy.		

Course details:

Unit	**Contents**	Hours/ Semester
1	**UV spectroscopy***:* Various electronic transitions (185–800 nm), Jablonski diagram, Beer–Lambert Law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Woodward-Fieser rules (for conjugated dienes and carbonyl compounds) &Fieser-Kuhn rule (for polyenes), UV spectra of aromatic and heterocyclic compounds. **IR spectroscopy**: Theory & principle of IR spectroscopy, Modes of stretching and bending, Fourier Transform Spectrometers, Background spectrum, Survey of important functional groups with examples, Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance, FTIR.	10
2	**Nuclear Magnetic Resonance**: Physical basis of Nuclear Magnetic Resonance spectroscopy, Basic principle, shielding mechanism, Chemical shift and Spin-spin coupling as functions of structure, Karplus curve- variation of coupling constant with dihedral angle, effect of deuteration,Hydroxyl proton exchange and influence of Hydrogen bondingon chemical shift, anisotropy, spin-spin splitting, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), effect on Analysis of high-resolution NMR spectra, FT and pulse-NMR, ^{19}F and ^{31}P NMR, Nuclear Overhauser effect (NOE). **Carbon-13 NMR Spectroscopy:**General considerations, chemical shift, coupling constants. Spin-spin, spin-lattice relaxations, Off resonance decoupling, DEPT, Interpretation of simple ^{13}C-NMR spectra. **2D NMR:** (COSY, INADEQUATE, DEPT, HMQC, HSQC, HMBC, NOESY)	15

3	**Mass spectroscopy**: Principles of Mass Spectrometry, Molecular ion peak, Metastable ions, McLafferty rearrangement, Nitrogen rule. Ion sources (EI, CI, Field Ionization, FAB, Plasma desorption, Field desorption, Laser desorption, MALDI, Thermospray, API, ESI, Atmospheric pressure secondary ion mass spectrometry, inorganic ionization techniques, formation and fragmentation of ions, fragmentation reactions, Mass analyzers, Ion cyclotron resonance and FT-MS.	10
4	**Structure elucidation**: Application of IR, UV-Visible, ^{1}H-NMR, ^{13}C-NMR, Mass spectroscopic techniques for structure elucidation &determination of organic compounds with exhaustive examples.	10
Total		45

Reference & Textbooks:

1. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan (4th Edition, Brookes Cole, 2008).
2. NMR spectroscopy, Basic principles, concepts, and applications in chemistry, Harald Gunther (2nd Ed., Wiley, 2001) (reprint)
3. High Resolution NMR Techniques in Organic Chemistry Timothy Claridge (2nd Ed. Elsevier, 2009)
4. Mass Spectrometry, Principles and applications, Edmond de Hoffmann, Vincent Stroobant (3rd Edition, Wiley, 2007)
5. Spectrometric identification of organic compounds, Robert M. Silverstein, Francis X. Webster, David Kiemle: (7th Edition, Wiley, 2005).
6. Organic Chemistry: Clayden, Greeves and Warren, Oxford Univ. Press, 2nd Ed (2012).
7. Spectroscopy of Organic Compounds, P. S. Kalsi, (8th Ed, New Age Publishers)

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM P205	Course Name: **Organic Practical**	
Semester: I	Credits: 6	**Core Course**
Pre-requisites: CHEM C101, CHEM C201, CHEM C204		
Course Outcome: This is a basic organic chemistry practical course. In this laboratory course, students would be able to use their knowledge of chemical reactivity to plan and execute the preparation of compounds using various C-C and C-hetero bond-forming reactions and various organic transformations from commercially available starting materials. Upon completion of this laboratory course, the students would also get confidence on working independently and characterize the synthesized compounds using various modern techniques.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**R_f determination & Mixture separation by TLC:** 1. Preparation of TLC stains and their application in chromatographic technique. 2. Determination of R_f Value of binary and ternary mixtures and number of component by TLC 3. Separation of organic mixtures (binary/ternary) by column chromatography	22
2	**Oxidation-reduction & nitration method:** 4. Preparation of amide: Synthesis of p-nitroacetanilide from acetanilide. 5. Reduction of ketone: Preparation of benzhydrol from benzophenone using $NaBH_4$ 6. Oxidation of olefin with $KMnO_4$: Preparation of adipic acid from cyclohexene 7. Preparation of pyridinium chlorochromate (PCC) and its use for the oxidation of an suitable alcohol	26

3	8. **Aldol reaction**: Preparation of dibenzylideneacetone 9. **Etherification** of alcohol: Preparation of 2-ethoxynaphthalene 10. **Hydrolysis of ester**: Preparation of salicylic acid from methyl salicylate 11. Preparation of: ethylbenzoate/ Anthranilic acid/Methyl Orange/azo-dye. 12. **Beckmann rearrangement**: Preparation of benzanilide from benzophenone oxime.	26
4	**Isolation/separation:** 13. Isolation of lycopene from tomatoes // carotene from carrots 14. Isolation of piperine from black pepper // casein from milk 15. Separation: mixture of toluene and o-toluidine // benzene and o-toluidine //ether and hydrocarbon //o-cresol and benzoic acid.	22
Total		96

Reference & Textbooks:

1) Quantitative and Qualitative analysis By A. I. Vogel
2) Experiments and Techniques in Organic Chemistry, D.Pasto, C. Johnson, & M.Miller, Prantice Hall.
3) Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
4) Hand Book of Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
5) Vogel's Text Book of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
6) Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
7) A Text Book of Practical Organic Chemistry (Qualitative). Arthur I. Vogel.

Assessment and Expectations from Class: Tutorial, Quiz, Endsem-100, attendance, Punctuality, doubt clearing class.

Course No. CHEM VAC1	Course Name: **Materials Characterization**	
Semester: II		**Value Added Course**
Pre-requisites: **C104, C202, C204**		
Course Outcome: The course aims to give the theory and hands-on-training of the instruments facilities available at Berhampur University. This will help the students to understand the spectroscopic techniques required for characterization of materials synthesized in laboratory.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**UV-visible spectroscopy**: Baseline correction with suitable solvent, blanking the instrument, determination of suitable concentration, quantitative measurement of sample of different concentration. Kinetic measurement of reaction to determine rate constant, spectral measurement of different compounds, data export in different format and plotting in origin.	10
2	**Photoluminescence spectroscopy**: Determination of excitation and emission peak for unknown sample, choosing right filter for correct measurement, using solid sample as well as solution sample, measurement in fluorescence and phosphorescence mode for lanthanide doped sample as well as organic molecules. Life time measurement and calculation of life time in single and double exponential plotting in origin. Data export and plotting in origin. Other tips in PL measurement.	10
3	**X-Ray Diffraction Studies**: Basic principles, Baseline correction, Crystal structure determination, Calculation of crystallite size from XRD data, Insertion of negative hkl indices in XRD graph, calculation of lattice parameters, Data export, plotting in origin and interpretation.	10
4	**Magnetic susceptibility Measurement**: Elementary idea about magnetic properties of metal complexes, Determination of magnetic susceptibility of transition metal complexes, Data export, plotting in origin and interpretation.	10
Total		40

Reference & Textbooks :

1. Modern Spectroscopy, J. M. Hollas, John Wiley, 4th edition, 2004, Sussex.
2. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan: Introduction to Spectroscopy, 4th Edition, Brookes Cole, 2008.
3. Magneto-chemistry: R. L. Carlin, Springer-Verlag, (1986).
4. X-Ray Diffraction Crystallography: Introduction, Examples and Solved Problems: Y. Waseda, E. Matsubara, K. Shinoda, Springer-Verlag Berlin Heidelberg 2011.

