New Modified Syllabus

UNIVERSITY OF JAMMU
(NAAC ACCREDITED 'A' GRADE UNIVERSITY)
Baba Sahib Ambedkar Road, Jammu-180006 (J&K)

NOTIFICATION
(20/Feb./Adp/53)

It is hereby notified for the information of all concerned that the Vice-Chancellor, in anticipation of the approval of the Academic Council, is pleased to authorize the adoption of the Syllabi and Courses of Study in the subject of **Chemistry** for Master Degree Programme for semester I to IV under **Choice Based Credit System (through regular mode)** in the main campus for the **(as given in the Annexure)** for the examinations to be held in the years indicated against each semester as under:-

Subject	Semester	For the examinations to be held in the year
Chemistry	Semester-I	Dec. 2020, 2021 and 2022
	Semester-II	May 2021, 2022 and 2023
	Semester-III	Dec. 2021, 2022 and 2023
	Semester-IV	May 2022, 2023 and 2024

The Syllabi of the courses is available on the University website: www.jammuuniversity.in

Sd/-
DEAN ACADEMIC AFFAIRS

No. F.Aed/II/19/7795-7800
Dated: 5-2-2020

Copy to:

1. Dean, Faculty of Science
2. HOD/Convener, Board of Studies in Chemistry
3. All members of the Board of Studies
4. C.A. to the Controller of Examinations
5. Asst. Registrar (Conf. /Exams. PG)
6. Incharge University Website for necessary action please

Sunita Sharma 5/2/2020
Deputy Registrar (Academic)

5/2 05/02/2020

CHOICE BASED CREDIT SYSTEM

M. Sc. CHEMISTRY

PROGRAMME SPECIFIC OUT COMES (PSO)

The courses are designed in such a manner that the student feels an essence of studying the specialized courses of Chemistry in various semesters with a keen interest. The curriculum of Choice Based Credit System of M.Sc. program in Chemistry is designed to motivate Post Graduate students to achieve the following program specific outcomes:

1. To enable the students to modulate, simulate and validate the advanced concepts related to different branches of Chemistry.
2. To practice and solve numerical problems and also to understand the mechanism of advanced organic/inorganic reactions and various theories associated with the latest developments.
3. To develop communication and other skills for use in a wide range of industrial areas.
4. To give a practical training with the sophisticated instruments/equipments.
5. To create an awareness and the impact of chemistry on the environment, society and development outside the scientific community.
6. To inculcate the scientific temperament in the students and outside the scientific community.
7. To understand good laboratory practices and safety measures and to develop research oriented skills.

POST GRADUATE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF JAMMU

M.Sc. CHEMISTRY (Choice Based Credit System)

S. No.	Course No.	Course Category	Title	Credits	
Semester-I					
1.	PSCHTC101	PSCC	Inorganic Chemistry-I	04	
2.	PSCHTC102	PSCC	Quantum Chemistry	04	
3.	PSCHTC103	PSCC	Organic Chemistry-I	04	
4.	PSCHTC104	PSCC	Principles of Spectroscopy	04	
5.	PSCHLC105	PSCC	Laboratory Course: Inorganic Chemistry	03	
6.	PSCHLC106	PSCC	Laboratory Course: Physical Chemistry	03	
7.	PSCHLC107	PSCC	Laboratory Course: Organic Chemistry	02	
Semester-II					
1.	PSCHTC201	PSCC	Inorganic Chemistry-II	04	
2.	PSCHTC202	PSCC	Chemical Dynamics, Surface and Electro Chemistry	04	
3.	PSCHTC203	PSCC	Organic Chemistry-II	04	
4.	PSCHTC204	PSCC	Applications of Spectroscopy in Organic Chemistry	04	
5.	PSCHLC205	PSCC	Laboratory Course: Inorganic Chemistry	03	
6.	PSCHLC206	PSCC	Laboratory Course: Physical Chemistry	02	
7.	PSCHLC207	PSCC	Laboratory Course: Organic Chemistry	03	
Semester-III					
1.	PSCHTE301	PSEC	Spectroscopy and Photochemistry in Inorganic Chemistry	04	
2.	PSCHTE302	PSEC	Thermodynamics and Statistical Mechanics	04	
3.	PSCHTE303	PSEC	Bio-organic and Medicinal Chemistry	04	
4.	PSCHTE304	PSEC	Catalysis: Fundamentals and Chemical Concepts	04	
5.	PSCHTE305	PSEC	Advanced Photochemistry and Radiation Chemistry	04	
6.	PSCHTE306	PSEC	Chemistry of Inorganic Rings, Cages, Clusters and Nanomaterials	04	
7.	PSCHTO307	PSOCC	Environmental Chemistry	04	
8.	PSCHLC308	PSCC	Laboratory Course: Inorganic Chemistry	02	
9.	PSCHLC309	PSCC	Laboratory Course: Physical Chemistry	03	
10.	PSCHLC310	PSCC	Laboratory Course: Organic Chemistry	03	
Semester-IV					
1.	PSCHTE401	PSEC	Analytical Chemistry	04	
2.	PSCHTE402	PSEC	Organotransition Metal Chemistry	04	
3.	PSCHTE403	PSEC	Bioinorganic and Supramolecular Chemistry	04	
4.	PSCHTE404	PSEC	Solid State Chemistry	04	
5.	PSCHTE405	PSEC	Polymer Chemistry	04	
6.	PSCHTE406	PSEC	Chemistry of Materials and Liquids	04	
7.	PSCHTE407	PSEC	Heterocyclic Chemistry and Asymmetric Synthesis	04	
8.	PSCHTE408	PSEC	Organic Synthesis	04	
9.	PSCHTE409	PSEC	Chemistry of Natural Products and Molecular Rearrangements	04	
10.	PSCHTO410	PSOCC	Chemistry in Daily life	04	
11.	PSCHLE411	PSEC	Laboratory Course: Inorganic Chemistry	06*	02*
12.	PSCHLE412	PSEC	Laboratory Course: Physical Chemistry	06*	02*
13	PSCHLE413	PSEC	Laboratory Course: Organic Chemistry	06*	02*

NOTE: The students of Chemistry Department in Semesters III and IV will register for a minimum of 4 credits of courses in each semester from other departments.

* See details below

COURSE STRUCTURE

All courses in Semesters I and II are compulsory. In semester III, the three courses from S. Nos. 1 to 6 (one each from Inorganic, Organic and Physical) are to be chosen by the students. In Semester IV, the three specializations offered to the students are Inorganic, Organic and Physical Chemistry.
The total credits to be earned by a student are 96 credits (88 credits to be earned from the M.Sc. Programme in Chemistry and 08 credits to be earned from other subjects) plus audit courses as detailed in the pattern if examination.

PATTERN OF EXAMINATION

Theory

There shall be two **Minors (I & II)** and one **Major** tests in each theory course. Each Minor test shall have marks weightage of 20% and its duration will be of 1½ hour. The Major test shall have marks weightage of 60% and its duration will be of 03 hours. **Minor**–**I** will be held after 3-4 weeks on completion of 20% of the prescribed syllabus. **Minor**–**II** will be held after 8-9 weeks on completion of 21% to 40% of the prescribed syllabus.

The major test will be held at the end of semester on completion of 41% to 100% of the syllabus. This test will have seven questions (each of twelve marks). The students have to attempt five questions in all. Question no. 1 (short answer type) will be compulsory and will be set out from 40% of syllabus covered in Minor I & II. The remaining six questions will be from across the syllabus of 41% to 100% i.e. beyond Minor I & II. The student has to attempt any four questions out of six questions.

There shall also be an **Audit course** for CBCS in the 3rd semester. Here a student shall attend classes but cannot be graded or given credit for this course. In this course, the registered research scholars of the Department will present their findings in the presence of all faculty members to the students of 3rd semester. The two lectures per week (from July to November) will be delivered by various research scholars and duration of each lecture will be of 30 minutes. It will be mandatory for all the students of 3rd semester to be present and attend this course. The work reported by various research scholars will help students for the purposes of their self enrichment and academic exploration. It will be also beneficial to those students who wish to choose research as their carrier. The students completing this course must have a minimum of 75% mandatory attendance failing which they will not be eligible to appear in the major examination. The Head of the Department shall be the Course Director who will draft the schedule of lectures in consultation with the faculty members.

In addition, there shall be a MOOC course through SWAYAM Portal **(Also an Audit course)** which the students have to study either in Semester III or Semester IV.

NOTE: *Candidates who have appeared in Minor Tests and failed to get the minimum required marks i.e. 14 out of 40 will not be allowed to take Major Test. Such candidates shall have to re-appear in the Minor Test/s only once in which he/she has failed, to be conducted at least fifteen days before the Major Test.*

Practical

(Semesters-I to III)

The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

Semester- IV

In Semester-IV, the laboratory course has been divided in two heads:

(a) 6-credits laboratory work of 150 marks, and

(b) 2-credits project work based on review of literature work on any recent research topic, the choice of which will be left to students in consultation with the concerned faculty member. This will have a weightage of 50 marks and will be evaluated by an external examiner. The three external examiners (Inorganic, Organic and Physical) shall be invited in 4^{th} semester to evaluate the project work and also to conduct the practical examination of students of their respective specializations. The project work will be in the form of small dissertation which will be kept in the custody of the Department, once a student successfully defends his/her work.

Course No.: PSCHTC101 **Course Category: PSCC**
Title: Inorganic Chemistry-I
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome**:** *This course will enable the students to learn the concept of group theory and its applications, stereochemistry and bonding, theories of bonding, metal-ligand equilibria as well as electronic spectra of transition metal complexes.*

Unit-I

Concept of Group theory in Chemistry and its Applications (12 hours)

Symmetry elements and symmetry operations, Definitions of group, Subgroup, Point symmetry groups, Schonfilies symbols, Multiplication table, Conjugacy relation and classes, Representation of symmetry operations by matrices, Character of a representation, Reducible & irreducible representation, Derivation of Character tables for C_2v, C_3v, C_{2h}, Application of Group theory in Infrared and Raman Spectroscopy.

Unit-II

Stereochemistry and Bonding in Main Group Compounds (12 hours)

VSEPR, Walsh diagram (tri- and penta atomic molecules), Bent rule and energetics of hybridization, dπ-pπ bonds, Chemistry of inorganic rings and cages, Borazines, Phosphazenes, Polyhedral boranes, Carboranes, Metalloboranes and Metallocarboranes.

Unit-III

Theories of Bonding in Transition Metal Complexes (12 hours)

Shortcomings in crystal field theory, Crystal field splitting in O_h, T_d, D_{4h} and C_{4v} systems, Structural effects of crystal field splitting, Variation of ionic ratio, Lattice energy, Molecular orbital theory, MO energy level diagrams for octahedral, tetrahedral and square planar complexes, π bonding and M.O theory, Variation of Δ_o with the π acceptor and σ donor ligand.

Unit-IV

Metal-Ligand Equilibria in Solution (14 hours)

Stepwise and overall formation constants and their interaction, Trends in stepwise constants, Factors affecting the 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, Formation of colored complexes in solution in different metal to ligand ratios, Calculation of stability constant of a complex formed in 1:1 metal to ligand ratio by spectrophotometric method, Determination of ε.

Unit-V

Electronic Spectra of Transition Metal Complexes (10 hours)

Spectroscopic ground states, Term symbol, Splitting of terms by ligands, Rules for electronic transitions, Correlation diagrams, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1 –d^9), Calculation of Dq, B and β Parameters, Nephelauxetic effect and Jahn-teller Effect, Charge transfer spectra.

Books Recommended:

1. Analytical applications of complex equilibria, J. Inczedy, Halsted Press: New York, NY (1976).
2. Solution Equilibria, F. R. Hartley, C. Burgess & R. M. Alcock, Prentice-Hall: Europe (1980).
3. Complexation in Analytical Chemistry, A. Ringbom, Wiley: New York (1963).
4. Chemical Applications of Group Theory, F.A. Cotton.
5. Group Theory and Symmetry in Chemistry Lowell H. Hall.
6. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
7. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
8. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley
9. Advanced Inorganic Chemistry, J. D. Lee.
10. Comprehensive Coordination Chemistry, G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon.
11. Group Theory and Chemistry, D. M. Bishop, Clarendon Press: Oxford, U.K. (1973).
12. Symmetry in Chemistry, H. H. Jaffe & M. Orchin, Dover Publications (2002).
13 Electronic Spectra of Transition Metal Complexes, D. Sutton, McGraw-Hill: New York (1968)
14. Ligand Field Theory and its Applications, Brian N. Figgis and Michael A. Hitchman, Wiley-VCH
15. Inorganic Solids: An Introduction to Concepts in Solid-State Structural Chemistry, D. M. Adams, John Wiley & Sons, London (1974).
16. Inorganic Chemistry by Catherine Housecroft and A G Sharpe Prentice Hall; 2nd edition (2004-11-18).
17. Inorganic Chemistry, Gary L. Miessler, Donald A. Tarr, Prentice Hall (4th Edition), 2010.
18. Concepts and Models of Inorganic Chemistry, Bodie Douglas, Darl Mcdaniel, John Alexander, Wiley; 3rd edition (2006).
19. Inorganic Chemistry, A.G. Sharpe, Pearson, India, 3rd edition, (2002).

PATTERN OF EXAMINATION

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Course No.: PSCHTC102 **Course Category: PSCC**
Title: Quantum Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *This course will help to understand the various aspects of quantum mechanics. In addition, the students will gather knowledge about angular momentum, approximation methods, chemical bonding, HMO methods and its applications.*

UNIT-I

Exact quantum mechanical results (15 hrs)

Schrodinger equation and the postulates of quantum mechanics, Operator concept, Some properties of quantum mechanical operators. Linear, Hermitian and Unitary operators, Commutator, operators for different observables, Schrodinger wave equation for Hydrogen like atoms in spherical polar coordinates, Separation into three equations, Quantum numbers and their importance, Radial and angular wave functions (Spherical harmonics), Complete solution of Schrodinger equation for the following model systems: Particle in a box (1 and 3 dimensional), Concept of degeneracy, One dimensional simple harmonic oscillator & the rigid rotator, Calculation of various average values for the above systems.

UNIT-II

Angular momentum and electronic structure of atom (12 hrs)

General theory of angular momentum, Eigen functions and Eigen values of angular momentum operators, Ladder operators, Commutation relations, Spin angular momentum, antisymmetry and Pauli's principle,

Electronic configuration, Russell-Saunders and jj-coupling schemes, Slater determinant. Vector model of the atom, Atomic term symbols, term separation of p^n configurations, spin-orbit coupling, Zeeman splitting, Virial theorem.

UNIT-III

Approximation methods (10 hrs)

Approximation methods, The Variation method, linear variation principle, Perturbation method – Postulates and calculation of first order perturbation (non-degenerate), Application of variation method and perturbation method to helium atom (Ground state energy).

UNIT-IV

Chemical Bonding (13hrs)

Molecular orbital theory (Homonuclear and heteronuclear diatomics), LCAO-MO approximation, H_2^+ molecular ion, Calculation of energy levels from wave functions, Physical picture of bonding and antibonding wave function, Brief introduction to H_2, Valence bond treatment of H_2, Comparison of MO and VB methods.

UNIT-V

HMO Method and its Applications (10 hrs)

Huckel's MO theory of conjugated systems; Application to ethylene, Butadiene, Cyclobutadiene, Allyl system (Allyl cation, Allyl radical and Allyl anion), Cyclopropenyl system (Cyclopropenyl cation, Cyclopropenyl radical and Cyclopropenyl carbanion), Calculation of properties- Delocalization energy, Electron density and bond order.