SEMESTER-III

Course No. CHEM C301	Course Name: **Physical Organic Chemistry**	
Semester: IV	Credits: 4	**Core Course**
Pre-requisites: **C101, C201**		
Course Outcome: This course gives an in-depth understanding of a broad range of organic reactions from physical organic chemistry perspective. The topics include thermodynamic & kinetic control of organic reactions, Curtin-Hammett Principle, probing the reaction mechanisms by kinetic isotope effects, stereoelectronic effects in conformations, allylic strain and various selected reactions. Also, a detailed study and application of the theories/rules governing various cyclic reactions will be carried.		

Course details:

Unit	**Contents**	Hours/ Semester
1	**Chemical Equilibria and Chemical Reactivity:** Thermodynamic and kinetic control of reactions; Correlation of reactivity with structure, linear free energy relationships, Hammond's postulate, Curtin-Hammett principle, substituent constants and reaction constants.	10
2	**Stereoelectronic Effects in Organic Chemistry:** Role of stereoelectronic effects in the reactivity of acetals, esters, amides and related functional groups; Reactions at sp^3, sp^2, and sp carbons, Cram, Felkin-Ahn, Zimmerman-Traxler, Houk, Cieplak, exterior frontier orbital extension (EFOE) and cation-complexation models as applied to p-facial stereoselectivity.	10
3	**Molecular strains**: Strain thermodynamics, various kinds of strains, ring strains, torsional strain, Allylic strain ($A^{1,2}$ and $A^{1,3}$) and other strains, Taft equation. Baldwin's rule of cyclization. Concept of aromatic, non-aromatic and anti-Aromaticity.	10
4	**Chemical Kinetics and Isotope Effects**: Various types of catalysis and isotope effects, importance in the elucidation of organic reaction mechanisms vide isotope labellings.	10
Total		40

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Reference & Textbooks:

1. Physical Organic Chemistry: Isaacs, N. S. (Prentice Hall, 1996).
2. Stereolectronic Effects in Organic Chemistry: Deslongchamps, P. (Elsevier Science, 1983).
3. Advanced Organic Chemistry, Part A and B: Carey, F. A., Sundberg, R. J. (Springer, 2007).
4. Modern Molecular Photochemistry: Turro, N. J. University Science Books, 1991.
5. Modern Physical Organic Chemistry: Anslyn, E. V., Dougherty, D. A. University Science Books, 2005.
6. The Conservation of Orbital Symmetry: Woodward, R. B., Hoffmann, R. Verlag Chemie, 1970.
7. Orbital Symmetry: A Problem Solving Approach: Lehr, R. E., Marchand, A. P. , Academic Press, 1972.

Course No. CHEM E302	Course Name: **Advanced Organic Synthesis**	
Semester: III	Credits: 4	**Elective Course**
Pre-requisites: **C101, C201, C204**		
Course Outcome: The student will learn about disconnection approach,retrosynthesis, synthetic strategyfor synthesis of heterocycles, total synthesis of natural products, target molecules synthesis. The student can independently plan to design the schemes for the syntheses oftarget molecules and execute the strategy using various reagents to synthesize the target molecules.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Disconnection approach and Retrosynthesis:** Art and science of total synthesis of natural and designed molecules. Introduction to the technical terms: Total Synthesis, Formal Synthesis, Linear synthesis, Convergent synthesis etc. The basis for retrosynthetic analysis and terminologies,Synthons and synthetic equivalents,Strategies for disconnection,disconnection approach, functional group interconversions. One group C-X and two group disconnections in 1,2-, 1,3-, 1,4- & 1,5-bifunctional compounds, Chemoselectivity, reversal of polarity- Umpolong, cyclization reaction, Disconnection approach for amines, alcohols, ethers, sulphides etc. Disconnection approach for carbonyl compounds and regioselectivity. **Protecting Groups:** Principles of protection and deprotection of functional groups, Protection of alcohol (Silyl, THP, benzyl, PMB, MOM etc.), diols (acetal,ketal, carbonates etc.), amine (Boc,Cbz, Fmoc etc.) carbonyl (acetal, ketal etc.), carboxyl (as ester, benzyl ester etc.) and their deprotection with suitable reagents; Selective protection and deprotection of various functional groups.	12
2	**Heterocycles:** Synthesis of saturated heterocycles, synthesis of 3-, 4-, 5- and 6-membered rings (1 or 2 hetero atom). Paal-Knorr synthesis of pyrrole, furan &thiophene. Aromatic heterocycles in organic synthesis. Synthesis of indole, pyrazole, pyridine, quinoline, isoquinoline, imidazoles,diazines. Fischer Indole synthesis, Skraup synthesis, Hantzsch Pyridine synthesis. **Total synthesis:** Synthesis of Hirsutene, Ingenol,Artimisnin, Longifolene,Prostaglandin F2α,Imatinib, Remdesivir. Flavipiravir, Ribavirin, Aspirin, L-DOPA, Salbutamol, Saccharin.	15
3	**Reagents in Organic Synthesis (ROS):**Gilman reagent, LDA, n-BuLi, t-BuLi, NaHMDS, KHDMS, t-BuOK, DCC, Yamaguchhi esterification, TMSI, Dioxirane, Criegee reagent $Pb(OAc)_4$,$NaIO_4$, CH_2N_2, SeO_2, NBS, Bu_3SnH-AIBN, OsO_4. ADmix-α, ADmix-β, Prevost &woodward reagents, Corey-Fuch, Ohira-Bestmann, Seyferth- Gilbert, Simon-Smith, Peterson Olefination, Julia Olefination,Horner Wittig,Wacker oxidation, Petasisreagent (Petasisolefination), Grubbs catalyst& RCM, Phase Transfer Catalyst (PTC), DDQ, Barton decarboxylation, sulphur ylide, azomethineylide,Keck Asymmetric allylation, Evans Oxazolidinone and Evans Aldol, Wenreb amide, Fetizon reagent (Ag_2CO_3/Celite), Vilsmeier-Haack reagent, Kulin-Kovichcyclopropanation reagent, Martin sulfurane, Mitsunobu (PPh_3/DEAD), PPA, Et_2NSF_3(DAST).	13
4	**Asymmetric synthesis**: Definition, Stereospecific, Stereoselective –enanatioselective and diastereoselective. Importance of asymmetric synthesis,enantioselective and diastereoselective transformations Reactions using Chiral Lewis Acids and Brønsted Acids, Asymmetric oxidation reactions (Epoxidations, Dihydroxylations,aminohydroxylations), Asymmetric reduction reactions (CBS, Noyri, Transfer Hydrogenation, Baker's Yeast), Allylations (Keck, Roush, Leighton), EnansAldol reactions, Brief idea on organocatalysis (Prolinecatalizedaldol reaction), Kinetic resolution.	10
Total		50