BOOKS RECOMMENDED

1. Physical Chemistry, P. W. Atkins, J. de Paula, Oxford, Tenth Edition, 2014.
2. Introduction to Quantum Chemistry, A.K. Chandra, McGraw Hill, Fourth Edition, 2001.
3. Quantum Chemistry, Ira. N. Levine, Pearson, Seventh Edition, 2016.
4. Molecular Quantum Mechanics, P.W. Atkins and R.S. Friedmann, Oxford, Fifth Edition, 2012.
5. Quantum Chemistry and Spectroscopy by T. Engel and P. Reid, Pearson, Third Edition, 2018.
6. Quantum Chemistry, J.P. Lowe and K.A. Peterson, Academic Press, Third Edition, 2005.
7. Physical Chemistry by R.J. Silby, R.A. Alberty and M.G. Bawendi, Wiley, Fourth Edition, 2004.
8. Quantum Chemistry by D.A. McQuarrie, Viva Books Pvt. Ltd, New Delhi, 2011.
9. Elementary Quantum Chemistry, F.L. Pilar, Second Edition, Dover Publication Inc., New York, 2001.
10. Physical Chemistry: A Molecular Approach, D.A McQuarrie and J.D. Simon, University Science Books, Third Edition 2001.

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Course No.: PSCHTC103 **Course Category: PSCC**
Title: Organic Chemistry-I
Credits: 04 **Maximum Marks: 60**
No. of hours: 60

Course Outcome: *This course is focussed on nature of bonding in organic molecules, stereochemistry, reaction mechanism, aliphatic nucleophilic substitution and free radical reactions.*

Unit-I

Nature of bonding in organic molecules (12 hrs)

Delocalized chemical bonding-conjugation, Crossconjugation, Resonance, Hyperconjugation, Tautomerism, Aromaticity in benzenoid and non-benzenoid compounds, Alternant and non-alternant hydrocarbons, Huckel's rule, Energy level of molecular orbitals, Annulenes, Antiaromaticity, Homo-aromaticity, Crown ether complexes and cryptands, Inclusion compounds, Cyclodextrins.

Unit-II

Stereochemistry (12 hrs)

Elements of symmetry, Chirality, R&S configuration, Molecules with more than one chiral center, Threo- and erythro- isomers, Methods of resolution, Optical purity, Enantiotopic and diastereotopic atoms, Groups and faces, Optical activity in the absence of chiral carbon (Biphenyls, Allenes and Spiranes), Stereochemistry of the compounds containing nitrogen and sulphur, Conformational analysis of cyclohexanes, Decalins, Effect of conformation on reactivity, Steric strain due to unavoidable crowding.

Unit-III

Reaction Mechanism: Structure and Reactivity (12 hrs)

Types of mechanisms, Kinetic and thermodynamic control, Curtin-Hammett principle, Potential energy diagrams, Transition states and intermediates, Methods of determining mechanisms, Isotope effects, Structure, stability and reactions of carbenes and nitrenes, Effect of structure on reactivity-Resonance and field effects, Steric effect, Qualitative treatment, The Hammett equation and linear free energy relationship, Substituent and reaction constants.

Unit-IV

Aliphatic Nucleophilic Substitutions (12 hrs)

The S_N2, S_N1, Mixed S_N1 and S_N2 and SET mechanisms, The neighbouring group mechanism, Neighbouring group participation by σ and π bonds, Classical and non-classical carbocations, Phenonium ions, Norbornyl system, The S_Ni mechanism.

Nucleophilic substitutions at an allylic, aliphatic trigonal and a vinylic carbon, Reactivity effects of substrate structure, Attacking nucleophile, Leaving group and reaction medium, Phase transfer catalysis and ultrasound, Ambident nucleophile and regioselectivity.

Unit-V

Free Radical Reactions (12 hrs)

Mechanism of free-radical reactions, Neighbouring group assistance, The effect of solvent and attacking radicals on reactivity, Allylic halogenations (NBS), Oxidation of aldehydes to carboxylic acids, Auto-oxidation, Coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer, Barton and Hunsdiecker reactions.

BOOKS RECOMMENDED

1. Advanced Organic Chemistry, Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, Oxford (2000).
3. Advance Organic Chemistry, Part-A: Structure & Mechanism (Fifth Edition), F.A. Carey & R.J. Sundberg, Published by Springer Science (2007).
4. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
5. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Corell University Press.
6. Organic Chemistry, R.T. Morrison & R.N. Boyd, Prentice Hall.
7. Stereochemistry of Organic Compounds, D. Nasipuri (3rd Edition), New Age International (P) Limited, New Delhi (2014).
8. Organic Synthesis, Michael B. Smith, McGraw Hill Education.
9. Steric and Stereoelectronic Effect in Organic Chemistry, V. K. Yadav, Springer Singapore (2016).
10. Modern Methods of Organic Chemistry, William Carruthers and Liancoldham, Cambridge University Press (4th edition, 2015).
11. Organic Chemistry, Stanley H. Pine, Tata McGraw Hill (5th Edition, 2007).

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Course No.: PSCHTC104 **Course Category: PSCC**
Title: Principles of Spectroscopy
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *By studying this course, the students are able to concentrate on physical aspects of various techniques of spectroscopy, namely, microwave, vibrational, Raman, NMR. Information about X-ray and neutron diffraction techniques will also be dealt.*

Unit-I

Unifying Principles **(10 hrs)**

Electromagnetic Radiation, Characterization, Quantization of energy, Regions of emr, Interaction of emr with matter, Phenomenon related to radiation-Transmission, reflection, refraction, dispersion, polarization, Width and intensity of spectral lines, Factors contributing to this effect: Collision broadening, Doppler broadening, Heisenberg's uncertainty principle, Transition probability, Population of states and Path length of sample, Results of time dependent Perturbation theory: Stimulated (Induced) absorption, Stimulated and spontaneous emission, Einstein coefficients, Lasers.

Unit-II

Microwave Spectroscopy **(10 hrs)**

Rotational spectroscopy of diatomic molecules based on rigid approximation, Determination of bond length and/or atomic masses from microwave data, Intensity of spectral lines, Effect of isotopic substitution, Non-rigid rotator, Classification of polyatomic molecules, Energy levels and spectra of symmetric top molecules and asymmetric top molecules.

Unit-III

Vibrational Spectroscopy **(12 hrs)**

Vibrating diatomic molecule: The energy of a diatomic molecule, The simple Harmonic oscillator, The Anharmonic oscillator, Selection rules, Overtones and combination bands, Dissociation energies from vibrational spectra, Vibrational-rotational spectra, P, Q and R branches, Breakdown of Born-Oppenheimer approximation, Vibrations of polyatomic molecules: Fundamental vibrations and their symmetry, Influence of rotation on the spectra of polyatomic molecules: Linear molecules, The Influence of nuclear spin.

Unit-IV

(a) Raman Spectroscopy **(6 hrs)**

Quantum theory of Raman effect, Classical theory of Raman effect, Pure rotational Raman spectra of linear and Symmetric top molecules, Raman activity of vibrations, Rule of Mutual exclusion, Vibrational-Raman spectra, Rotational fine structure, Selection rules

(b) Nuclear Magnetic Resonance Spectroscopy **(8 hrs)**

Nuclear spin, Nuclear Magnetic resonance, Saturation, Shielding of magnetic nuclei, Chemical shift and its measurements, Factors affecting chemical shift, Deshielding, Spin-spin interactions, Factors affecting coupling constant, Basic idea about NMR instrument, FT NMR, Advantages of FT NMR

Unit-V

Diffraction Techniques **(14 hrs)**

X-ray diffraction**:** Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, Identifications of

unit cells from systematic absences in diffraction pattern, Structure of simple lattices and X-ray intensities, Structure factor and its relation to intensity and electron density, Phase problem, Description of the procedure for an X-ray structure analysis.
Neutron diffraction: General introduction, Crystal structure determination, Magnetic structure analysis, Elementary idea of electron diffraction

BOOKS RECOMMENDED

1. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
2. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
3. Fundamentals of molecular spectroscopy, C.N. Banwell and E.M. McCash, Tata McGraw Hill.
4. Solid State Chemistry and its applications, A.R. West, John Wiley & Sons.
5. Solid State Chemistry: An Introduction, L. Smart and E. Moore, Nelson Thrones Ltd., UK.
6. Atomic and molecular spectroscopy- Basic concepts and applications. Rita Kakkar, Cambridge Press, 2017.

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Course No.: PSCHLC105 **Course Category: PSCC**
Title: Laboratory Course: Inorganic Chemistry
Credits: 03 **Maximum Marks: 75**
No. of hours: 45

***Course Outcome*:** *This course will help the students to learn how the rare analysis of metals is analyzed and simultaneously to separate and estimate the quantity of two metal ions in the given mixture.*

1. Qualitative analysis of less common (rare) metals

Analysis of mixture containing less common metal ions: Tl, W, Mo, Se, Te, Zr, Ti, Ce,

Th, V, U, Li (four metal ions in cationic/anionic forms)

2. Separation and quantitative estimation of two metal ions

Cu-Ni: Estimation of both by gravimetric method

Ba-Cu: Estimation of Ba gravimetrically and Cu volumetrically

Ag-Cu, Estimation of Ag gravimetrically and Cu volumetrically

Cu-Zn: Estimation of both by gravimetric method

Ni-Zn: Estimation of both by gravimetric method

Cu-Fe: Estimation of both by gravimetric method

Ca-Mg: Estimation of both by titrating against EDTA solution

Zn-Mg: Estimation of both by titrating against EDTA solution

3. To determine the total hardness of water (due to presence of Ca^{2+} and Mg^{2+} salts)

4. Any other experiment introduced by the teacher

Books Suggested:

1. Vogel's Qualitative Inorganic Analysis, 7th Edn., Pearson Education Ltd.
2. Vogel's Textbook of Quantitative Inorganic Analysis, 4th Edn., Longman Group Limited, London.

PATTERN OF EXAMINATION

The daily evaluation of practical records / assignments / viva-voce, etc. shall have a marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

Course No.: PSCHLC106 **Course Category: PSCC**
Title: Laboratory Course: Physical Chemistry
Credits: 03 **Maximum Marks: 75**
No. of hours: 45

Course Outcome: *Error analysis and statistical analysis data will be analyzed by the students before proceeding to the actual performance of various experiments as mentioned in the following details.*

Number of hours for each experiment: 3-4 hours
A list of experiments under different headings is given below. Typical experiments are to be selected from each type. Students are required to perform at least 25 experiments.

Error Analysis and Statistical Data Analysis
Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F&Q test; linear regression analysis, curve fitting, calibration of volumetric apparatus, burette, pipette and standard flask.

Phase Equilibria
To construct the phase diagram for three component system (e.g. Chloroform-acetic acid-water, ethanol-benzene-water, ethanol-ethyl acetate-water, acetic acid-benzene-water).

Chemical Kinetics
i) Determination of the effect of (a) change of temperature (b) change of concentration of reactants and catalyst and (c) ionic strength of media on the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
ii) Determination of velocity constant of hydrolysis of an ester/ionic reaction in micellar media.
iii) Determination of the rate constant for the oxidation of iodine ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.
iv) Flowing clock reactions.
v) Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsonted relationship (iodide ion is oxidized by persulaphate ion).

Solutions
i) Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.
ii) Determination of the degree of disassociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

Viscosity
i) Determination of molecular weight of high polymer (polystyrene) from viscosity measurements.

Surface-Tension
Study of variation of surface tension of solution with concentration and determination of surface excess, Study of interfacial tension between two immiscible liquids, CMC from surface-tension measurements

Any other practical introduced by the teacher

BOOKS RECOMMENDED

1. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.
3. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.
4. Experiments in Physical Chemistry by Shoemaker.
5. Practical Physical Chemistry, Viswanathan and Raghavan.
6. Advanced Physical Chemistry, J.B. Yadav, Goel Publishing House.

PATTERN OF EXAMINATION

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Course No.: PSCHLC107 **Course Category: PSCC**
Title: Laboratory Course: Organic Chemistry
Credits: 02 **Maximum Marks: 50**
No. of hours: 30

Course Outcome: *The organic synthesis of various compounds with characteristic functional groups will be carried out. IR spectra will be used to identify various functional groups.*

Quantitative Analysis
Separation, purification and identification of compounds of binary mixture (two solids) using TLC, chemical tests, IR spectra to be used for functional group identification.

Organic Synthesis
Acetylation: Acetylation of $–NH_2$ and –OH groups.
Synthesis of oximes of carbonyl compounds.
Aldol condensation: Dibenzal acetone and benzylidene acetone from benzaldehyde.
Cannizaro reaction: Benzyl alcohol and benzoic acid from benzaldehyde.

Any other experiment introduced by the concerned teacher.

BOOKS RECOMMENDED

1. Experiments and techniques in Organic Chemistry, D. Pasto, C. Johnson and M.Miller, Prentice Hall.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.
3. Systematic Qualitative Organic Analysis, H. Middlenton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
6. Monograph on Green Chemistry by Green Chemistry Task Force Committee, DST.

PATTERN OF EXAMINATION

The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weighage of 50%.

Course No.: PSCHTC201 **Course Category: PSCC**
Title: Inorganic Chemistry-II
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome**:** *By studying this course, the students will come to know the mechanism of reactions in inorganic complexes, magnetic properties of complexes and metal clusters framework of complexes.*

Unit-I
Mechanism of Substitution Reactions in Octahedral Transition Metal Complexes **(14 hours)**

Energy profile of a substitution reaction, Inert and labile complexes, Factors affecting the inert and labile nature, Calculation of CFAE (Crystal field activation energy), Mechanism of nucleophilic substitution reactions in octahedral complexes SN^1 or dissociation and SN^2 or association (or displacement) mechanisms, Acid hydrolysis, SN^1 conjugate base mechanism for base hydrolysis of octahedral complexes, Evidence of SN^1 CB mechanism, Anation reaction, Decarboxylation reaction in octahedral complex and Substitution reaction without breakage of metal to ligand bond.

Unit-II
Mechanism of Substitution Reactions in Square Planar Complexes and Electron Transfer (or Oxidation-Reduction) Reaction **(10 hours)**

Mechanism of substitution reactions in Pt(II) complexes, Factors effecting the reactivity of square planar complexes, Trans-effect, Theories of trans-effect-Grinberg's electrostatic polarization theory and Chatt and Orgel pi-bonding theory, Application of trans-effect to synthesis of complexes, Reductions -oxidation reaction, One electron transfer reaction, Outer sphere, Inner sphere redox reaction, Marcus Hush theory.

Unit-III
Magnetic Properties of Transition Metal Complexes **(12 hours)**

Magnetic properties of transition metal complexes and lanthanides, Spin-orbit coupling and susceptibility of transition metal ions and rare earths, Magnetic moments of metal complexes with crystal field terms of A, E and T symmetry, T.I.P, Intramolecular effects, Antiferromagnetism and ferromagnetism of metal complexes, Super paramagnetism, High and low spin equilibria, Anomalous magnetic moments, Magnetic exchange coupling and spin crossover.

Unit-IV
Metal Carbonyls, Nitrosyls, Dinitroge and Oxygen Complexes **(12 hours)**

Metal carbonyls, Structure and bonding, Vibrational spectra of metal carbonyls for bonding and structural elucidation, Important reactions of metal carbonyls, Preparation, Bonding, Structure and important reactions of transition metal nitrosyls, Dinitrogen and oxygen complexes, Tertiary phosphine as ligand.

Unit-V
Metal Clusters **(12 hours)**

Factors favoring M-M bonding, Carbonyl Clusters, Classification: Low – Nuclearty carbonyl clusters (M_3 and M_4 clusters), Structural Patterns in $M_3(CO)_{12}$ (M = Fe, Ru, Os) and $M_4(CO)_{12}$ (M=CO, Rh, Ir) Clusters, Metal carbonyl scrambling, High nuclearity clusters, M_5,

M_6, M_7, M_8 and M_{10} clusters, Electron Count theory and capping rule, Wade-Mingo's rule, Metal Halide Clusters: Major structural types in Dimuclear Metal-Metal systems- Edge Sharing Bioctahedra, Face sharing Bioctahedra, Tetragonal prismatic and trigonal antiprismetic structures, Quadruple bonds, Structure and bonding in $[Re_2Cl_8]^{2-}$.