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Reference & Textbooks:

1) Organic Chemistry: Clayden, Greeves & Warren Oxford Univ. Press, 2^{nd} Ed (2012).
2) Organic Synthesis: The Disconnection Approach. S. Warren, Paul Waytt, Wiley, Second Ed (2008)
3) Classics in Total Synthesis: Targets, Strategies, Methods; K. C. Nicolaou & E. J. Sorensen. Wiley-VHC Publishers
4) Classics in Total Synthesis-II: Targets, Strategies, Methods; K. C. Nicolaou & S. A. Snyder. Wiley-VHC Publishers

5) Logics in Chemical Synthesis: E. J. Corey, E. J. Corey and Xue-Min Cheng, Wiley & Sons
6) Green's Protective groups in Organic Synthesis: Peter G. M. Wuts, Wiley 5th Ed (2014)
7) Heterocyclic Chemistry: J. A. Joule and K. Mills, Wiley, 5th Edition, 2010
8) Advanced Organic Chemistry: F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed. (2005)
9) A Guide Book of Mechanism in Organic Chemistry: Peter Sykes, Longman.6th Ed.(1999)
10) Structure and Mechanism in Organic Chemistry: C. K. Ingold, Cornell University Press, 3rd (1957).
11) Organic Chemistry: R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
12) Designing Organic Synthesis, A programmed introduction to synthon approach: S. Warren, Wiley.
13) Organic Synthesis-Concept, Methods and Starting Materials: J. Fuhrhop and G. Penzillin, VCH, Weinheim, Germany.
14) Some Modern Methods of Organic synthesis: W. Carruthers, Cambridge Univ. Press.
15) Advanced Organic Chemistry: Reactions, Mechanisms and Streucture, J. March, Wiley.
16) Principles of Organic synthesis, R. Norman and J. M. Coxon, Blackie Academic & Professional.
17) Name reactions and Reagents in Organic Synthesis 2nd Ed, Bradford P Munday, Michael G. Ellerd and Frank G. Favaloro, Jr. Wiley Interscience

Course No. CHEM E303	Course Name: **Organometallic Chemistry**	
Semester: III	Credits: 4	**Elective Course**
Pre-requisites: **C102, C202**		
Course Outcome: The student will learn about Main Group Organometallics; Transition Metal Organometallics and Applications of Organometallics to Organic Synthesis and Catalysis.		

Course Details

Unit	Contents	Hours/ Semester
1	**Main Group Organometallics**: Synthesis and reactions of organolithium compounds; Synthesis and reactions of organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Thallium(I) organyls (synthesis of TlCp); Organyls of sodium, synthesis of NaCp; Silicon and tin organyls of coordination number 4.	12
2	**Transition Metal–Carbon σ-Bond:** Metal alkyl complexes: Synthesis, stability and structure; Reactions; Activation of C-H bonds.; transition metal carbene, carbyne, vinylidene and allenylidene complexes: Synthesis; structure and bonding and reactivity	12
3	**Transition Metal-Carbon π-Bond:** (a) Alkene complexes: Synthesis, bonding, reactivity (b) Alkyne complexes: Synthesis, bonding, reactivity (c) Cyclopropenyl cation ($C_3R_3^+$) as a ligand; C_4R_4 as a ligand (R = H, Me, Ph). (d) Cyclopentadienyl complexes: discovery, bonding and roperties of Cp complexes of 3d metals; Substituted metallocenes; Half and bent sandwich complexes (e) Allyl and dienyl complexes: synthesis; structure and reactivity (f) Arene complexes: Bis-arene complexes; Arene half-sandwich complexes; η^2 to η^4 coordinated arenes; η^6-arene-chromium tricarbonyl in organic synthesis; Seven and eight-membered ring ligands	16
4	**Applications to Organic Synthesis and Catalysis;** Stiochiometric reactions for Organometallic catalysts: Dissociation & Substitution, Oxidative addition & carbonylation, Oxygen transfer from Peroxo and Oxo Species, Reductive & Hydride elimination, Insertion reaction, nucleophilic and electrophilic attack on coordinated ligands, Isomerization reaction, Hydrogenation, Hydrosilation and Hydrocynation of unsaturated compounds, Hydroformylation, Wacker (Smidt) Process, Olefin Metathesis, Fischer-Tropsch synthesis, Zeigler-Natta polymerization, Water gas reaction	16
Total		56

Reference & Textbooks:

1. Inorganic Chemistry-Principles of Structure and Reactivity: J. E. Huheey, E. A. Keiter, R. L. Keiter, Harper-Collins, NY, 4th Ed. (1993).
2. Organometallic Chemistry: A Unified Approach R. C. Mehrotra & A. Singh, New Age International, 2nd Ed. (2000).
3. The Organometallic Chemistry of the Transition Metals: R. H. Crabtree, John Wiley 3rd Ed. (2001).
4. Basic Organometallic Chemistry: Concepts, Synthesis and Applications B. D. Gupta & A. J. Elias, Springer Science, 2nd Ed. (2013).
5. Organometallics 1, M. Bochmann, Oxford University Press, New York (1994).
6. Organometallics 2, M. Bochmann, Oxford University Press, New York (1994).

Assessment and Expectations from Class: Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E304	Course Name: **Analytical Chemistry**	
Semester: III	Credits: 4	**Elective Course**
Pre-requisites: B. Sc. Chemistry (Hons.)		
Course Outcome: The student will learn the practical knowledge for Qualitative analysis of mixtures containing not less than six radicals, volumetric estimation of metal including magnetic state determination and preparation of inorganic metal complexes.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Thermal methods of analysis:** Thermo analytical methods: TGA, DTGA and DTA, Instrument, Instrumental and application to physical studies (reaction kinetics and information for the constitution of phase diagram), Analytical applications, Separation of Ca, Sr, and Ba comparison of purity.	10
2	**Electrical methods of analysis:** Voltametry and polarography: Dropping mercury electrode, Ilkovic equation, Current-potential curves, Reversible reactions, The residual current, Current maxima, Analytical applications, Amperometric titration using rotating platinum electrode, Cyclic voltammetry.	10
3	**Atomic absoption spectroscopy:** Atomic Absorption spectroscopy-Principle, difference between atomic absorption spectrophotometry and flame emission spectroscopy, Advantages of Atomic Absorption spectroscopy, Instrumentation, Detection limit and sensitivity. Flame photometry, principle, Instrumentation interference in flame photometry, Application.	10
4	**Chromatography:** Definition and classification of chromatography, Chromatography terminology. Theory of chromatographic migration, thin layer chromatography, Principle and preparation of TLC plate, choice of adsorbent and solvent system, experimental techniques and application of TLC. Ion exchange mechanism of ion exchange, technique of ion exchange and application of ion exchange for separations, Gel permeation chromatography, Electrophoresis, its apparatus and methodology	10
Total		40

Reference & Text books:

1. Instrumental methods of chemical analysis, Gurdeep R. Chatwal and Sham K. Anand, Himalaya Publishing House, New Delhi.
2. Instrumental Methods of Analysis, . H.HWillard, L.L. Merritt , J.A. Dean and F.A. Settle, CBS publishers, new Delhi.
3. Chromatography: Fundamentals and applications of chromatography and related, E. Heftmann, Elsavier, Ansterdam.

4. Atomic Absorption Spectrometry, Bernhard Welz, Michael Sperling, Wiley, New York.
5. Analytical Chemistry, Dhruba Charan, Dash,PHI learning Private limited, New Delhi.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E305	Course Name: **Nanochemistry**	
Semester: III	Credits: 4	**Elective Course**
Pre-requisites: B. Sc. Chemistry and M. Sc. I-II courses		
Course Outcome: This course will give basic concept of nano particles and nanotechnology and its applications.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Introduction to nano scale Science and Technology:** Nanotechnology, Classification of nanostructures, Summary of the electronic properties of atoms and solids: The isolated atom – Bonding between atoms - Giant molecular solids - The free electron model and energy bands - Crystalline solids -Periodicity of crystal lattices - Electronic conduction; Effects of the nanometre length scale - Changes to the system total energy - Changes to the system structure - How nanoscale dimensions affect properties-Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nanosystems	10
2	**Synthesis and Stabilization of Nano particles:** Chemical Reduction; Reactions in Micelles, Emulsions; Photochemical and Radiation Cryochemical Synthesis: Physical Methods; Particles of Various Shapes and Films.	10
3	**Experimental Techniques: Electron Microscopy:** Transmission electron microscopy (TEM), Scanning electron microscopy (SEM): Diffraction Techniques: X-ray diffraction, Neutron diffraction and some miscellaneous Techniques: X-ray fluorescence spectroscopy, UV- visible spectroscopy	10
4	**Applications of Nanoparticle:** Catalytsis on Nano particles, Semiconductors, Sensor, Electronic Devices, Photochemistry and nanophotonics, Application of Carbon Nano tubes, Nanochemistry in Biology and Medicine	10
Total		40

Reference & Text books:

1. Nanomaterials and Nanochemistry, Br‘echignac C., Houdy., and Lahmani M. (Eds.) Springer Berlin Heidelberg New York. 2007.
2. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
3. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
4. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.
5. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
6. Nanoparticle Technology Handbook. M. Hosokawa, K. Nogi, M. Naito and T. Yokoyama (Eds.) First edition 2007. Elsevier
7. Nanotechnology Basic Calculations for Engineers and Scientists. Louis Theodore, John wiley & sons, inc., publication, 2006.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM CT300	Course Name: **Environmental Chemistry**	
Semester: III	Credits: 4	**Elective Course**
Pre-requisites: Basic knowledge of Environment		
Course Outcome: The student will learn the basics of Environment and different types of pollutants in the environment		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Environmental Processes** Environment and its classification, Environmental Impact Assessment and management, Factors influencing environment, Components of Environment; Environmental degradation, Biogeochemical cycles; Hydrological cycle, Gaseous cycles (Oxygen cycle, CO2 cycle, Nitrogen cycle), Sedimentary cycles (Sulfur cycle, Phosphorous cycle)	10
2	**Natural Resources** Introduction, classification of resources; land resources , formation of soil, soil erosion, Water resources, Sources of fresh water, Uses of water, causes for the depletion of water resources ;mineral resources, Forest resources, Deforestation, consequences of deforestation; affords to control deforestation, Renewable and nonrenewable resources, Conventional and nonconventional energy resources	10
3	**Environmental pollution** Introduction, Pollutants, Types of pollutants, Classification of pollution, effects of pollution, Radiation pollution: sources, effect and control of radiation pollution, Thermal pollution: sources, effects and its control, Industrial pollution, Sewage and sewage treatment	10
4	**Air Pollution and its control** Atmosphere; structure and composition of atmosphere, Classification of air pollutants, Consequences of air pollution (Ozone layer depletion, Greenhouse effect, Global climate, Smog, Acid rain) , Control of air pollution, air quality and standards.	10
Total		40

Reference & Text books:

1. Environment and Ecology: Dr. Sunakar Panda
2. Environmental Chemistry: A.K. De
3. Air Pollution: Wark & Werner
4. Environmental Pollution Control in Process Industries: S.P. Mahajan
5. Environmental Chemistry: B.K. Sharma & H.Kaur
6. Introduction to Air Pollution: P.K. Trivedi
7. Environmental Pollution Analysis: By S.M. Khopkar
8. A Text Book of Environmental Pollution: D.D. Tyagi, M. Mehre
9. Environmental Pollution Engineering and Control: C.S. Rao

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM P306	Course Name: **Inorganic Practical**	
Semester: II	Credits: 6	**Core Course**
Pre-requisites: CHEM C102, C202		
Course Outcome: The student will learn the practical knowledge for preparation of inorganic metal complexes, estimate the various ions present in metal complexes, use of EDTA in volumetric analysis and complete analysis of brass, cement and chromo ion ore.		