Books Recommended:

1. Inorganic Reaction Mechanism, F. Basolo & G. Pearson.
2. Inorganic Reaction Mechanism, J. O. Edwards.
3. Selected Topics in Inorganic Chemistry, Malik, Madan & Tuli.
4. Mechanism of Inorganic Reactions, D.Katakis & G.Gordon, John Wiley & Sons: N.Y. (1987).
5. Ligand Substitution Processes, H. Langford & H.B.Gray, W.A. Benjamin, Inc. New York
6. Magnetochemistry by R.L. Carlin, Springer Verlag.
7. Magnetism and Transition Metal Complexes, F. E. Mabbs & D. J. Machin, Chapman and Hall: U.K. (1973).
8. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, John Wiley
9. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
10. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon.
11. Comprehensive Coordination Chemistry eds., G. Wilkinson, R.D. Gillars and J. A. Mc Cleverty, Pergamon.
12. Inorganic Chemistry – Principles of Structure & Reactivity, J E Huheey, Elllen A Keiter & Richard L Keiter, IV Edition (2005)
13. Introduction to metal pi-complex chemistry, M. Tsutsui, M. N. Levy, A. Nakamura, Springer
14. Inorganic Chemistry, Gary L. Miessler, Donald A. Tarr, Prentice Hall (4th Edition), 2010.
19. Concepts and Models of Inorganic Chemistry, Bodie Douglas, Darl Mcdaniel, John Alexander, Wiley; Third edition (2006)
20. Inorganic Chemistry by A. G. Sharpe, Pearson India; 3rd Edition (2002).
21. Basic Organometallic Chemistry: Concepts, Syntheses and Applications 2nd Edition, B. D. Gupta and A. J. Elias, 2nd Edition, Universities Press.

PATTERN OF EXAMINATION

There shall be two **Minors (I & II)** and one **Major** tests in each theory course. Each Minor test shall have marks weightage of 20% and its duration will be of 1½ hour. The Major test shall have marks weightage of 60% and its duration will be of 03 hours. **Minor–I** will be held after 3-4 weeks on completion of 20% of the prescribed syllabus. **Minor–II** will be held after 8-9 weeks on completion of 21% to 40% of the prescribed syllabus.

The major test will be held at the end of semester on completion of 41% to 100% of the syllabus. This test will have seven questions (each of twelve marks). The students have to attempt five questions in all. Question no. 1 (short answer type) will be compulsory and will be set out from 40% of syllabus covered in Minor I & II. The remaining six questions will be from across the syllabus of 41% to 100% i.e. beyond Minor I & II. The student has to attempt any four questions out of six questions.

NOTE: *Candidates who have appeared in Minor Tests and failed to get the minimum required marks i.e. 14 out of 40 will not be allowed to take Major Test. Such candidates shall have to re-appear in the Minor Test/s only once in which he/she has failed to be conducted at least fifteen days before the Major Test.*

Course No.: PSCHTC202 **Course Category: PSCC**
Title: Chemical Dynamics, Surface and Electro Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *This course will help to understand chemical kinetics using various theories of bimolecular and unimolecular reactions. Polymer Chemistry, Micelles and Advanced Electrochemistry details will be imparted to the students. A brief idea of nano materials is also introduced.*

Unit - I

Chemical Dynamics – I **(12 hours)**

Collision theory of reaction rates, Steric factor, Activated complex theory, Arrhenius equation and the activated complex theory; Ionic reactions, Kinetic salt effects, Kinetic and thermodynamic control of reactions, Steady state kinetics, Photochemical and thermal reaction between hydrogen and bromine, Photochemical reaction between hydrogen and chlorine, Pyrolysis of acetaldehyde, Decomposition of ethane, Decomposition of nitrogen pentoxide, Formation and decomposition of phosgene, Oscillatory reactions (Belousov-Zhabotinsky reaction), Homogeneous catalysis, Kinetics of enzyme reactions, Numericals.

Unit – II

Chemical Dynamics – II **(12 hours)**

General features of fast reactions, Study and kinetics of fast reactions by flow method, Relaxation method (Kinetics of first order reaction reversed by a first order, second order reaction reversed by first order and first order reaction reversed by a second order reaction), Trimolecular reactions, Unimolecular reactions (Lindemann-Christiansen, Hinshelwood, Rice-Ramsperger-Kassel (RRK)) theories of unimolecular reactions), Intermolecular and Intramolecular energy transfer, Laser induced unimolecular reactions, Combination and Disproportionation Reactions, Mechanisms of atom and radical combinations, Numericals.

Unit - III

Surface Chemistry and Micelles **(14 hours)**

Surface tension and surface free energy, Capillary action, Pressure difference across curved surface (Laplace equation), Vapour pressure of droplets (Kelvin equation), Nature and thermodynamics of liquid interfaces: Surface thermodynamic quantities for a pure substance, The total surface energy, Adsorption and its types, Adsorption isotherms, Freundlich and Langmuir adsorption isotherms, BET equation, Determination of surface area, Gibbs adsorption equation, Surface films on liquids, Catalytic activity at surfaces, Numericals.

Micelles

Surface active agents, Classification of surface active agents, Micellization, Hydrophobic interaction, Critical micellar concentration (CMC), Factors affecting the CMC of surfactants, Counter ion binding of micelles, Thermodynamics of micellization-phase separation and mass action models, Solubilisation, Micro emulsion, Reverse micelles.

Unit – IV

Electrochemistry-I **(10 hours)**

Debye-Huckel limiting law, Debye-Huckel-Onsager treatment and its extension, Debye-Huckel-Jerum mode, Thermodynamics of electrified interfaces, Lippman equation, Method of determination of surface excess, Structure of electrified interfaces: Helmholtz-Perrin,

Guoy-Chapman and Stern models, Over potential, Exchange current density, Butler-Volmer equation, Tafel plot, Numericals.

Unit – V

Electrochemistry-II, Polarography and Nano Chemistry (12 hours)

Analogies between semiconductor and electrolyte, Structure of semiconductor-electrolyte interface, The diffuse charge region inside an intrinsic semiconductor (The Garrett-Brattain Space), Differential capacity due to space charge.

Bioelectro Chemistry: Cells, membranes and mitochondria, membrane potentials, Older and modern theories of membrane potentials, Electrochemical mechanism of nervous system: General and facts.

Polarography: Theory, Ilkovic equation, Half wave potential and its significance.

Nanomaterials: Definition and methods of preparation, Properties of nanomaterials: Physicochemical, optical, electrical/electronic, redox, mechanical and magnetic, Use of nanoparticles in health, communication and energy sectors.

BOOKS RECOMMENDED

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Chemical Kinetics, K.J. Laidler, Pearson, 3rd Edition.
3. Physical Chemistry of Surfaces, A.W. Adamson, John Wiley and sons, 5th Edition.
4. Micelles, Theoretical and Applied Aspects, V.Moroi, Plenum.
5. Modern Electrochemistry Vol. 1, Vol. 2A and Vol. 2B, J.O.M. Bockris and A.K.N. Reddy, Plenum.
6. Nanomaterials, B. Viswanathan, Narosa Publishing House.

PATTERN OF EXAMINATION

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Course No.: PSCHTC203 **Course Category: PSCC**
Title: Organic Chemistry- II
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The contents of this course are focussed on electrophilic, nucleophilic substitution, addition, elimination reactions from their mechanistic point of view. Rearrangement and pericyclic reactions will also be dealt in this course.*

Unit-I

Aromatic Electrophilic & Nucleophilic Substitutions (12 hrs)

The arenium ion mechanism, orientation and reactivity, energy profile diagrams, The ortho/para ratio, ipso attack, Orientation of other ring systems, Friedel-Crafts reaction of alkenes and alcohol substrates, Vilsmier reaction.

The S_NAr, S_N1, benzyne and $S_{RN}1$ mechanisms, Reactivity effect of substrate structure, leaving group and attacking nucleophiles, The Von Richter and Sommelet-Hauser rearrangements.

Unit-II

Addition of Carbon-Carbon Multiple Bonds (12 hrs)

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, Regio- and chemoselectivity, Orientation and reactivity, Addition to cyclopropane ring, Hydroboration, Michael reaction, Sharpless asymmetric epoxidation.

Elimination Reactions

The E2, E1 and E1cB mechanisms, Base and stereoelectronic effect on E2/S_N2 competition; Orientation of the double bond, Reactivity: Effects of substrate structures, Attacking base, the leaving group and the medium, Mechanism and orientation in pyrolytic eliminations, Peterson olefination.

Unit-III

Addition to Carbon-Hetero Multiple Bonds (12 hrs)

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles [LAH, $NaBH_4$, BH_3, DIBAL-H], Addition of Grignard, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, The Wittig reaction, Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel and Claisen Condensations, Hydrolysis of esters and amides.

Unit-IV

Pericyclic Reactions (12 hrs)

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene and 1,3,5-hexatriene system, Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams, FMO and PMO approach, Electrocyclic reactions-conrotatory and disrotatory motions, 4n and 4n+2 systems, Cycloadditions: Antrafacial and suprafacial additions, 4n and 4n+2 systems, 1,3-dipolar cycloadditions, Sigmatropic rearrangements-suprafacial and antrafacial shifts of H, Sigmatropic shifts involving carbon moieties, Claisen, Cope and Ene reaction.

Unit-V

Rearrangements (12hrs)

General mechanistic considerations-Nature of migration, Migratory aptitude, Memory effects.

A detailed study of the following rearrangements:

Pinacol-Pinacolone, Tiffeneau-Demjanov, Favorskii, Stevens, Arndt-Eistert synthesis, Neber, Hofman, Curtius, Schmidt, Baeyer-Villiger and Eschenmoser reactions.

BOOKS RECOMMENDED

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers, Oxford (2000).
3. Advance Organic Chemistry, Part-A: Structure & Mechanism (Fifth Edition), F.A. Carey & R.J. Sundberg, Published by Springer Science (2007).
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentic-Hall.
6. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
7. Advanced Organic Chemistry: Reaction Mechanisms, Reinhard Bruckner, Academic Press, USA.
8. Pericyclic reactions by Ian Flemmings, University Oxford Press (2015, 2nd Edition).
9. Modern Methods of Organic Chemistry, William Carruthers and Liancoldham, Cambridge University Press (4th edition, 2015).
10. Polar rearrangements, Laurence M. Harwood, Oxford Science Publications, Oxford University Press (1992).
11. Organic Chemistry, Stanley H. Pine, Tata McGraw Hill (5th Edition, 2007

PATTERN OF EXAMINATION

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Course No.: PSCHTC204 **Course Category: PSCC**
Title: Applications of Spectroscopy in Organic Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The course is designed from application point of view. The different spectroscopic techniques used in organic chemistry will be considered and number of examples will be put before the students to solve making use of different spectroscopic techniques.*

Unit-I
Ultraviolet and Visible Spectroscopy (12 hrs)
Various electronic transitions (185-800 nm), Beer-Lambert law, Effect of solvent on electronic transitions, Ultraviolet bands for carbonyl compounds, Unsaturated carbonyl compounds, Dienes, Conjugated polyenes, Fieser-Woodward rules for conjugated dienes and carbonyl compounds, Ultraviolet spectra of aromatic compounds, Steric effect in biphenyls.
Circular Dichorism (CD): Principle of CD exciton chirality, Methods and applications.

Unit-II
Infrared Spectroscopy (12 hrs)
Basic principles, Characteristic vibrational frequencies of Alkanes, Alkenes, Alkynes, Aromatic compounds, Alcohols, Ethers, Phenols and Amines, Detailed study of vibrational frequencies of carbonyl compounds (Ketones, Aldehydes, Esters, Amides, Acids, Anhydrides, Lactones, Lactams and Conjugated carbonyl compounds), Effect of hydrogen bonding and solvent effect on vibrational frequencies, Overtones, Combination bands and Fermi resonance.

Unit-III
Nuclear Magnetic Resonance Spectroscopy (14 hrs)
General introduction and definition, Larmour frequency, Chemical shift, Spin-spin interaction, Shielding mechanism, Chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides and mercapto), Chemical exchange, Effect of deuteration, Complex spin-spin interaction between two, three, four and five nuclei (first order spectra), Virtual coupling, Stereochemistry: Hindered rotation, Karplus curve-variation of coupling constant with dihedral angle, Simplification of complex spectra: Nuclear magnetic double resonance, Contact shift reagents, Solvent effects, Fourier transform techniques, Nuclear overhauser effect (NOE), Resonance of other nuclei –F, P.

Unit-IV
Carbon-13 NMR Spectroscopy (10 hrs)
General considerations, Chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), DEPT, APT.
Two dimensional NMR spectroscopy– COSY, NOESY, HSQC, HMBC and INADEQUATE techniques.

Unit-V
Mass Spectrometry (12hrs)
Introduction, Ion production – El, Cl, FD and FAB, Factors affecting fragmentation of organic compounds, Common functional groups, Molecular ion peak, Metastable peak,

McLafferty rearrangement, Nitrogen rule, High resolution mass spectrometry, Examples of mass spectral fragmentation of organic compounds with respect to their structure determination, Introduction to modern MS techniques (MALDI, ESI).

BOOKS RECOMMENDED

1. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
2. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley & Sons (2005).
3. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley (1992).
4. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, (6^{th} Edition) Tata McGraw Hill Education (2011).
5. Organic Spectroscopy, William Kemp; Palgrave USA (2008).
6. Introduction to spectroscopy 94^{th} edition, Donald L. Pavia, Gary M. Lampman, George S. Kriz and James R. Vyvyan, Brooks/Cole, Cangage Learning (2009).
7. Comprehensive chiroptical spectroscopy: Applications in stereochemical analysis of synthetic compounds, natural products and biomolecules, Vol. 2, John Wiley & sons (2012).
8. Application of Mass spectrometry to Organic Chemistry, R. I. Reed, Academic Press London & New York.

PATTERN OF EXAMINATION

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Course No.: PSCHLC205 **Course Category: PSCC**
Title: Laboratory Course: Inorganic Chemistry
Credit: 03 **Maximum Marks: 75**
No. of hours: 45

***Course Outcome*:** *This course will help the students in volumetric as also commercial analysis. The green methods of preparation of inorganic complexes along with spectrophotometric determination will be focused.*

1. Volumetric Analysis:

Potassium iodate titrations: Determination of iodide, hydrazine, antimony (III) and arsenic (III)

2. Commercial Analysis:

i) Determination of available chlorine in bleaching powder
ii) Determination of Oxygen in hydrogen peroxide.
iii) Determination of Boric acid in borax.