Course Details

Chapter/ Unit	**Contents**	Hours/ Semester
1	Preparation and characterization of i) Nickel (II) complexes: $[Ni(NH_3)_6]Cl_2$, $[Ni(en)_3]Cl_2.2H_2O$, $[Ni(en)_2]Cl_2.2H_2O$ ii) *cis* and *trans* Cobalt(III) complexes: *trans*-$[CoCl_2(en)_2]Cl$, *cis*-$[CoCl_2(en)_2]Cl$ iii) Bis(acetylacetonato)oxovanadium (IV), $[VO(acac)_2]$ iv) *bis*-chloro-*bis*-triphenyl phosphine nickel (II): $[NiCl_2(PPh_3)_2]$	24
2	i) Analysis of Ni in Tris(ethylenediamine)nickel(II) chloride, $[Ni(H_2NC_2H_4NH_2)_3]Cl_2$ ii) Analysis of Mn in Calcium manganate, $[Ca_2MnO_4]$ iii) Analysis of Fe and $[C_2O_4]^{2-}$ in Potassium trisoxalatoferrate(III) trihydrate, $K_3[Fe(C_2O_4)_3].3H_2O$ iv) Analysis of cu in Copper(I) tetraiodomercury(II), Cu_2HgI_4 v) Analysis of cobalt in Chloropentamminecobalt(III) chloride, $[Co(NH_3)_5Cl]Cl_2$ vi) Analysis of Fe and $[C_2O_4]^{2-}$ in Potassium bis(oxalato)cuprate(II) dihydrate, $K_2[Cu(C_2O_4)_2].2H_2O$	36
3	Volumetric analysis involving EDTA as reagent. i) Determination of Ca^{2+} and Mg^{2+} in Dolomite. ii) Determination of Nickel in Stainless steel.	12
4	Complete analysis of: i) Brass ii) Cement iii) chromo iron ore.	18
Total		90

Reference &Textbooks:

1. Practical inorganic chemistry, G. Pass and H. Sutcliffe, Chapman & Hall, 2nd Ed., 1974.
2. Advanced practical inorganic chemistry, D. M. Adams and J. B. Raynor, John Wiley & Sons, 1967.
3. Experimental inorganic chemistry, R. E. Dodd and P. L. Robinson (Elsevier), 1957.
4. Text book of quantitative inorganic analysis. I. Vogel, 4th Ed. (revised), ELBS publications, 1978.

Assessment and Expectations from Class: Endsem-100, attendance, Punctuality, doubt clearing class.

Course No. CHEM VAC2	Course Name: **Chemistry and Society**	
Semester: III		**Value Added Course**
Pre-requisites: If any		
Course Outcome: The course aims to give the students a brief idea about applications of Chemistry in food, medicine, agriculture as well as in daily life. In addition to theory, students will be given hands-on training on preparation of soap, detergent, sanitizer, etc.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Chemistry in food:** Carbohydrates: Classification, sugar and non-sugar, Glucose, fructose, starch and cellulose. Importance of carbohydrates. Proteins & amino acids: Classification, essential and nonessential amino acids and their importance, Zwitter ion structure, Proteins: classification and function. Lipids: Classification, oils and fats, metabolism of lipids. Vitamins: Classification, Nomenclature and disease caused by the deficiency of vitamins.	10
2	**Chemistry in Medicines:** Development of new drugs, Different types of general drugs, analgesics, antipyretics, antiseptics and antibiotics, broad spectrum antibiotics. Metals in medicines: Metal deficiency and disease, toxic effect of metals.	10
3	**Chemistry in Agriculture:** Fixation of Nitrogen, Fertilizers: classification of fertilizers- nitrogenous, phosphorous and potassium fertilizer. Pesticides: classification- insecticides, fungicides and rodenticides. Detrimental effects of pesticides (DDT, BHC, Parathion).	10
4	**Chemistry in daily life:** General idea on soap, detergents, sanitizers, shampoo, cosmetics and perfumes used in daily life. Advantage and disadvantage of synthetic detergent, Detrimental effects plastics on environment and measures to minimize plastic uses in daily life. Practical (Hands-on-experience): Preparation of soaps, detergents, hand sanitizers and extraction of curcumin from turmeric, Preparation of common medicinal molecule: paracetamol/Aspirin/methyl salicylate.	10
Total		40

Reference & Textbooks:

1. Chemistry in Context: Applying Chemistry to Society, 9th Ed, American Chemical Society, ISBN 9781260222029.
2. Aurand, L. W. and Wood, A. E. (1973). Food Chemistry. The AVI Publishing Co., Connecticut.
3. Belitz, H. D., Grosch, W. and Schieberler, P. (2004). Food Chemistry. Springer, Berlin.
4. DeMan, J. M. (1999). Principles of Food Chemistry. A Chapman and Hall Food Science Book, Aspen Publ., Inc., Gaithersburg, Maryland.
5. Fennama, O. R. (ed). (1996). Food Chemistry. Marcel Dekker, Inc., New York
6. Meyer, L. H. (1976). Food Chemistry. Reinhold Publ. Corporation, New York.
7. Potter, N. M. (1995). Food Science. The AVI Publishing Co., Connecticut.
8. Chemistry and Medicines: An Introductory Text, James R Hanson; RSC.
9. Textbook of Agro-Chemistry by H. P. Hegde, Discovery Publishing Pvt. Ltd (2009).

SEMESTER-IV

Course No. CHEM C401	Course Name: **Physical Chemistry-III**	
Semester: IV	Credits: 4	**Core Course**
Pre-requisites: **C103, C203**		
Course Outcome: This course gives an in-depth understanding of various aspects of Electrochemistry, Surfactants, Micelles. In addition, it also gives various aspects of X-ray diffraction studies		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Electrochemistry-I:** Ion-solvent interactions, Born Model, Ion-ion interactions, Debye-Huckel (ion-cloud) model, Bjerrum Model of ions association, Structure of electrified interfaces,Thermodynamics of electrified interface; Electrocapillarity: Lippmann equations, Over potential, Butler Volmer equation, Tafel plot.	10
2	**Electrochemistry-II:** Electrolytic conductance, transport number and its determination, Kohlrausch's law and application to determine solubility; degree of dissociation; Activity and activity coefficient, Ionic strength, Debye-Huckel limiting law, Debye Huckel-Onsager equation and its verification; Nernst equation: single, standard electrode potential, application of potential measurement; Conductometric and potentiometric titrations.	10
3	**Surface Chemistry:** Adsorption, Freundlich and Langmuir adsorption isotherm, Surface tension, Capillary action, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Gibb's adsorption isotherm, Estimation of surface area (BET equation);Colloidal solution, properties of colloidal; Microemulsion, micelles, Reverse micelles Thermodynamics of micellization, Phase separation and mass action models.	10
4	**Solid state:** Crystal systems and lattices, Miller planes, Schottky defect, Frenkel defect, Color centre; line defect: Edge dislocation, screw dislocation, Extended defect: Stacking faults, subgrain boundaries and antiphase domains; Bragg's Law, Band theory.	10
Total		40