4. **Green methods of preparation of the following:**

(i) Bis(acetylacetonato)copper(II)
(ii) Tris(acetylacetonato)iron(III)
(iii) Tris(acetylacetonato)manganese(III)
iv) Bis(ethylenediammine)dioxolatocobolt(III) chloride dihydrate
v) trans-dichlorobis(ethylenediammine)cobalt(III) chloride
vi) Vanadyl acetylacetonate
vii) cis-Potassiun diaquadioxalatochromate(III) dihydrate
viii) trans- Potassiun diaquadioxalatochromate(III) dehydrate

5. **Spectrophotometric Determinations**

(i) Ni by extractive spectrophotometric method.
(ii) Fe by Job's method of continuous variations
(iii) Fe in vitamin tablets
(iv) Nitrite in water in colorimetric method

6. **Any other experiment introduced by the Teacher**

Books Suggested:

1. Synthesis and Characterization of Inorganic Compounds, William L. Jolly, Prentice Hall.
2. Vogel's Textbook of Quantitative Inorganic Analysis, 4th Edn., Longman Group Limited, London.
3. A text Book of Quantitative Inorganic Analysis: A.I.Vogal.
4. Applied Analytical Chemistry: Vermani.
5. Commercial Methods of Analysis: Shell & Biffen
6. Experimental Inorganic Chemistry by W.G. Palmer, Cambridge
7. Inorganic Synthesis, MC Graw Hill.
8. Handbook of Preparative Inorganic chemistry Vol. I and II, Academic press.
9. Standard methods of chemical analysis by W.W. Scaff, Technical Press

PATTERN OF EXAMINATION

The daily evaluation of practical records / assignments / viva-voce, etc. shall have a marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

Course No.: PSCHLC206 **Course Category: PSCC**
Title: Laboratory Course: Physical Chemistry
Credits: 02 **Maximum Marks: 50**
No. of hours: 30

Course Outcome: *The aim of this course is to develop the experimental skill to the students by taking instrumentation tools and also physical tools to evaluate the various properties of solutions.*

Heat of solution:
Study the heat of solution of benzoic acid/oxalic acid by solubility method at different temperatures and the effect of electrolyte on it.

Adsorption:
Study the adsorption of oxalic acid on charcoal and hence check the validity of Langmuir adsorption isotherm and classical adsorption isotherm.

Critical solution temperature:
Determine the mutual solubility curve of phenol and water and hence find its consolute temperature and the effect of electrolyte on the system.

Abbe's refractometer:
Determine the refractive indices of given organic liquid at room temperature

pH meter and Conductivity meter:
Determine the pH of various mixtures of sodium acetate and acetic acid in aqueous solution and hence determine the dissociation constant of acid.
Determine the strength of strong and weak acid and their mixture using pH metry.
Determine the strength of strong and weak acid and their mixture using conductivity meter.
Study of kinetics of second order reaction using conductivity –meter .

Phase-Equilibria
Phase diagram of two component eutectic systems (Naphthalene-benzoic acid; acetamide-benzoic acid; naphthalene-diphenyl).
Phase diagram of two component compound forming systems (salicylic acid – benzamide, acetamide-β-naphthol).

Any other practical introduced by the teacher.

BOOKS RECOMMENDED

1. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.
3. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.
4. Experiments in Physical Chemistry by Shoemaker.
5. Practical Physical Chemistry by Viswanathan and Raghavan.
6. Advanced Practical Physical Chemistry by J. B. Yadav, Goel Publishing House.

PATTERN OF EXAMINATION

The daily evaluation of practical records / assignments / viva-voce, etc. shall have a marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

Course No.: PSCHLC207 **Course Category: PSCC**
Title: Laboratory Course: Organic Chemistry
Credits: 03 **Maximum Marks: 75**
No. of hours: 45

Course Outcome: *The students will be trained in synthesising the starting materials which may be of useful in the synthesis of more compounds. They will also get training as to how the two components can be separated from each other. The quantitative analysis will also form the part of the experimental course.*

a. **Organic Synthesis:** Sandmeyer reaction: p-Chlorotoluene from p-toluidine. Knoevenagel Condensation: Synthesis of cinnamic acid.
b. Friedel Crafts Reaction: β-Benzoyl propionic acid from succinic anhydride and benzene. Aromatic electrophilic substitutions: Synthesis of 4-nitroaniline and 4-bromoaniline. Beckmann rearrangement of acetophenone and benzophenone oximes.
   The products may be characterized by spectral techniques.
c. Separation and identification of organic compounds from two component mixture. The products may be characterized by spectral techniques.
d. **Quantitative Analysis:** Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method. Estimation of amines/phenols and glucose using bromated bromide solution/acetylation method. Determination of iodine and saponification values of an oil sample.

Any other experiment introduced by the concerned teacher.

BOOKS RECOMMENDED

1. Experiments and techniques in Organic Chemistry, D. Pasto, C. Johnson and M.Miller, Prentice Hall.
2. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath.
3. Systematic Qualitative Organic Analysis, H. Middlenton, Adward Arnold.
4. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
5. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
6. Monograph on Green Chemistry by Green Chemistry Task Force Committee, DST.

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Course No.: PSCHTE301 **Course Category: PSEC**
Title: Spectroscopy and Photochemistry in Inorganic Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome**:** *This course is aimed to have an insight of various spectroscopic tools in analyzing the inorganic molecules/complexes. The ligand field photochemistry is also a part of the course.*

Unit-I

Vibrational Spectroscopy **(12 hours)**

Symmetry and shape of AB2, AB3, AB4, AB5 and AB6 molecules, Mode of bonding of ambidentate ligands, nitro, thiocyanato, ethylenediamine and diketonato complexes, Raman Spectroscopy: Stokes and anti-stokes lines, Polarisability of ellipsoids, Rotational and vibrational Raman spectroscopy, Selection rules, Resonance Raman spectroscopy, Basic understanding and its applications particularly for study of active sites of metalloproteins.

Unit-II

a) Nuclear Magnetic Resonance of Paramagnetic Substances in Solution (12 hours)

The chemical shift in diamagnetic and paramagnetic molecules, The contact and Pseudocontact shifts, Factors affecting nuclear relaxation,

b) Nuclear Qudrupole Resonance (NQR) spectroscopy

Introduction, Quadrupole moment and field gradient, Quadrupole relaxation energies of quadrupole states, Effect of magnetic field on the NQR spectra, Applications and structural informations from NQR spectra.

Unit-III

Electron Spin Resonance Spectroscopy **(12 hours)**

Basic Principle, Spin Hamiltonian, Hyperfine coupling, Spin polarization and McConnell relationship, Isotropic and anisotropic hyperfine coupling constants, Spin-orbit coupling and significance of g- tensor, Application to transition metal complexes (having one unpaired electron) including biological systems and inorganic free radical viz. BF_2, F_2 , PH_4, etc.

Unit-IV

Mossbauer Spectroscopy **(12 hours)**

Basic Principles, Spectral parameters and spectrum display, Application of the technique to the studies of:
(a) Bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spin,
(b) Sn^{2+} and Sn^{4+} compounds, Nature of M-L bond, Coordination number and structure, and
(c) Detection of oxidation state and inequivalent MB atoms.

Unit-V

Ligand Field Photochemistry **(12 hours)**

Electronically excited states of metal complexes, Energy dissipation by radiative and non-radiative processes, Franck-Condon Principle, Mechanism of photo substitution reaction of Cr(III) complexes, Examples, Adamson's rule, Photo substitution and photo reduction reactions of Co(III) complexes, Photo substitution reactions of Rh(III) complexes.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.

2. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
3. Vibrational Spectroscopy- Modern Treheb, Barnes, A.J., and W.J. Orville-Thomas, Elsevier, 1977.
4. Chemical Applications of Group Theory, F.A. Cotton.
5. Introduction to Magnetic Resonance, A. Carrington and A.D. Maclachalan, Harper & Row.
6. Fundamentals of Molecular Spectroscopy. C.N. Banwell, Tata McGrew Hill.
7. Concepts of Inorganic Photochemistry, A. W. Adamson and P. D. Fleischauer, Wiley.
8. Physical Methods for Chemistry, R. S. Drago, Saunders Company.
9. Infrared and Raman Spectra : Inorganic and coordination compounds, K. Nakamoto, Wiley.
10. Structural Methods in Inorganic Chemistry, E.A. V. Ebsworth, D. W. H. Rankin and S. Cradock, ELBS.
11. Progress in Inorganic Chemistry, Vol. 8, ed., F. A. Cotton, Vol. 15, ed. S.J. Lippard, Wiley.
12. Applications of physical methods to Inorganic and Bioinorganic Chemistry, Robert A. Scott, Charles M. Lukehart, Wiley.
13. Inorganic Reaction Mechanism F. Basolo & R.G. Pearson
14. Inorganic Reaction Mechanism J.O. Edwards.
15. Photochemistry – Rohtagi Mukherjea.

PATTERN OF EXAMINATION

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Course No.: PSCHTE302 **Course Category: PSEC**
Title: Thermodynamics and Statistical Mechanics
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *This course will be useful in understanding the non-equilibrium thermodynamics, transport phenomenon, thermodynamics of mixtures, statistical mechanics / thermodynamics and their applications.*

Unit –I
Non Equilibrium Thermodynamics (12 hours)

Thermodynamic criteria for non-equilibrium states, Entropy production and entropy flow, Entropy balance equations for different irreversible processes (e.g. heat flow, chemical reaction etc.), Transformation of the generalized fluxes and forces, Non equilibrium stationary states, Phenomenological equations, Microscopic reversibility and Onsager's reciprocity relations, Electro kinetics phenomena, Diffusion, Electric conduction, Irreversible thermodynamics for biological systems, Coupled reactions.

Unit –II
Transport Phenomenon (12 hours)

Mass Transport: Diffusion, Diffusion coefficient, Time evaluation of concentration gradient, Fick's first and second laws, Statistical view of diffusion, Einstein-Smoluchowski equation, Thermal conductivity, Viscosity of gases and fluids, Poiseuillie's law, Einstein relation, Nernst-Einstein equation, Stokes-Einstein equation, Relation between flux and viscosity, Diffusion coefficient and mean free path, Thermal conductivity/viscosity and mean free path, Sedimentation and centrifugation, Ionic conduction, Strong and weak electrolytes.

Unit –III (12 hours)
Thermodynamics of Mixtures

Brief resume of classical concepts of thermodynamics including free energy, Chemical potential and entropies, Partial molar properties: Partial molar free energy, Partial molar volume and partial molar heat content and their significances, Determinations of these quantities, Concepts of fugacity and determination of fugacity.
Non ideal systems: Excess functions for non-ideal solutions, Activity, Activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions, Determination of activity and activity coefficients, Ionic strength.

Unit –IV (12 hours)
Statistical Mechanics

Role of statistical mechanics, Ensemble: Micro canonical, Canonical and Grand canonical, Postulates of ensemble averaging, Phase space, Stirling's approximation, Occupation number, Micro and macro states, Statistical weight factor, Probability, Concept of distribution, Thermodynamic probability, Types of statistics: Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Most probable distribution of three types of statistics, Lagrange's undetermined multipliers, Evaluation of β, Comparison of three statistics, Molecular partition function and its significance, Thermodynamic properties in terms of partition function, Numericals

Unit –V **(12 hours)**

Applications of statistical mechanics

Factorisation of molecular partition function, Canonical ensemble partition function (Independent and distinguishable molecules or particles; Independent and indistinguishable molecules or particles), Evaluation of translational, rotational, vibrational, electronic and nuclear partition functions, Contribution of translational, rotational and vibrational partition functions to thermodynamic functions, Effect of nuclear spin on diatomic molecules, Equilibrium constant of ideal gas in terms of partition function. Heat capacities of solids: Einstein theory and Debye theory, Numericals.

BOOKS RECOMMENDED

1. Thermodynamics for Chemists: S. Glasstone.
2. Statistical Thermodynamics: M.C. Gupta.
3. Physical Chemistry: P.W. Atkins.
4. Chemical Thermodynamics: R.P. Rastogi and R.R. Misra.
5. Statistical Mechanics and Properties of Matter: E.S.R. Gopal.
6. Statistical Mechanics, D.A. McQuarrie.
7. Thermodynamics of Irreversible Processes, Rolf Haase.
8. Fundamental of Chemical Thermodynamics, E.N. Yeremin.
9. Introduction to Irreversible Thermodynamics, Prgogine.
10. Modern Thermodynamics, D. KondePudi and I. Prigogine.
11. Physical Chemistry, Engel and Reid.

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Course No.: PSCHTE303 **Course Category: PSEC**
Title: Bio-Organic and Medicinal Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The aim of this course is to let the students understand enzymatic action, chemistry of vitamin B complex, coenzymes, drug design, design of drugs, synthesis of antibiotics, etc.*

Unit-I

Enzymes, kinds and mechanism of enzymatic reactions (10 hrs)

Introduction, Remarkable properties of enzymes like catalytic power, Specialization and regulation, Fischer's lock and key and Koshland's induced fit hypothesis, Concept and identification of active site by the use of inhibitors, Enzyme modification by site-directed mutagenesis, Orientation and steric effects in enzyme catalysis (acid, base and covalent catalysis).

Unit-II

Chemistry of Vitamin B-Complex and Coenzymes (12 hrs)

Introduction, Classification and nomenclature of vitamins, Occurrence, Functions and mechanism of action of thiamine, Riboflavin and Pantothenic acid, Cofactors as derived from vitamins, Coenzymes, Prosthetic groups, Apoenzymes, Structure and biological functions of coenzyme A, Thiamine pyrophosphate, Pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD, Lipoic acid, Vitamin B_{12}.

Unit-III

Drug-design and Co-crystals (14 hrs)

Introduction, Concept of Lead compounds, Factors governing drug design and rational approach, Drug design through method of variations, Disjunction and conjunction, Bioisosteric replacement, Rigid analogs, Homologation of alkyl chains, Changes in ring size and ring position isomers, Alteration of stereochemistry, Fragments of lead molecules.

Co-crystals: General introduction, Historical perspective, Designing and characterization techniques, Factors affecting designing of co-crystals and applications in pharmaceuticals.

Unit-IV

Structure and mode of action (12 hrs)

Cardiovascular drugs: Antihypertensive and hypotensive drugs:

Hydralazine (Apresoline hydrochloride), Methyldopa (Aldomet), Procainamide (Pronestyl), Antisympathetic drugs- Propanolol (Indral), Verapamil (Isoptin) and Prenylaminelactate (Synadrin), Rosuvastatin (Crestor)

Antiparkinsonian Agents: Biperiden hydrochloride (Akineton hydrochloride), Ethopropazine hydrochloride (Profenamine) and Levodopa (Bendopa).

Anticancer drugs: Adriamycin, Texol, Tamoxifen.

Antihistaminic drugs: Cetrizine, Promethazine hydrochloride and Chloropheniramine meleate (Alermine).

Antimalarials: Chloroquine phosphate (Resochin) and Mepacrine hydrochloride (Quinacrine).

Antidiabetic: Sitagliptin (Januvia), Metformin (Glucophage)

Unit-V

Antibiotics (12 hrs)

Introduction, Classification, Isolation and chemistry of Pencillins, Chloramphenicol and Tetracyclines (oxy tetracycline).

Vitamins: Occurrence, Chemistry, Functions and Mechanism of action of Ascorbic acid, α-Tocopherol and Vitamin K_1 & K_2.

BOOKS RECOMMENDED

1. Bio-organic Chemistry: A Chemical Approach to enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
2. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer, Philip L.R. Bonner, 2nd edition.
3. Enzymatic Reaction Mechanism, C. Walsh and W.H. Greeman.
4. Enzyme Structure and Mechanism, A. Fersht and W.H. Freeman.
5. Textbook of Organic Medicinal and Pharmaceuticals Chemistry, 8th Ed., Edited by R.F. Doerge, J.B. Lippincott Co., Philadelphia 1982.
6. Pharmaceutical Chemistry in Perspective, B.G. Reuben and H.A. Wittcoff, John Wiley and Sons., N.Y.
7. Principles of Medicinal Chemistry, Lea and Febiger, Philadelphia, USA.
8. Strategies of Organic Drug Synthesis and design, D. Lendnicer, John Wiley and Sons, N.Y.
9. Burger's Medicinal Chemistry, Drug Discovery and Development, John Wiley and Sons.
10. Crystal Engineering: Desi Raju, World scientific publishing Singapore 2011.