Reference & Text books:

1. J.O'M. Bockris and A.K.N. Reddy, Modern Electrochemistry, Vol. 1 & 2A and 2 B, (1998) Plenum Press, New York.
2. Y. Moroi, Micelles : Theoretical and Applied Aspects, (1992) Plenum Press, New York.
3. F.W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
4. A.R. West, Solid State Chemistry and its Applications, (1984) John Wiley & Sons, Singapore.
5. S. Glasstone. An introduction to electrochemistry, Macmillan.
6. Richard M. Pashley and Marilyn E. Karaman, Applied Colloid And Surface Chemistry, John wiley and sons, England
7. Hans-Jürgen Butt, Karlheinz Graf, Michael Kappl, Physics and Chemistry of Interfaces, Wiley VCH, Weinheim.
8. Walter J. Moore, Physical Chemistry , Orient Longman, London 1972..
9. Gordon M Barrow, Physical Chemistry, Tata Mcgraw-Hill, New Delhi.,

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E402	Course Name: **Bio-organic Chemistry**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: **C101, C201, C301, E302**		
Course Outcome: The student will learn about the real chemistry of life that involve carbohydrates, aminoacids, nuclei acids and proteins. They will understand the mechanism going on in biological life (DNA, RNA, NADH).		

Course Details

Unit	Contents	Hours/ Semester
1	**Chemistry of Carbohydrates and Lipids:** Sugar monomers & their configurations, Structure of polysaccharides: starch and glycogen, Structure and biological functions of glucoaminoglycans, Carbohydrate metabolism: Photosynthesis, Kreb's cycle, Glycogenolysis. Characterization and degradation of Fatty acids, Oils.	10
2	**Chemistry of Amino acids and Proteins:** Amino acids, Peptides and Proteins, Chemical and enzymatic hydrolysis of proteins to peptides, Amino acid sequencencing,Primary structure proteins, Secondary structure proteins: α-helix, βsheet, super secondary structure, triplex helix structure of collagen. Tertiary structure of proteins ,folding and domain structure. Quaternary structure, Amino acid metabolism: degradation and bio synthesis of Proline, valine and isoleucine.	10
3	**Chemistry of Nucleic acids:** Purine and pyramidines bases of nucleic acids, Pairing via hydrogen bonding, Structure of ribo nucleic acid (R.N.A) and de-oxyribo nucleic acid (D.N.A), Double helix model of DNA, Chemical and enzymatic hydrolysis of nucleic acid, The chemical basis of heredity, An overview of replication of DNA, Transcription, Translation and Genetic code.	10
4	**Mechanisms in Biological Chemistry:** Nature's oxidizing agent (NAD^+), Nature's reducing agent (NADH), ATP, ADP, Phosphoenolpyruvate, Mechanism of glycolysis and citric acid cycle, amino acid ammonia lyases, Synthesis of Haemoglobin and its function, DNA synthesis.	10
Total		40

Reference & Textbooks :

1. Principle of Biochemistry (Lehninger): D. L. Nelson and M. M. Cox, W. H. Freeman and company, New York.
2. Fundamentals of Biochemistry: D. Voet, J. G. Voet and C. W. Pratt; John wiley and sons.
3. Bioinorganic Chemistry: Bertini, Gray, Lippard, Valentine, Viva Books Private Limited.
4. Outlines of Biochemistry: Eric Conn, Paul Stumpf, George Bruening & Roy H. Doi, John Wiley & Sons
5. Organic Chemistry: Clayden, Greeves and Warren, Oxford Univ. Press, 2nd Ed (2012).
6. Advanced Organic Chemistry: F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
7. A Guide Book of Mechanism in Organic Chemistry: Peter Sykes, Longman.6th Ed.(1999)
8. Structure and Mechanism in Organic Chemistry: C. K. Ingold, Cornell University Press, 3rd (1957).
9. Organic Chemistry: R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E403	Course Name: **Bio-inorganic & Supramolecular chemistry**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: **C102, C202**		
Course Outcome: The student will learn about Bioinorganic Chemistry of Alkali and Alkaline Earth Metals**,** Metalloproteins**,** Metalloenzymes; Supra molecular Chemistry		

Course Details

Chapter/ Unit	**Contents**	Hours/ Semester
1	**Bioinorganic Chemistry of Alkali and Alkaline Earth Metals**: Essential and trace elements in biological systems, structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump; ionophores: valinomycin and crown ether complexes of Na^+ and K^+; photosynthesis: chlorophyll a, PS I and PS II; role of calcium in muscle contraction, blood clotting mechanism.	12
2	**Metalloproteins:** Heme proteins and oxygen uptake, Structure and functions of haemoglobin, myoglobin, hemocyanin and hemerythrin, Iron-sulphur proteins: rubredoxin and ferredoxins, Nitrogenase, Bio-inorganic aspects of nitrogen fixation.	12
3	**Metalloenzymes:** Zinc enzymes – carboxypeptidase and carbonic anhydrase, Iron Enzymes – catalase, peroxidase and cytochrome p-450, Copper enzymes – superoxide dismutase, Mg enzymes – vitamin B_{12}.	12
4	**Supra molecular Chemistry:** A) Molecular recognition: Spherical recognition, Recognition of anionic Substrate, Tetrahedral recognition, Co receptor molecules and multiple recognition, Binding and recognition of neutral molecules. B) Supra molecular reactivity and catalysis. C) Molecular assembly in supra molecular chemistry. D) Supra molecular devices: Suitable binding, photochemical and electrochemical sensor wires.	12
Total		48

Reference & Textbooks :

1. Lehninger Principle of Biochemistry D. L. Nelson and M. M. Cox, W. H. Freeman, 6th Ed. (2012).
2. Fundamentals of Biochemistry, Life at the Molecular Level: D. Voet, J. G. Voet and C. W. Pratt, wiley, 5th Ed. (2016).
3. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, University Science Books, US (1994).
4. Supramolecular Chemistry: Concepts and Perspectives, J. M. Lehn, Wiley VCH (1995).

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E404	Course Name: **Asymmetric Synthesis**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: **C101, C201, E302**		
Course Outcome: This is an advanced level course where students would learn asymmetric construction of C-C and C-hetero bond-forming reactions. Various aspects of asymmetric synthesis such as basic principle of enantioselective reactions, dynamic kinetic asymmetric transformations (DYKAT), synthesis of enantioenriched organic compounds via resolutions (kinetic, parallel kinetic, and dynamic kinetic resolutions), and various diastereoselective processes would be taught is this course. A study of asymmetric synthesis is illustrated to achieve enantiopure compounds.		

Course Details

Unit	**Contents**	Hours/ Semester
1	Basic principles of Asymmetric synthesis–Definition, Stereospecific, Stereoselective – enanatioselective and diastereoselective. Importance of asymmetric synthesis, conditions for an efficient asymmetric synthesis, energetic considerations, Concepts and principles of enantioselective and diastereoselective transformations (including Curtin-Hammet principle, 1,2-induction and 1,3-induction models. Reactions using Chiral Lewis Acids and Brønsted Acids	10
2	Asymmetric C-C bond forming reactions (Asymmetric alkylations, Asymmetric additions to C=O, C=N, C=C bonds) Asymmetric oxidation reactions (alcohol oxidation, Dihydroxylations, epoxidations, chiral sulfoxides, aminohydroxylations etc.)	10
3	Hydrogenation and Asymmetric reductions of C=C, C=O and C=N bonds. Resolutions (Kinetic, Parallel Kinetic, Dynamic Kinetic resolutions) Non-linear effects and autocatalysis.	10
4	Desymmetrization reactions, Introduction to Organocatalysis (Covalent and non-covalent catalysis), Proline based organocatalytic reactions: Aldol, nitroaldol, Mannich, Michael addition reactions and other conjugate additions, Henry reaction etc. Enzyme catalyzed reactions: aldol, nitroaldol, epoxidation, sulfoxidation, Baeyer-Villiger oxidation, Ketone reduction.	10
Total		40

Reference & References:

1. Walsh, P. J., Kozlowski, M. C. Fundamentals of Asymmetric Catalysis, University Science Book, **2009**.
2. Ojima, I. Catalysis in Asymmetric Synthesis, Wiley-VCH, **2004**.
3. Carreira, E., Kvaermo, L. Classics in Stereoselective Synthesis, Wiley-VCH, **2009**.
4. Berkessel, A., Groger, H. Asymmetric Organocatalysis: From Biomimetic Concepts to Applications in Asymmetric Synthesis, Wiley-VCH, **2005**.
5. Hassner, A. Advances in Asymmetric Synthesis**,** Vol 3, Elsevier, **1999**.
6. Smith, M. B. Organic Synthesis, 2nd edition, McGraw Hill, New Delhi, 2004.
7. Ojima, I. Catalytic Asymmetric Synthesis, 3rd ed., Wiley, New Jersey, 2010.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class

Course No. CHEM E405	Course Name: **Polymer Chemistry**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: Basic Organic & Physical chemistry		
Course Outcome: The student will learn about Structure and Properties, Basics of Polymer; Polymer Characterization; Structure and Properties		

Course Details

Chapter/ Unit	**Contents**	Hours/ Semester
1	**Basics of Polymer:** Importance of polymers, Basic concepts: Monomer, repeat units, degree of polymerization, Linear, branched and network polymers, Classification of polymers, Polymerization: Condensation, addition, radical and coordination polymerization, Polymerization conditions and polymer reactions, Polymerization in homogenous and heterogeneous systems.	12
2	**Polymer Characterization:** Polydispersion-average molecular concept, Number, weight and viscocity average molecular weights, Polydispersity and molecular weight distribution, Practical significance of molecular weight, Measurement of molecular weights, End group, viscosity, Light scattering, osmotic and ultracentrifugation methods, Analysis and testing of polymers, chemical analysis of polymers, Spectroscopic methods, X-ray diffraction study, Microscopy, Thermal analysis and physical testing-tensile strength, Fatigue impact, Tear resistance, Hardness and abrasion resistance.	12
3	**Structure and Properties:** Morphology and order in crystalline polymers-centrifugation of polymer chains, Crystal structure of polymers, Morphology of crystalline polymers, strain induced morphology, crystallization and melting, Polymer structure and physical properties-crystalline melting point, melting points of homogenous series, effect of chain flexibility and other steric factors, entropy and heat of fusion, Glass transition temperature, Tg, Relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking, Property requirements and polymer utilization	12
4	**Properties of Commercial Polymers:** Polyethylene, poly vinyl chloride, polyamides, phenolic resins, epoxy resins and silicone polymers, Functional polymers- Fire retarding polymers and electrically conducting polymers, Biomedical polymers –contact lens, dental polymers, artificial heart, kidney, skin and blood cells.	12
Total		48

Reference & Textbooks:

1. Textbook of Polymer Science: F. W. Billmeyer Jr, Wiley
2. Polymer Science: V. R. Gowariker, N. V. Biswanathan and J. Sreedhar, Wiley, Eastern.
3. Physics and Chemistry of Polymers: J. M. G. Cowie, Blackie Academic and Professional.

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments

Course No. CHEM E406	Course Name: **Industrial Chemistry**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: Basics in Chemistry		
Course Outcome: The student will gain knowledge on various industrial products, their preparation and learn how to make chemical products for industry with perspective toPetroleum, coal based chemicals, Oil based industries, Stoichiometry and unit operation, Pesticides, Fertilizer, Medicine and Pharmacological industries, High energy materials and industrial hygiene with safety. The will help in inculcating entrepreneurship among students		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Petroleum, coal and polymer:**Composition of petroleum, cracking processes, commercial production of Ethylene, Acetylene, Polymerisation mechanism, addition, condensation, step growth, chain growth, method of polymerisation, Zeigler-Natta polymerization, distillation of coal.	10
2	**Oil, Detergents, Fermented product and Unit operation:** **-Oil based industries:**Oils and fats, solvent extraction of oils, hydrogenation of oils, use of oil in the manufacturing of soap, paints and varnishes. **-Surface active agents:** Classification and manufacturing of detergents used for cleaning purpose. **-Fermentation industries:** A general discussion of Fermentation conditions, manufacturing of Penicillin. -U**nit operation:** Distillation, Absorption and Stripping, Extraction and leaching, crystallization, Psychometric, Drying, Evaporation, less conventional operation	10
3	**Pesticides, Fertilizer and Medicines:** Pesticides: Classification- insecticides, fungicides and rodenticides, Detrimental effects of pesticides (DDT, BHC, Parathion), Manufacture/synthesis of DDT, BHC, Parathion. Fertilizers: classification, synthesis of fertilizers- nitrogenous, phosphorous and potassium fertilizer. Medicines: Different types of drugs, analgesics, antipyretics, antiseptics and antibiotics, broad spectrum antibiotics. Metals in medicines: Metaldeficiency and disease, toxic effect of metals.	10
4	**High Energy Materials, Industrial Chemical Safety:** *Explosives:* Definition, classification, synthesis and uses: nitrobenzene, TNT, PETN, picric acid, ethylene glycol dinitrate, nitroglycerine, nitrocellulose, RDX. *Fire retardants:* Definition, classification, and uses. Personal protective equipments, *Industrial hazards and Safety:* Process hazards checklists, hazard surveys, safety program, Various common industrial hazardous warning/safety symbols.	10
Total		40

Reference & Textbooks :

1. Industrial Chemistry by B. K. Sharma
2. Analytical Chemistry by G. D. Christain
3. Introduction to chromatography: Bobbit
4. Instrumental Methods of analysis (CBS)- H.H . Willard, L.L. Mirrit, J.A. Dean
5. Instrumental Methods of Analysis : Chatwal and Anand
6. Instrumental Methods of Inorganic Analysis(ELBS) : A.I. Vogel
7. Chemical Instrumentation: A Systematic approch- H.A. Strobel

8. The principals of ion-selective electrodes and membrane transport: W.E.Morf
9. Physical Chemistry – P.W. Atkins 9. Principal of Instrumental Analysis- D. Skoog and D.West

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class, Assignments.