PATTERN OF EXAMINATION

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Course No.: PSCHTE304 **Course Category: PSEC**
Title: Catalysis: Fundamentals and Chemical Concepts
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The students will acquire the advance knowledge of heterogeneous/homogeneous catalysis, catalytic polymerization, electrocatalysis, photolysis and photocatalysis.*

Unit-I

Heterogeneous Catalysis **(14 hrs)**

Introduction to heterogeneous catalysis, Energy profile diagram and diffusion of gas, Adsorption: Physical and chemical adsorption, Chemisorption of gases on solid surfaces, Nature of adsorbed layer, Dissociative adsorptions, Models OF chemisorptions, Simple adsorptio isotherm, Langmuir adsorption, BET adsorption isotherm and Surface area determination.

Preparation and separation of the catalysts, Meso and microporous materials, Nano material catalysts and significance, Zeolites and related molecular sieves, Supported and bifunctional catalysts and catalyst regeneration, Activity and life of the catalysts, Active centres, Promoters and poisons, Catalyst deactivations, Characterization of Solid Catalysts: Structure and surface morphology, Porosity, Pore volume and Diameter, Particle size, X-ray diffraction, DTA-TG, SEM, TEM, X-ray absorption spectroscopy and XPS.

Heterogeneous reactions: Mechanism of catalytic reactions, Oxidation reduction reactions, Fisher tropsch catalysis, Selective catalytic reduction.

Unit-II

Homogeneous Catalysis **(10 hrs)**

Introduction to homogeneous catalysis and energy profile diagram, Intermediate stages in homogenous Catalysis, General scheme for calculating kinetics of the reactions, Decomposition of hydrogen peroxide, Acid-base catalysis, Hydrogenation, Hydroformylation, Isomerization, Wacker reaction, Coupling reactions (Suzuki, Heck and Sonogashira) and asymmetric oxidations.

Unit-III

Catalytic polymerizations **(12 hrs)**

Homogeneous and heterogeneous catalysis in polymerizations reactions (few examples), Ziegler – Natta catalyst in polymerizations reactions.

Catalyst for energy and environment

Catalytic gasification, Steam reforming, Electro-catalysis, Fuel cells for energy production like methanol, Molten carbonate and solid oxide fuel cells, Catalysts for environmental pollution in emission control and selective catalytic reduction.

Unit-IV

Photolysis and photocatalysis **(12 hrs)**

Photo-sensitized and photo-oxidations reactions, Semiconductor photocatalysts, Generation of hydrogen by photo-catalysts and harnessing solar energy, Photodegradation of dyes.

Phase transfer catalysis

Mechanism of PTC, Types of phase transfer catalysis with selected examples and advantages.

Unit-V

Electrocatalysis (12 hrs)

Basic electrocatalytic concepts, Comparison of electrocatalysts, Electrosorption, Porous gas diffusion electrodes, Electrolysis of water and role of electrocatalysts, Hydrogen evolution reaction and investigation of its detailed mechanisms, Choice of electrocatalysts, Oxygen reduction reaction and electro-organic oxidation, e.g., methanol, Special features of electro-catalysis, Principles of electrosysnthesis.

BOOKS RECOMMENDED

1. G.C. Bond, "Heterogeneous catalysis and applications" Oxford (1987).
2. D. K. Chakraborty and B. Vishwanathan, "Heterogeneous catalysis" New Age (2008).
3. J. M. Thomas and W.J. Thomas "heterogeneous catalysis" VCH publication (1997).
4. M. Beller, A. Renken and R. van Santen, "Catalysis", Wiley VCH (2012).
5. G. Panchenov and V. Lebedev, "Chemical kinetics and catalysis" Mir publication (1976).
6. R. Van Santen and J. Niemantsvedict, "Chemical Kinetics and Catalysis", Plenum Press (1995).
7. D. Briggs and M. Seah, "Practical surface analysis by AES & XPS", John Wiley (1983).
8. Holy Hammerich, Bernd, Speiser (Ed) "Organic Electrochemistry: Revised and expanded", 5th Edn., CRC Press (2015).

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Course No.: PSCHTE305 **Course Category: PSEC**
Title: Advanced Photochemistry and Radiation Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *On completion of this course, the students will gain knowledge about photochemistry and radiation chemistry and the related phenomenon associated with these concepts.*

Unit I
Molecular Photochemistry: An Overview (14 hrs)
Transitions between states (Chemical, classical and quantum dynamics, Vibronic states), Potential energy surfaces, Transitions between potential energy surfaces, The Franck-Condon Principle and radiative transitions, A classical model of radiative transitions, The absorption and emission of light - state mixing, Spin-orbit coupling and spin forbidden radiative transitions, Absorption complexes, Delayed fluorescence and phosphorescence.

Unit II
Photophysical Radiationless Transitions (12 hrs)
Wave mechanical interpretation of radiationless transitions between state factors that influence the rate of vibrational relaxation, Energy transfer: Theory of radiationless energy transfer, Energy transfer by electron exchange: An overlap or collision mechanism, The role of energetic in energy transfer mechanism, Diffusion controlled quenching, The Perrin formulation, Triplet-triplet, Triplet-singlet, Singlet-triplet energy transfer, Multiphoton energy transfer processes, Reversible energy transfer.

Unit III
Radiation Chemistry (12 hrs)
An overview, G-value, The mechanism of interaction of high energy radiation with matter, Photoelectric effect, Compton effect, Pair production, Total absorption co-efficient, Excitation and ionization, Stopping power and linear energy transfer.

Unit IV
Radiation dosimetry (12 hrs)
Radiation dose and its measurement, Standard free air chamber method, Chemical dosimeter (Frick's Dosimeter), Short lived intermediates (ions, excited molecules, free radicals: Various mechanisms of their formation and energy transfer processes).

Unit V
Flash photolysis (10 hrs)
Principle and its applications, Radiolysis of water and aqueous solutions, Radiolysis of molecules of biological interest (Carbohydrates, Amino acids, Peptides and Nucleic acids).

BOOKS RECOMMENDED

1. Turro, N. J. *Modern Molecular Photochemistry,* Univ. Science Books (1991).
2. Gilbert, A. & Baggot, J. *Essentials of Molecular Photochemistry* Blackwell Scientific (1990)
3. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).

4. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).

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Course No.: PSCHTE306 **Course Category: PSEC**
Title: Chemistry of Inorganic Rings, Cages, Clusters and Nanomaterials
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *In this course, the students will acquire the knowledge of chemistry of some important materials and their applications.*

Unit-I
Bonding Modes **(12 hrs)**
Synthesis, Structure, properties (physical and chemical) and modes of bonding in Silioxanes, Borazines, Phosphazenes, Polyhedral Boranes, Carboranes, Metalloboranes and Metallocarboranes, Applications of Silioxanes, Borazines, Phosphazenes, Polyhedral boranes, Carboranes, Metalloboranes and Metallocarboranes.

Unit-II
Silicates and Aluminosilicates **(12 hrs)**
Types and Classification, Synthesis, Structure, properties and Applications of naturally occurring silicates and aluminosilicates, Syntheses of pillared clays and zeolites, Characterization of clays, Pillared clays and Zeolites from measurement of surface area, Surface activity pore size, Distribution and interlayer spacing, Application of clays, Pillared clays and zeolites with emphasis of catalyses.

Unit-III
Properties of Nanomaterials **(12 hrs)**
Electronic Properties: Classification of materials: Metal, Semiconductor, Insulator, Band structures, Brillouin zones, Mobility, Resistivity, Superparamagnetism, Blocking, Important properties in relation to nanomagnetism.
Optical Properties: Photoconductivity, Optical absorption and transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Thermal Properties and Mechanical Properties.

Unit-IV
Synthesis and Characterization of Nanomaterials **(12 hrs)**
Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Post-synthetic size-selective processing, Sol-gel, Micelles and microemulsions.
Biological Methods of Synthesis: Use of bacteria, Fungi, Actinomycetes for nanoparticles synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles, Mechanism of formation, Viruses as components for the formation of nanostructured materials, Synthesis process and application, Role of plants in nanoparticle synthesis.

Unit-V
Characterization Techniques and Applications of Nanomaterials **(12 hrs)**
X-ray diffraction, Scanning Probe Microscopy, SEM, TEM, Optical microscope and their description, Operational principle and application for analysis of nanomaterials, UV-VIS-IR spectrophotometers, Applications of nanomaterials in modern technologies

BOOKS RECOMMENDED

1. F. A. Cotton, G. Wilkinson, C A. Murillo and M Bochmann. Advanced Inorganic Chemistry Sixth Edition, Wiley-India (2011).
2. Sels, B.F. & Kustov, L.M. Zeolites and Zeolite-like materials 1st Edition, Elsevier (2016).
3. Wells, A.F. Structural Inorganic Chemistry, 5th Edition, Oxford University Press, Oxford (1984).
4. Liebau, F. Structural Chemistry of Silicates: Structure, Bonding, and Classification, Springer- Verlag Berlin Heidelberg (1985).
5. Dupas, C., Houdy, P. & Lahmani, M. Nanoscience: Nanotechnology and Nanophysics, Springer (2004)
6. Wilson, M., Kannangara, K., Smith, G., Simmons, M. & Raguse, B. Nanotechnology: Basic Science and Emerging Technologies, Overseas Press (2005).
7. Poole Jr., C. P. & Ovens, F. J. Introduction to Nanotechnology, Wiley Interscience (2003)
8. Edelstein, A.S. & Cammarata, R. C., Ed. Nanomaterials: Synthesis, Properties and Applications, Institute of Physics Publishing (1996) 39
9. Rao, C.N.R., Müller & Cheetham, A.K., Eds. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim (2004)
10. Edelstein, A.S. & Cammarata, R.C., Ed. Nanomaterials: Synthesis, properties and Applications, Institute of Physics Publishing (1996).

PATTERN OF EXAMINATION

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The major test will be held at the end of semester on completion of 41% to 100% of the syllabus. This test will have seven questions (each of twelve marks). The students have to attempt five questions in all. Question no. 1 (short answer type) will be compulsory and will be set out from 40% of syllabus covered in Minor I & II. The remaining six questions will be from across the syllabus of 41% to 100% i.e. beyond Minor I & II. The student has to attempt any four questions out of six questions.

There shall also be an **Audit course** for CBCS in the 3rd semester. Here a student shall attend classes but cannot be graded or given credit for this course. In this course, the registered research scholars of the Department will present their findings in the presence of all faculty members to the students of 3rd semester. The two lectures per week (from July to November) will be delivered by various research scholars and duration of each lecture will be of 30 minutes. It will be mandatory for all students of 3rd semester to be present and attend this course. The work reported by various research scholars will help the students for the purposes of their self enrichment and academic exploration. It will be also beneficial to those students who wish to choose research as their carrier. The students completing this course must have a minimum of 75% mandatory attendance failing which they will not be eligible to appear in the major examination. The Head of the Department shall be the Course Director who will draft the schedule of lectures in consultation with the faculty members.

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Course No: PSCHTO307 **Course Category: PSOCC**
Title: Environmental Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *It is an open choice course not for the students of chemistry but for the students from other streams. The course is designed in such a way that the students from different streams get a flavour of the things which surround them in their day to day activities.*

Unit I

Environment: (12hrs)

Earth's Atmosphere: Structure and composition of atmosphere, Temperature measurements and controls: Vertical temperature and stability of atmosphere, Biogeochemical cycle of Carbon, Nitrogen, Oxygen and Sulphur.

Soils

Composition of soil and its profile, Various micro and macro nutrients present in soil, Nitrogen, Phosphorus and Potassium in soil, Acid-base and ion exchange reactions in soils, Soil pollution due to fertilizers, pesticides and solid waste (plastics and metals).

Unit II

Hydrosphere (12hrs)

Chemical composition of water bodies – lakes, streams and rivers; Hydrological cycle; Types, sources and classification of water pollutants like industrial water pollution, pollution pesticide, detergent and oil pollutants. Effects of water pollutants on life and environment; Water quality parameter and their analytical methods: Dissolved oxygen, Biochemical oxygen demand, Chemical oxygen demands, Solids, Contents of chloride and chlorine demand

Unit III

Industrial Pollution (12 hrs)

Environmental implications and abetment of Cement industry, sugar mill, paper and pulp mill, thermal power plant and polymer/plastic industry, Solid Waste Management: Landfill, Incineration, Resource reduction, Recycling and reuse, Composting and organic farming.

Unit IV

Atmosphere (12 hrs)

Atmospheric chemistry: Chemical composition of atmosphere – particles, ions and radicals and their formation, Chemical and photochemical reactions in atmosphere, Smog formation, oxides of N, C, S, O and their effects, Air pollution – Types and sources, Depletion of stratospheric ozone, Industrial and transport-related air pollution, Chlorofluoro hydrocarbons, Green house effect (Global warming) and acid rains.

Unit V

Environmental Toxicology (12 hrs)

Hazardous waste: Introduction, origin, transport, effects and fates, Chemical solutions to environmental problems biodegradability, Principles of decomposition better industrial processes.

Bhopal gas tragedy, MIC and its impacts and Minamata disasters; Nuclear Hazards: Chernobyl and Three Mile Island

BOOKS RECOMMENDED

1. Environmental Chemistry, S. E. Manahan, Lewis Publishers
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers
3. Environmental Chemistry, A. K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S. M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F. J. Welcher, Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
8. Environmental Chemistry, C. Baird and W. H. Freeman.

PATTERN OF EXAMINATION

There shall be two **Minors (I & II)** and one **Major** tests in each theory course. Each Minor test shall have marks weightage of 20% and its duration will be of 1½ hour. The Major test shall have marks weightage of 60% and its duration will be of 03 hours. **Minor**–**I** will be held after 3-4 weeks on completion of 20% of the prescribed syllabus. **Minor**–**II** will be held after 8-9 weeks on completion of 21% to 40% of the prescribed syllabus.

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Course No.: PSCHLC308 **Course Category: PSCC**
Title: Laboratory Course: Inorganic Chemistry
Credits: 02 **Maximum Marks: 50**
No. of hours: 30

Course Outcome: *This course aims to develop an understanding of quantitative as also qualitative analysis, separation of cations by paper chromatography. The students will also be trained to prepare and characterise the compounds using the available techniques.*

Preparation of selective inorganic compounds and their study by IR, electronic spectra, and magnetic susceptibility measurement. Handling of air and moisture sensitive compounds involving vacuum lines.
Selection can be made from the following:

1. Sodium amide, Inorg. Synth., 2, 128 (1946).
2. Trialkoxyboranes- Preparation, IR and NMR spectra. J. Am. Chem. Society, Vol 92, 1970.
3. Preparation of vanadylacetyacetonate; Inorg. Synth. 5, 113 (1957).
4. Preparation of tris(ethylenediamine)nickel(II)chloride; Inorg. Synth. 6, 200 (1960)
5. Preparation of tris(acetylacetonato)manganese(III); Inorg. Synth. 7, 183, (1963).
6. Preparation of tris(acetylacetonato)alumimium(III), Inorg. Synth. 7, 183, (1963).
7. Preparation of Trioxalato salts $M'_3[M'''(C_2O_4)_3].3H_2O$ (M' = K and M''' = Al, Fe, Co or Cr); Inorg. Synth. 1, 35, (1939).
8. Dichlorophenylborane-synthesis in vacuum line.

Gravimatric and Volumetric analysis: Vanadium, Nickel, Manganese, Aluminium, Chromium, Chloride (Volhard's method) etc.

Paper Chromatography: Separation and identification of group cations

1. Separation and identification of group I cations (Pb^+, Ag^+, Cr^+).
2. Separation and identification of group II cations (Hg^{2+}, Cu^{2+}, Cd^{2+} and Bi^{2+}).
3. Separation and identification of group III cations (Fe^{3+}, Al^{3+}, Cr^{3+}).
4. Separation and identification of group IV cations (Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}).

Any other experiment introduced by the concerned teacher.

BOOKS RECOMMENDED

1. Vogel's textbook of quantitative chemical analysis (5^{th} and 6^{th} edition).
2. G. R. Chatwal, Instrumental Methods for Chemical Analysis, 5^{th} ed., Himalaya Publications (India).
3. V. K. Ahluwalia and S. Dingra, Advanced experimental Inorganic Chemistry, Manakin Press Pvt. Ltd., 2016.

PATTERN OF EXAMINATION

The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

Course No.: PSCHLC309 **Course Category: PSCC**
Title: Laboratory Course: Physical Chemistry
Credits: 03 **Maximum Marks: 75**
No. of hours: 45

Course Outcome: *On successful completion of this course, the student should understand the concepts and conventions of rate of reaction, thermodynamics, pH and conductivity measurements.*

Number of hours of each experiment 3-4 hours. A list of experiments under different heading is given below .Typical experiments are to be selected from each type.

Chemical Kinetics

i) Study the kinetics of bromination of phenol by bromide-bromate mixture in an acid medium as a clock reaction.
ii) To find out the order of reaction between potassium bromate and potassium iodide.

Thermodynamics

i) Determination of partial molar volume of solute (e.g. KCl) and solvent in a binary mixture.
ii) Determination of temperature dependence of solubility of compound in two solvents having similar intermolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.

Conductivity

i) Determine the hydrolysis constant of aniline hydrochloride at different temperatures conductometrically.
ii) Estimate the concentration of HCl, CH_3COOH and $CuSO_4.5H_2O$ in a given solution by carring out conductometric titration with NaOH solution.
iii) Determine the equivalent conductance of a strong electrolyte i.e. NaCl, KCl at several concentrations and hence verify Debye Huckel Onsager equation.
iv) Determine the equivalent conductance of a weak electrolyte i.e. CH_3COOH at infinite dilution by Kohlurasch law.
v) Determine the degree of hydrolysis and hydrolysis constant of CH_3COONa, NH_4Cl conductometrically.

pH metry

i) Determine the strength of unknown solution of HCl by titrating it with NaOH solution using pH meter.
ii) To find the strength of unknown solution of NH_3 solution by titrating it with CH_3COOH solution.
iii) To find the strength of unknown solution of Na_2CO_3 solution by titrating it with HCl solution.
iv) To find out the dissociation constant of polybasic acid e.g. phosphoric acid by titrating it with NaOH solution.

Any other practical introduced by the teacher.

BOOKS RECOMMENDED

1. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.

3. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.
4. Experiments in Physical Chemistry by Shoemaker.
5. Practical Physical Chemistry by Viswanathan and Raghavan.

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Course No.: PSCHLC310 **Course Category: PSCC**
Title: Laboratory Course: Organic Chemistry
Credits: 03 **Maximum Marks: 75**
No. of hours: 45

***Course Outcome*:** *The objective of this course is to make the students to understand how the qualitative analysis is useful for identification of mixture or organic compounds. Some organic compounds are also to be analyzed using spectroscopic techniques.*

Qualitative Analysis
Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two solids and one liquid), using TLC for checking the purity of the separated compounds, chemical analysis, IR, PMR and mass spectral data.

Paper Chromatography
Separation and identification of carbohydrates from given mixture by paper chromatography and determination of R_f values.

Spectroscopy
Identification of some simple organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR and MS).

Any other experiment introduced by the concerned teacher.

BOOKS RECOMMENDED

1. Vogel's text book of Quantitative analysis, revised, J. Bassett, R.C. Denney, G.H. Jaffery and J. Mendham, ELBS.
2. Experiments and techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miler, Prentice Hall.
3. Systematic Qualitative Organic analysis, H. Middlenton, Adward Arnold.
4. Experimental Organic Chemistry, Principles and Practice, Lawrence M. Harwood and Christopher J. Moody, Blackwell Scientific Publications.
5. Spectrometric Identific of Organic compounds, R.M. Silverstein, G.C. Bassler and T.C. Marrill, John Wiley.
6. Spectroscopic methods in Organic chemistry, D.H. Williams, I. Fleming, Tata McGraw Hill.
7. Organic Spectroscopic, William Kemp.
8. Monograph on Green Chemistry by Green Chemistry Task Force Committee, DST

PATTERN OF EXAMINATION

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Course No.: PSCHTE401 **Course Category: PSEC**
Title: Analytical Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome**:** *This course is focused on various advanced analytical techniques and its applications.*

Unit-I
Electron Spectroscopy **(12 hrs)**
Definition of a solid surface, Types of surface measurements, X-Ray photoelectron spectroscopy (XPS/ESCA): Introduction, principle, chemical shifts as a function of oxidation states, Instrumentation, Applications.
Auger electron spectroscopy: Principle, instrumentation- Radiation source, Energy analyzer, Detector, Auxiliary system, Applications- Quantitative analysis.

Unit-II
Electron Microscopy **(12hrs)**
Scanning electron microscopy (SEM): Basics, Instrumentation, Applications, Transmission electron microscopy (TEM): Introduction, Basic theory, Electron gun, Electromagnetic lenses, Imaging, Operating parameters- Magnification, Resolution, Depth of field, Sample preparation, Specimen orientation and manipulation, Applications, Selected Area Electron Diffraction, Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM) and Scanning Tunnelling microscopy (STM).

Unit-III
Thermoanalytical and Electroanalytical Methods **(12 hrs)**
Introduction, Thermogravimetry (TG), Instrumentation, Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC), Applications of thermal methods.
Potentiometric method: Reference electrodes and indicator electrodes, Hydrogen, Calomel and Ag-AgCl electrodes, Glass electrode, Performance and limitations, Measurement of pH, Potentiometric titrations, Redox and Precipitation titrations.

Unit-IV
(a) Potentiometry **(12 hrs)**
General principles, Liquid-junction potential, Reference electrodes, pH meter, Direct Potentiometric measurements, Potentiometric pH measurements with glass electrode and combination pH electrode, Potentiometric titration.
(b) Conductometry
Basic principles, Instrumentation, Conductance cells, Conductometric titrations- Acids of different pka values at various concentrations by strong and weak base, Modifications for titration of weak acid, Mixture of a strong and weak acid.

Unit- V
Application of Electrochemistry **(12 hrs)**
Electrode reaction fundamentals, Potentials of electrochemical reactions, Electrochemical cells and practical considerations, Solvent/electrolyte for electrochemistry, Working,

reference and auxiliary electrodes, Applications: Potential sweep methods, Linear sweep voltametry (LSV).
Cyclic voltametry (CV), Practical considerations for potential sweep methods, Example of application of CV to study Rh complexes, Surface- attached analytes in CV

BOOKS RECOMMENDED

1. Instrumental Analysis, 2nd Ed., Bauer, Christian, O'Reilly, Allyn and Bacon, 1978.
2. Principles of Instrumental Analysis, 5th Ed- Indian Reprint, Skoog, Holler, Nieman, Harcourt Asia, 2001.
3. Instrumental Analysis, Skoog, Holler, Crouch, Brooks Cole- Cenage Learning, 2003.
4. Transmission Electron Microscopy, Williams and Carter, Plenum Press, New York and London, 1996.
5. Nature and Science, 4(3), 2006, Ma, et al, Transmission & Scanning Electron Microscopy.
6. Instrumental Methods of Analysis, 7th edn. H.H. Willard, L.L. Merritt, Jr. and J.A. Dean and F.A. Settle, Jr. Publishers and Distributors, New Delhi, 1986.
7. Instrumental Analysis, G. D. Christian, (Second Edition) James E. Reilly, Allyn and Bcon, Inc., Bostan London.
8. Fundamental of Analytical Chemistry, D.A. Skoog D.M. West and F.J. Holler, Saunders College Publishing, New York, 1988.
9. Principles of Instrumental Analysis by Skoog Holler, Neiman (2001). V. Edn.
10. Solid State Chemistry and its applications, Anthony R. West, John Wiley & Sons.
11. Physical Principles of Electron Microscopy: An introduction to TEM, SEM and AFM by R.F. Eqerton, Springer, 2008.
12. Introduction to Atomic Force Microscopy, Paul E. West, Pacific Nanotechnology, USA.
13. Solid State Chemistry Techniques, A. K. Cheetham and Peter Day, Oxford Science Publications.
14. Scanning Probe Microscopy and Spectroscopy, Ronald Weisendanger, Cambridge University Press.

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Course No.: PSCHTE402 **Course Category: PSEC**
Title: Organotransition Metal Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *This course will enable the students to learn the functions, structures and importance of organotransition metal compounds.*

Unit-I
Compounds of Transition Metal-Carbon Multiple Bonds (12 hrs)
Alkylidenes, Alkylidynes: Low valent (Fischer) and high valent (Schrock) carbenes and carbynes-Synthesis, Nature of bond, Structural characteristics, Nucleophilic and electrophilic reactions of the ligands, Catalytic and other applications.

Unit–II
Transition Metal – π Complexes (10hrs)
Transition Metal – π complexes with unsaturated organic molecules like alkenes, Alkynes, Allyls, Diene and Arene complexes, Preparation, Properties, Chemical reactions, Nature of bonding and structural properties.

Unit-III
σ – Bonded Transition Metal Complexes (Hydrocarbyls) (12 hrs)
Types, Bonding and structure of hydrocarbyls, Routes of synthesis, Thermal stability and decomposition pathways, Chemical reactions and applications of organo-copper compounds in organic synthesis.

Unit-IV
Homogeneous Catalysis (12 hrs)
Stoichiometric reactions for catalysis, Activation of C-H bond, Homogeneous hydrogenation catalysis (Wilkinsons Catalyst), Asymmatric Hydrogenation using Chiral Catalyst, Zeigler-Natta polymerization of olefins, Catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), Methanol carbonylation and olefin oxidation: Wacker, Monsanto and Cativa process.

Unit-V
Fluxional Organometallic Compounds (14 hrs)
Fluxionality and dynamic equilibria in compounds such as η^2-olefin, η^3-allyl and dienyl complexes, Non-rigid molecules in different coordination geometry.
Transition Metal Compounds with Bonds to Hydrogen
Chemistry of transition metal compounds with bonds to hydrogen: Types, Synthesis and chemical reactions, Aluminohydrides and Borohydrides.

BOOKS RECOMMENDED

1. Principles and Applications of Organotransitiion Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Finke, University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.
3. Metallo-organic Chemistry, A.J. Pearson, Wiley.

4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.
5. Basic Organometallic Chemistry, Concepts, Syntheses and Applications, B.D. Gupta and A.J. Elias, University Press.

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Course No.: PSCHTE403 **Course Category: PSEC**
Title: Bioinorganic and Supramolecular Chemistry
Credit: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The focus of this course is to enable the students to learn about the bioinorganic and molecular recognition and design of molecules for the beneficial of society.*

Unit-I **(12 hrs)**

Metal complexes in transmission of energy: Chlorophyll's, Photosystem I and photosystem II in cleavage of water.

Nitrogen fixation: Biological nitrogen fixation and its mechanism, Nitrogenase, Chemical nitrogen fixation.

Transport and storage of dooxygen: Heme proteins and oxygen uptake, Structure and function of hemoglobin, Myoglobin, Hemocyanins and hemerythrin, Model synthetic complexes of iron, cobalt and copper.

Unit-II **(12 hrs)**

Structure, function and biochemistry of enzymes containing following metals:

i) Zinc
Zinc Fingers, Carboxy peptidase, Carbonic anhydrase

ii) Copper
Type I, Type II, Type III
Blue Proteins: Azurins, Plastocynins & Blue Oxidases, Model compounds of Blue copper proteins
Non Blue Proteins: Tyrosinase, Galactose oxidase, SOD

iii) Cobalt
Vitamin B12 co enzymes and model compounds, Actions of Cobalamines, Adenosylcobalamine as a coenzyme, Ribonucleotide reductase, Methylcobalamine as cofactor

Unit-III **(12 hrs)**

Metal Storage, Transport and Biomineralization: Ferritin, Transferrin and Siderophores.

Structure and function of metalloproteins in electron transport processes – Cytochromes and Iron-Sulphur proteins,

Iron enzymes – catalase, peroxidase and cytochrome P-450

Molybdenum oxotransferase enzymes–Xanthine oxidase, Mo-cofactors, Antagonism between Cu and Mo, Hydroxylase

Unit-IV

Supramolecular Chemistry **(12 hrs)**

Molecular recognition

Introduction to recognition, Information and complementarity, Molecular receptors- Design principles, Spherical recognition- Cryptates of metal cations, Tetrahedral recognition by macrocyclic cryptands, Recognition of ammonium ions and related substrates, Recognition of neutral molecules, Recognition of anionic substrates (anionic coordination)

Intermolecular Interactions: General Properties, van der Waals Interactions, Hydrogen bonds, Halogen bonds, Other interactions

Unit- V **(12 hrs)**

Multi-component Crystals: General classification and nomenclature, Solid solutions, Host-guest compounds, Solvates and hydrates, Donor-acceptor complexes, Co-crystals

Transport processes and carrier design:

Carrier – mediated transport, Cation transport processes – Cation carriers, Anion transport processes – anion carriers, Coupled processes.

Molecular and Supramolecular devices: Supramolecular photochemistry, Supramolecular electronic devices, Supramolecular ionic devices

Books Suggested:

1. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, University, Science Books.
3. Inorganic Biochemistry Vols. I and II ed., G. L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry, Vols. 18 and 38 ed., J.J. Lippard, Willey.
5. Supramolecular Chemistry, J. M. Lehn, VCH.
6. Bioinorganic Chemistry: A Short Course-Rosette M.Malone, Wiley Interscience, 2002.
7. Biological Inorganic Chemistry-An Introduction, Robert Crichton, Elsevier Science, 2007.
8. Supramolecular Chemistry: A Concise Introduction, J. L. Atwood and J. W. Steed, John Wiley & Sons, 2000.
6. Perspectives in Supramolecular Chemistry, G. R. Desiraju, Vol. 2, John Wiley & Sons.
7. Crystal Engineering, G. R. Desiraju, Cambridge university Press India Pvt. Ltd., 2011.

PATTERN OF EXAMINATION

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Course No.: PSCHTE404 **Course Category: PSEC**
Title: Solid State Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *The students will have an understanding of general principles of solid state reactions, preparation, methods and crystal symmetry, defects/structure of solids and their electronic, ionic conduction and magnetic properties.*

Unit-I
Structure of Solids (12 hrs)
Closed packed structures: cubic close packing and hexagonal close packing, Some important structure types: NaCl, ZnS, CsCl and perovskite ($SrTiO_3$), Crystal systems, Bravais lattice, Lattice planes, Miller indices and directions, Symmetry: Point symmetry, Space symmetry and point groups, Representation of point groups and selected examples, Space groups.

Unit-II
Preparative Methods (10 hrs)
General Principles of Solid State Reactions, Preparation of materials in solid state: Precursor, ceramic, Sol-gel, Hydrothermal, Electrochemical reduction methods, Vapour phase transport and high pressure methods, Preparation of thin films, Growth of single crystals.

Unit III
Crystal Defects and Solid Solutions (12 hrs)
Crystal defects - Perfect and imperfect crystals, Intrinsic and extrinsic defects, Point defects (Schottky and Frenkel defects), Thermodynamics of Schottky and Frenkel defect formation, Colour centres, Line defects: Edge dislocation and Screw dislocation, Plane defects: Grain boundary and Staking faults, Topochemical control of solid state organic reactions, Solid solutions: Substitutional solid solutions, Interstitial solid solutions, More complex solid solutions mechanisms, Requirements for solid solutions and formation.

Unit-IV
Electronic and Ionic Conduction (12 hrs)
Metals, insulators and semiconductors, Electronic structure of solids, Chemical and physical approaches- Band theory, Band structure of metals, Insulators and Semiconductors, Intrinsic and extrinsic semiconductors, Doping of semiconductors, Applications of semiconductors, Ionic conductivity in solids, Solid electrolytes- Fast ion conductors: α-AgI, β-Alumina, Halide ion conductors, Oxide ion conductors, Superconductivity: The discovery of superconductors, Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity, Effect of magnetic field, High T_C superconductivity, New superconductors, Applications of High T_C superconductors.