Course No. CHEM E407	Course Name: **Organic synthesis in Medicines**	
Semester: IV	Credits: 4	**Elective Course**
Pre-requisites: **C101, C201, E301, E302, E402**		
Course Outcome: This course is designed to impart the fundamental knowledge on the applications of organic synthesis for the human society. The chapter deals with different medicines that were synthesized through organic synthesis. The student leanrs how to synthesize Analgesics, Anthelmintics, Muscle relaxant, Anathesia Synthesis, Tranquilizers, Respiratory, Anti-Bacterial, Anti-microbes, Anti-Biotic, Cardiotonic, Thyroid, Immuno suppressants, Antimetabolite, Nervous stimulant, Fungicide, Herbicides, Pesticides, Perfume and fragnances, Anti-virals.		

Course Details

Unit	**Contents**	Hours/ Semester
1	**Analgesics (**Paracetamol, Aspirin, Ibuprofen, Flurbiprofen, Naproxen, Diclofenac, Piroxicam, Fentanyl, Papaverine, Ketoprofen, Metamizole, Nimusulide, Tramadol, Meloxicam, Ketorolac.Levocetirizine, Flupiritine, L-DOPA). **Anthelmintics**(Albendazole,Loperamide, Chloroquine). **Muscle relaxant** (bacolofen, metaxalone, Styramate, chlorozoxazone). **Anathesia Synthesis:** Bupivacine, Procaine, Cocaine, Etidocaine: Prilocaine, Morphine, Propofol, Ketamine. Sevoflurane. **Tranquilizers** (Diazepam, Zolpidem, Osemozotan, Propanolol); **Respiratory** (Salbutamol, Adrenaline, fenoterol)	10
2	**Anti-Bacterial (**Sulfamethoxazole, levofloxacin. Moxifloxacin, furazolidone); Dettol, 4-chloro3-5-dimethyl phenol. **Anti-microbes** (Metronidazole, Cefoperazone, Daptomycin, Penicillin); **Anti-Biotic (**Sulfamethoxazole, Trimethoprim, Chloramphenicol); **Thyroid** (levothyroxine), **Cardiotoni**c (isoproterenol, denopamine), **Immuno suppressants** (mycophenolic acid); **Antimetabolite** (azathioprine, cyclophosphamide).**Nervous stimulant** (Dopamine, Benzedrine)	10
3	**Fungicide (**Azyoxystrobin, Tricyclazole, Carbendaziem, Traidimefon, Benomyl, Fenarimol) **Herbicides (**Paraquat Dichloride, Oxyfluorfen, Glyphosate); **Pesticides (**DDT, Warfarin, Avicides, Fenthion, Avitrol, Parathion.	10
4	**Perfume and fragnances:**Methyl Cinnamate (Strawberry), Phenylethyl ethyl ether (Kewra), (Z) - Z-Hex-2-enal (Aroma insect repellent), (*E*)-Tetradec-11-enal (spruce budworm), Vanillin, Coumarin, Muscone, Civetone, musk ketone, cashmeran, □-ionone, rose oxide, Withasomine**Anti-virals: (**Remdesvir, Lopinavir, Flavipiravir: Ribavirnin, Galidesivir).	10
Total		40

Assessment and Expectations from Class: Tutorial, Quiz, Midsem-20, Endsem-80, attendance, Punctuality, doubt clearing class

Reference & Textbooks:

1. Robert P. Martin, Drugs and the Pharmaceutical Sciences,Vol.185. Informa Health care Publishers.
2. Guidebook for drug regulatory submissions / SandyWeinberg. By John Wiley & Sons. Inc. FDA Regulatory Affairs: a guide for prescription drugs, medical devices, and biologics /edited by Douglas J. Pisano, David Mantus.
3. Generic Drug Product Development, Solid Oral Dosage forms, Leon Shargel and Isader Kaufer, Marcel Dekker series, Vol.143
4. Clinical Trials and Human Research: A Practical Guide to Regulatory Compliance By F. A. Rozovsky and R.K. Adams
5. Synthesis of Best-Seller Drugs, 2016, Pages 783-800, Ruben Vardanyan, Victor Hruby, Elseiver

Course No. CHEM D408	Course Name: **Dissertation**	
Semester: IV	Credits: 6	**Core Course**
Pre-requisites: All semester theory & practical papers		

Course Outcome: The student will work in real in some national laboratory/state or at Berhampur University of his/her choice. The student will inform ahead regarding where she/he is interested to work, provided with a consent letter from respective supervisor. Each student has to work for at least 300 hours in a reputed research laboratory or industry on a specific project under the guidance.

a) The dissertation supervisor should be a Professor/Associate Professor/Assistant Professor/Scientist/Scientific Officer or Equivalent (having at least PhD degree).
b) The research work will be submitted in the form of a dissertation within one week of last theory examination/as instructed by HOD. The student has to present his work in power point before an External examiner and an Internal examiner for evaluation.

Course Details

Chapter	**Contents**
1	Literature review
2	Learning objectives
3	Dissertation work along with instrumental techniques
4	Report writing in proper format

Course No. VAC3	Course Name: **Cultural Heritage of South Odisha**	
Semester: IV		**Value Added Course**
Pre-requisites: If any		
Course Outcome: The teaching imparted to the P.G. students of Berhampur University on the various dimensions of the literary and cultural heritage of South Odisha will help them to acquire a valuable understanding of the same. They will be inspired adequately to take the positives learnt from the course and use them in future in their personal literary and cultural pursuits and thereby promote the literature and culture of Odisha on a global scale.		

Course Details

Chapter/ Unit	**Contents**	Hours/ Semester
1	Literary works of Kabi Samrat Upendra Bhanja	08
2	Other Litterateurs of South Odisha	08
3	Cultural Heritage of South Odisha	08
4	Folk and Tribal Traditions of South Odisha	08
Total		32