Unit-V
Magnetic and Dielectric Properties (12 hrs)
Magnetic properties – Classification of materials, Behaviour of substances in a magnetic field, Effect of temperature: Curie and Curie-Weiss laws, Calculation of magnetic moments, Mechanisms of ferro and anti-ferromagnetic ordering, Super exchange and double exchange, Ferromagnetic domains and hysteresis, Soft and hard magnetic materials, Dielectric

materials, Ferroelectricity, Pyroelectricity, Piezoelectricity, Applications of Ferro-, Piezo- and Pyroelectrics.

BOOKS RECOMMENDED

1. Solid State Chemistry and its applications, A.R. West, John Wiley, New York.
2. Principles of the Solid State, H.V. Keer, New Age International (P) Limited, India.
3. Solid State Chemistry, An Introduction, L. Smart and E. Moore, Nelson Thrones Ltd, U.K.

PATTERN OF EXAMINATION

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Course No.: PSCHTE405 **Course Category: PSEC**
Title: Polymer Chemistry
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *Basic aspects of polymer chemistry and their characterization, structure and properties of polymers, polymer processing and properties of commercial polymers are discussed in this course work.*

Unit-I
General Aspects **(12 hours)**
Importance of polymers, Basic concepts: Monomers, Repeat units, Degree of polymerization, Linear branched and network polymers, Classification of polymers, Polymerization: Condensation, Addition, Radical chain-ionic, Co-ordination and co-polymerization, Polymerization conditions and polymer reactions, Polymerization in homogenous and heterogeneous systems.

Unit-II
(a) Polymer Characterization **(14 hours)**
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, Abrasion resistance.
(b) Thermodynamics of Solutions of High Polymers
Entropy of mixing of solvent and solute, Enthalpy of mixing of solvent and polymeric solute, Free energy of mixing of polymeric solute with solvent, Chemical potential and activity of solvent, Osmotic pressure of polymeric solutions.

Unit-III
Structure and Properties **(12 hours)**
Morphology and order in crystalline polymers, Configurations of polymer chains, Crystal structures of polymers, Crystallization and melting, Polymer structure and physical properties: Crystalline melting point, T_m-melting points of homogeneous series, Effect of chain flexibility and other steric factors, Entropy and heat of fusion, Glass transition temperature, Effect of molecular weight, Diluents, Chemical structure, Chain topology, Branching and cross linking.

Unit-IV
Polymer Processing **(10 hours)**
Property requirements and polymer utilization, Plastics, Elastomers and fibres, Processing techniques: Compounding, Calendaring, Die casting, Rotational casting, Film casting, Injection moulding, Blow moulding, Extrusion moulding, Thermoforming, Foaming, Reinforcing and fibre spinning.

Unit-V
Properties of Commercial Polymers **(12 hours)**
Polyethylene, Polyvinyl chloride, Polyamides, Polyesters, Phenolic resins, Epoxy resins and silicon polymers, Functional polymers, Fire retarding polymers and electrically conducting polymers, Biomedical polymers, Contact lens, Dental polymers, Artificial heart, Kidney, Skin and blood cells.

BOOKS RECOMMENDED

1. Textbook of Polymer Science, F.W. Billmeyer Jr. Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R.M. Ottanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.R. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J.M.G. Cowie, Blackie Academic and Professional.

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Course No.: PSCHTE406 **Course Category: PSEC**
Title: Chemistry of Materials and Liquids
Credits: 04
No. of hours: 60 **Maximum Marks: 100**

Course Outcome: *Students will acquaint knowledge about chemistry of materials like alloys, composites, glasses, ceramics, organic superconductors, fullerenes, etc. The properties of liquids along with the various theories of liquids also forms a part of discussion in this course,*

Unit-I

Multipurpose Materials and Composites (12 hrs)

Ferrous alloys and its classification, Fe-C phase transformations in ferrous alloys, Cast iron, Stainless steels, Non-ferrous alloys, Mechanical properties of ferrous and non-ferrous alloys and their applications.

Microscopic composites, Particle-reinforced composites, Large particle composites, Dispersion strengthened composites, Fiber-reinforced composites, Influence of fiber length, Influence of fiber orientation and concentration, Fiber phase, Matrix phase, Polymer matrix composites, Carbon-carbon composites, Hybrid composites, Processing of fiber-reinforced composites, Structural composites, Laminar composites, Sandwich panels.

Unit-II (12 hrs)

Glasses and Ceramics

Glassy state, Glass formers and glass modifiers, Heat treatment of glasses, Ceramics, Classification of ceramics, Glasses and glass ceramics, Clay products, Refractories, Properties of glasses and ceramics and their applications.

Non-linear Optics

Nonlinear optical materials: Nonlinear optical effects, Second and third order molecular hyper polarisability and second order electric susceptibility, Materials for second and third harmonic generation.

Unit-III (12 hrs)

Thin films and Langmuir-Blodgett (LB) films

Films at liquid-liquid interfaces and on liquid surfaces other than water, Charged films: Equation of a charged film, Interfacial potentials, Langmuir-Blodgett film, Growth techniques, Photolithography, Properties and applications of thin and LB films.

Organic Superconductors and Fullerenes

Conducting organics, Organic superconductors, Magnetism in organic materials, Fullerences-doped, Fullerences as superconductors, Artificial photosynthetic devices.

Unit-IV

General Properties of Liquids (12 hrs)

Liquids as dense gases, Liquids as disordered solids, Some thermodynamic relations, Internal pressure and its significance in liquids, Equations of state, Critical constants, Different types of intermolecular forces in liquids, Different potential functions for liquids, Additivity of pair potential approximation, Configurational integral, Surface energy and nearest-neighbour bonds, Interfaces and Young's relation, Stretching and compressing of liquid, Tensile strength of a van der Waals liquid, Rheology, Applications of non-Newtonian liquids.

Unit-V

Theory of Liquids (12 hrs)

Partition function method, Model approach, Simple cell model, Communal energy and entropy, LJD model, Significant structure model.

Methods of Structure Determination and Computational Techniques

Spectroscopic techniques for liquid dynamic structure studies, Neutron and X-ray scattering spectroscopy, Computation Techniques - Monte Carlo and Molecular dynamics methods.

BOOKS RECOMMENDED

1. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Saunders Collage.
2. Materials Science and engineering, An Introduction, W.D. Callister, Wiley.
3. Principles of the Solid state, H.V. Keer, Wiley Eastern.
4. Materials Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS.
5. An Introduction to the Liquid State, P. A. Egelstaff, Academic Press, New York, 1967.
6. The Dynamic Liquid State, A. F. M. Barton, Longman, First Edition, 1974.
7. The Liquid State, J. A. Pryde, Hillary Hourse, New York, 1967.
8. Significant Liquid Structures, H. Eyring and M. S. John, Wiley, 1969.
9. The Liquid Phase, D.H. Trevena, WYKEHAM Publications.
10. Computer Simulation of Liquids, M. P. Allen and D. J. Tildesley, Oxford, 1987.

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Course No.: PSCHTE407 **Course Category: PSEC**
Title: Heterocyclic Chemistry and Asymmetric Synthesis
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *An exhaustive study of heterocyclic chemistry will be presented which will help the students to grasp its chemistry. The non-enzymatic and enzymatic approaches will be discussed as far as asymmetric synthesis is concerned.*

Unit-I
Nomenclature of Heterocycles (10 hrs)
Replacement and systematic nomenclature (Hantzsch-Widmann system) for monocyclic, Fused and bridged heterocycles and simple spiroheterocycles, Carbocycles, Ring assemblies, Same repeating units, Different repeating units.

Unit-II
Six-Membered Heterocycles with One heteroatom (14 hrs)
Synthesis and reactions of pyridinium salts and pyridines, Synthesis and reactions of benzopyrylium salts, Coumarins and chromones,
Six Membered Heterocycles with two or more Heteroatoms
Synthesis and reactions of diazines and triazines (Pyrazines, Pyridazines and 1,2,4-triazines).

Unit-III
Benzo-Fused Five Membered Heterocycles (14 hrs)
Synthesis and reactions including medicinal applications of benzopyrroles, Benzofurans and benzothiophenes.
Seven- and Large-Membered Heterocycles
Synthesis and reactions of azepines, oxepines and thiepines.

Unit-IV
Asymmetric synthesis: Non-enzymatic approaches (12 hrs)
Models of asymmetric synthesis using naturally occurring chiral compounds, Nucleophile and electrophile bearing chiral auxillary, Asymmetric carbon – carbon bond formation using alkylation, Michael reaction and addition to carbonyl compounds. Cram's rule and Felkin–Ahn model, Asymmetric oxidation and reduction.

Unit-V
Asymmetric Synthesis: Enzymatic approach (10 hrs)
Use of different types of enzymes- lipases (PLAP), Oxidases, Reductases, Bayer-Villiger monooxygenase, Penicillin acylase and Baker yeast in organic synthesis, Enzyme-triggered cyclization of haloalkyl oxiranes catalyzed by epoxide hydrolases, Application to biomimetic natural product ((3*R*,9*R*,10*R*)-panaxytriol, (-)-pestalotin and (2*R*,5*S*)-pityole) synthesis.

BOOKS RECOMMENDED

1. Heterocyclic Chemistry, Thomas L. Gilchrist, 3rd Edition, Addison Wesley Longman Limited 1997.
2. Heterocyclic Chemistry, Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag.

3. The Chemistry of Heterocycles, J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
4. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Pandler, Wiley Interscience.
5. An Introduction to Heterocyclic Compounds, R.M. Acheson, John Wiley and Sons.
6. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, Eds. Pergamon Press.
7. G.Solladie, J.D. Morrison (ed.), Asymmetric Synthesis, Academic Press.
8. Advanced Asymmetric Synthesis, ed. G.R. Stephenson, Blackie, Glasgow, 1996.
9. Organic Synthesis, Michael B. Smith, McGraw Hill, International Edition.
10. Fundamentals of Asymmetric synthesis by G. L. David Krupadanam, 2014.

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Course No.: PSCHTE408 **Course Category: PSEC**
Title: Organic Synthesis
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *On successful completion of this course, the students will gain knowledge about disconnection approach, retrosynthesis, transition metal catalysed organic synthesis as well as various oxidising agents used for the oxidation of organic compounds and application of reduction by borrowing hydrogen.*

Unit-I

Disconnection Approach (14 hrs)

An introduction to synthons and synthetic equivalents, Disconnection approach, Functional group inter-conversions, Importance of the order of events in organic synthesis, One group C-X and two group C-X disconnections (1,2 and 1,3-difunctionalised compounds), Chemoselectivity, Reversal of polarity.

Protecting Groups

Principle of protection of alcohol (Acetal, Acetyl and silyl ethers) and carbonyl groups.

Unit-II

One Group C-C Disconnections (10 hrs)

Alcohols and carbonyl compounds, Regioselectivity, Use of acetylenes and aliphatic nitro compounds in organic cynthesis.

Two Group C-C Disconnections

Biological, Cope and Claisen reaction, Diels-Alder reaction, 1,3-difunctionalised compounds, α, β-unsaturated carbonyl compounds, 1,5-difunctionalised compounds, Michael addition and Robinson annelation.

Unit-III

Retrosynthesis and Synthesis of Following Compounds (12 hrs)

Reserpine (Woodward synthesis), Longifolene (Corey synthesis), Hirsutene [Paquette (1990) and Oppolzer (1994) synthesis].

Unit-IV

Organometallic Compounds of Transition Elements (12 hrs)

Hydrogenation, Hydrosilylation and hydrogen-transfer isomerization catalyzed by Ni, Pd and Rh complexes, Coupling reactions (C-C, C-N and C-O bond formation) catalyzed by Pd, Ni and Cu complexes, Carbonylation (Hydroxymethylation, hydroformylation and hydrocarboxylation of alkenes) catalyzed by Fe, Co, Pd and Ni compounds.

Unit-V

Oxidations (12 hrs)

Oxidation of alcohols (Chromic acid, $KMnO_4$, $Pb(OAc)_4$, Oppenauer, Swern); Aldehydes and ketones (chromium trioxide complexes), Amine (H_2O_2, peracids and quinones), Sulfides (peracid, HIO_4), Oxidation of alcohols by O_2 catalysed by Pd and Co.

Oxidation with osmium and ruthenium tetraoxide, Iodobenzene diacetate and thalium (III) nitrate, Reductions via borrowing hydrogen and its applications.

BOOKS RECOMMENDED

1. Designing Organic Synthesis, S. Warren, John Wiley & sons.
2. Organic Synthesis– Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlage VCH (1997).
3. Progress in Total Synthesis Vol. 1, E. Danishetsky and S. Danishetsky, Appleton Centyrt Crafts, N.Y.
4. The Logic of Chemical Synthesis, E.J. Corey and X.M. Cheng, John Wiley and Sons, New York, N.Y.
5. Organometallic Chemistry: A unified approach, R. C. Mehrotra, New Age International Publishers (2009).
6. Applications of Transition Metal Catalysis in Organic Synthesis, Brandsna, Vasilvsky, Verkruijsse, Springer-Verlag Berlin Heidelberg (1999).
7. Art in Organic Synthesis, Nitya Anand, Jasjit S. Bindra, S. Randanathan, Wiley-Blackwell.
8. Principles of Organic Synthesis, R.O.C. Norman and J. M. Coxon, CRC Press, Taylor & Francis (3rd Edition, 2017).
9. Hand book of reagents for organic synthesis: Oxidising and reducing agents, S.D. Burke and R.L. Danheiser, John Wiley and sons, New York, 1999.
10. Oxidation and reduction in organic synthesis, T.J. Donohoe, Oxford Science Publication, 2000.

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Course No.: PSCHTE409 **Course Category: PSEC**
Title: Chemistry of Natural Products
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *This course is aimed to deliver the knowledge about the natural products like terpenoids, carotenoids, alkaloids, steroid, plant pigments and marine* natural products.

Unit-I
Terpenoids and Carotenoids **(12 hrs)**
Classification, Occurrence and isoprene rule, Structure determination, Stereochemistry and synthesis of the following representative molecules:
α–Terpineol, Menthol, Farnesol, Santonin, β–Carotene and Squalene.

Unit-II
Alkaloids **(12 hrs)**
Definition, Physiological action, Occurrence and isolation, Structure elucidation and synthesis of Quinine, Morphine and Atropine.

Unit-III
Steroids **(12 hrs)**
Occurrence, Basic skeleton, Diel's hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of Cholesterol, Testosterone, Estrone, Progestrone.

Unit-IV
Plant Pigments **(12 hrs)**
Occurrence and general methods of structure determination of anthocyanins, Flavones & isoflavones, Synthesis of Apigenin, Quercetin, Cyanidin and Cyanin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

Unit-V
Marine natural products **(12 hrs)**
General introduction, Isolation of marine natural products, Detailed study of following marine natural products:
Marine toxins (Saxitoxin and Tetrodotoxin), Nucleosides (pyrimidines and purines D-arabinosides and pyrimidines and purines 1-β-D-ribosides).

BOOKS RECOMMENDED

1. Natural Products: Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B.Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Harlow, Essex, England 91994).
2. Organic Chemistry, Vol.2, I.L. Finar, Longman.
3. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
4. Introduction to Flavonoids, B.A. Bohm, Harwood Acade–mic Publishers.
5. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M. I. Choudhary, Harwood Academic Publishers.

6. Chemistry of Natural Products, S.V. Bhat, B.A. Nagasampagi and M. Sivakumar, Narosa Publishing House, New Delhi.
7. Bioactive Marine Natural Products, D. S. Bhakuni and D. S. Rawat, Anamaya Publishers, New Delhi (2005).

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Course No.: PSCHTO410 **Course Category: PSOCC**
Title: Chemistry in Daily life
Credits: 04 **Maximum Marks: 100**
No. of hours: 60

Course Outcome: *It is an open choice course not for the students of chemistry but for the students from other streams. The course is designed in such a way that the students from different streams get a flavour of the things in their day to day activities.*

Unit-I
Water and its treatment **(14 hrs)**
Water and water formation, Importance of water, Water requirements (Domestic, Industrial, Institutional, Public and Agriculture), Water quality standards: Desirable limits, Permissible limits, PPM and PPB, Drinking water physical parameters: Color, Taste-odor, Turbidity, Suspended solids and temperature, Hard and soft water, Hardness of water, Disadvantages of hard water, Mineral and distilled water, Water softening by lime-soda, zeolite, Ion-Exchange method and demineralization processes (Reverse Osmosis), Defects like scale and sludge formation, Caustic embrittlement, Corrosion, Priming and foaming caused in boilers by impure water and their remedies.
Waste water characteristics, Waste water treatment, Flowchart of waste water treatment plant: Sedimentation, Coagulation Flocculation, Settling tanks, Disinfection (Chlorination, UV, Ozonization).

Unit-II
Green Chemistry **(10 hrs)**
Introduction and basic principles, Designing of a green chemical syntheses, Green solvents and catalysts in organic synthesis, The revolution in biology in relation to green chemistry, Feedstocks: Maximum utilization of renewable and biological materials, green chemistry in sustainable development.

Unit-III
Fuel Chemistry **(12 hrs)**
Classification of fuels and their calorific value.
(a) **Coal**: Composition, Carbonization, Coal gas, Producer gas and water gas, Uses of coal tar based chemicals, Coal gasification (Hydro Gasification and Catalytic gasification).
(b) **Petroleum:** Composition of crude petroleum, Refining and different types of petroleum products and their applications, Fractional distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), Advantages of gaseous fuel over solid and liquid fuel, Classification of three stages of fuel used in cryogenic engines

Unit-IV
Polymer **(10 hrs)**
Classification, Preparation, Structure, Properties and applications of the polymers, (Polyolefins, Polystyrene) and styrene copolymers, Poly (vinyl chloride), Poly (vinyl acetate), Acrylic polymers, Fluoro Polymers, Polyamides, Phenol formaldehyde Resins (Bakelite, Novalac), Polyurethanes, Silicone Polymers, Conducting Polymers, Biomedical polymers: implants, contact lens and dental polymers.

Unit-V

Drugs and Agrochemicals (14 hrs)

(a) Drugs: Drugs classes and side effects: Analgesics agents, Antipyretic agents, Anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); Antibiotics (Chloramphenicol); antibacterial and antifungal agents (sulphonamides; sulphanethoxazol, sulphacetamide, trimethoprim); Antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone).

(b) Agrochemicals: Definition, importance and general classification of agrochemicals, Classification of pesticides on chemical nature and according to target species and mode of action, Physical and chemical properties, Degradation, Mode of action, Uses and toxicity of Organophosphorus like Acephate, Dimethoate, Chlorpyiphos, Temephos, Quinolphos, methyl parathion; Organochlorines like Endosulfan and Carbamate like Cartap hydrochloride.

BOOKS RECOMMENDED

1. B.S.N. Raju, *Water Supply and Wastewater Engineering*, Tata Mcgraw Hill Publishing Co Ltd, **2001**
2. Kent James A. (ed.), Reigel's Handbook of Industrial Chemistry, Kluwer Academic/Plenum Publishers, 10th edition, New York.
3. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
4. Seymour/Carraher's Polymer Chemistry: Sixth Edition, Revised and Expanded, Charles E Carraher, Jr. Marcel Dekker, inc. New York.
5. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
6. Shreve R.N. Brink. J.A., Chemical Process Industries, International student edition, Pubs: McGraw Hill Book Co. New York, 1960.
7. Melnikov N.N., Chemistry of Pesticides, Pubs: Springer-Verlag, New York, 1971.
8. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
9. Agricultural insect pests of the topics and their control-D.S.Hill, Cambridge Univ. Press, 1983.
10. Chemistry of Insecticides and Fungicides: U.S. Shree Ramulu Oxford & IBH Pub., 2nd, 1995.

PATTERN OF EXAMINATION

There shall be two **Minors (I & II)** and one **Major** tests in each theory course. Each Minor test shall have marks weightage of 20% and its duration will be of 1½ hour. The Major test shall have marks weightage of 60% and its duration will be of 03 hours. **Minor–I** will be held after 3-4 weeks on completion of 20% of the prescribed syllabus. **Minor–II** will be held after 8-9 weeks on completion of 21% to 40% of the prescribed syllabus.

The major test will be held at the end of semester on completion of 41% to 100% of the syllabus. This test will have seven questions (each of twelve marks). The students have to attempt five questions in all. Question no. 1 (short answer type) will be compulsory and will be set out from 40% of syllabus covered in Minor I & II. The remaining six questions will be

from across the syllabus of 41% to 100% i.e. beyond Minor I & II. The student has to attempt any four questions out of six questions.

NOTE: *Candidates who have appeared in Minor Tests and failed to get the minimum required marks i.e. 14 out of 40 will not be allowed to take Major Test. Such candidates shall have to re-appear in the Minor Test/s only once in which he/she has failed, to be conducted at least fifteen days before the Major Test.*

Course No.: PSCHLE411 **Course Category: PSEC**
Title: Laboratory Course: Inorganic Chemistry
Credits: 08 **Maximum Marks: 200**
No. of hours: 120

Course Outcome: *Students will employ critical thinking and the scientific method to design, carry out, record and analyze the results of chemical experiments and get an awareness of the impact of chemistry on the environment, society, and other cultures outside the scientific community. There will also be a course based on review of literature on any modern scientific topic.*

Preparation of selective inorganic compounds and their study by IR, Electronic spectra, ^1H NMR, TGA and magnetic susceptibility measurement. Handling of air and moisture sensitive compounds involving vacuum lines.

Selection can be made from the following:

1. Preparation of tetraamminecarbonatocobalt(III) nitrate and its conversion to pentaamminecholorocobalt(III) chloride; Inorganic Syntheses; Wiley-Interscience: pp 103 (1983).
2. Preparation of trans-dicholoro bis(ethylenediamine)cobalt(III) chloride and its conversion to cis-isomer; Inorg. Synth. 14, 63 (1973,).
3. Preparation of tris(ethylenediamine)nickel(II) chloride and its conversion to bis(ethylenediamine)nickel(II) chloride; Inorg. Synth. 6, 200, (1960); Inorg. Synth. 6, 198, (1960).
4. Preparation of pentaamminecholorocobalt(III) chloride and study of Linkage isomers by its conversion to pentaammminenitritocobalt(III) chloride and to nitro isomer followed by IR characterization; Inorganic Chemistry 18, 1869 (1979).
5. Preparation and mangnetic moment of $Cu(acac)_2H_2O$; Inorg. Synth. 20: 53 (1980).
6. Separation of optical isomer cis-$[Co(en)_2Cl_2]Cl$. J. Chem. Soc., 1960, 4369.
7. Ion exchange separation of oxidation state of vanadium. J. Chem. Educ., 1980, 57, 316; 1978, 55, 55.
8. Preparation of Fe(II)chloride (use it as Friedelcraft chlorination source). J. Org. Chem., 1978, 43, 2423, J. Chem. Edu., 1984, 61, 645; 1986, 63, 361.
9. Preparation and use of Ferrocene, J. Chem. Edu., 1966, 43, 73; 1976, 53, 730.
10. Preparation of phosphine Ph_3P and its transition metal complexes. Inorg. Synth. 15, 45 (1974).
11. Reaction of Cr(III) with a multidentate ligand: a kinetic experiment (visible spectra Cr-EDTA complex) J.A. C. S., 1953, 75, 5670.
12. Preparation of metal-pyridine complexes, $M(C_5H_5N)_y(NCS)_2$, (M = Mn, Fe, Co or Ni; y = 4, for M= Cu or Zn; y = 2), J. Chem. Edu, 50, 70 (1973).
13. Preparation of Chromium(III) complexes, $[Cr(H_2O)_6]NO_3.3H_2O.[Cr(H_2O)]_4Cl_2]Cl.2H_2O$, $[Cr(en)_3]Cl_3.Cr(acac)_3$, Inorg. Synth.,13, 184 (1972).
14. Controlled synthesis of two copper oxalatehydrate complexes, $K_2[Cu(C_2O_4)_2]\cdot 4H_2O$ and $K_2[Cu(C_2O_4)_2]\cdot 2H_2O$: Kinetic vs thermodynamic factors. *J. Chem. Educ.*, 2009, 86 (5), p 598.
15. Preparation and check the purity of isomer of *cis*- and *trans*-potassium diaquadioxalatochromate(III) complexes, $K[Cr(C_2O_4)_2(H_2O)_2].2H_2O$. *Nature, Volume 169, Issue 4313, pp. 1103 (1952).*

16. Prepare ammine complexes of Ni(II) and carry out its ligand exchange reactions with bidentate ligands like acetylacetone(acac), dimethylglyoxime (DMG), glycine (gly) by substitution method (one pot synthesis).

Gravimatric and Volumetric analysis: Barium, Copper, Cobalt, Iron, Vanadium, Nickel, Manganese, Aluminium, Chromium, Zinc, Sulfur, Chloride (Volhard's method) etc.

Separation by Paper/TLC/Column Chromatography:

1. Separation of Permanganate and Bichromate ions on Alumina column and their Estimation from Beer Law plots.
2. Determination of ionisable chloride in a Complex by cation exchange column (separation followed by Mohr's titration of elute for estimation).
3. Separation of Cobalt(II) and Nickel(II) on anion exchange column followed by estimation through EDTA titrations.
4. Separation of two Cobalt (III) complexes *viz* $[Co(NH_3)_6]Cl_3$ and $[Co(NH_3)_5Cl]Cl_2$ on Silica column.
5. Ion exchange separation of Hydration/ionization isomers of Chromium(III) Chloride ($CrCl_3$).
6. Determination of Rf value of cations of transition metal ions by paper and thin layer chromatography

Any other practical introduced by the teacher.

BOOKS RECOMMENDED

1. Vogel's textbook of quantitative chemical analysis (5^{th} and 6^{th} edition).
2. G. R. Chatwal, Instrumental Methods for Chemical Analysis, 5^{th} ed., Himalaya Publications (India).

PATTERN OF EXAMINATION

In Semester-IV, the laboratory course has been divided in two heads:

(a) **6-credits** laboratory work of 150 marks
The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

(b) **2-credits** project work based on review of literature work on any recent research topic, the choice of which will be left to students in consultation with the concerned faculty member. This will have a weightage of 50 marks and will be evaluated by an external examiner. The three external examiners (Inorganic, Organic and Physical) shall be invited in 4^{th} semester to evaluate the project work and also to conduct the practical examination of students of their respective specializations. The project work will be in the form of small dissertation which will be kept in the custody of the Department, once a student successfully defends his/her work.

(c) The overall marks reflected in the marks sheet will be out of 200.

Course No.: PSCHLE412 **Course Category: PSEC**
Title: Laboratory Course: Physical Chemistry
Credits: 08 **Maximum Marks: 200**
No. of hours: 120

Course Outcome: *Students will employ critical thinking and the scientific method to design, carry out, record and analyze the results of chemical experiments and get an awareness of the impact of chemistry on the environment, society, and other cultures outside the scientific community. There will also be a course based on review of literature on any modern scientific topic.*

1. Determination of Planck's constant by means of LED's method based on expression of diode current for $V<V_0$. The dependence of current with temperature is to be measured, keeping the V slightly below V_0 and material constant η to be obtained from V-I characteristics of the diode.
2. Four Probe set-up for measuring the resistivity of very low to highly resistive samples at temperature up to 200°C with PID controlled oven, having the following setup:
   (i) Four Probe Arrangement with built-in RTD sensor & PID controlled Oven
   (ii) D.C. Microvoltmeter
   (iii) Constant Current Source for low resistivity samples like thin films for metals and alloys
   (iv) Low Current Source
3. Measurement of Magentoresistance of Semiconductors with the apparatus consisting of:
   a) Four Probe Arrangement
   b) Sample: Ge Crystal (n-type)
   c) Magnetoresistance setup
   d) Electromagnet
   e) Constant Current Power Supply
   f) Digital Gaussmeter
4. Study of Dependence of Hall Coefficient on Temperature by the following setup:
   a) Hall Effect Setup
   b) Hall Probe (Ge: p-type) with a small oven
   c) Electromagnet
   d) Constant Current Power Supply
   e) Digital Gaussmeter
5. Study of the energy band-gap and diffusion potential of P-N Junctions.
6. To determine the specific rate constant for the oxidation of ethanol by potassium dichromate using spectrophotometer.
7. To determine the critical micelle concentration of a surfactant using spectrophotometer.
8. To determine the surface tension of a given liquid by using tensiometer.
9. To determine the critical micelle concentration of a surface active material by using tensiometer.
10. Determine the molecular mass of polystyrene from viscometric measurements.
11. To determine the rate constant for the inversion of sucrose by polarimetry.
12. To determine the transition temperature and the heat of transition of the given hydrated salt by differential thermal analyzer.
13. To find the velocity of sound in liquids using ultrasonic interferometer.

Any other practical introduced by the teacher.

BOOKS RECOMMENDED

1. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
2. Findley's Practical Physical Chemistry, B. P. Levitt, Longman.
3. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.
4. Experiments in Physical Chemistry by Shoemaker.
5. Practical Physical Chemistry by Viswanathan and Raghavan.

PATTERN OF EXAMINATION

In Semester-IV, the laboratory course has been divided in two heads:

(a) **6-credits** laboratory work of 150 marks
The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

(b) **2-credits** project work based on review of literature work on any recent research topic, the choice of which will be left to students in consultation with the concerned faculty member. This will have a weightage of 50 marks and will be evaluated by an external examiner. The three external examiners (Inorganic, Organic and Physical) shall be invited in 4^{th} semester to evaluate the project work and also to conduct the practical examination of students of their respective specializations. The project work will be in the form of small dissertation which will be kept in the custody of the Department, once a student successfully defends his/her work.

(c) The overall marks reflected in the marks sheet will be out of 200.

Course No.: PSCHLE413 **Course Category: PSEC**
Title: Laboratory Course: Organic Chemistry
Credits: 08 **Maximum Marks: 200**
No. of hours: 120

Course Outcome: *Students will employ critical thinking and the scientific method to design, carry out, record and analyze the results of chemical experiments and get an awareness of the impact of chemistry on the environment, society, and other cultures outside the scientific community. There will also be a course based on review of literature on any modern scientific topic.*

Multi-Step Synthesis of Organic Compounds

The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.

Photochemical reaction: Benzophenone→Benzpinacol→Benzpinacolone

Beckmann rearrangement: Benzanilide from benzophenone
Benzophenone→Benzophenone oxime→Benzanilide

Benzilic acid rearrangement: Benzilic acid from benzoin
Benzoin→Benzil→Benzilic acid

Synthesis of heterocyclic compounds-Three component coupling for the synthesis of dihydropyrimidinones and 1,4-dihydropyridines.

Fisher– Indole synthesis: Preparation of 2-phenylindole from phenylhydrazine

Synthesis using microwaves/Ultrasonicator
Alkylation of diethyl malonate with benzyl chloride
Synthesis using phase transfer catalyst

Extraction of Organic Compounds from Natural Sources

1. Isolation of caffeine from tea leaves
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins)
3. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported)
4. Isolation of piperine from black pepper
5. Isolation of lycopene from tomatoes

Spectrophotometric (UV/VIS) estimations of any two of the following:

1. Amino acids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine

Spectroscopy

Identification of some organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR and MS).

Any other experiment introduced by the concerned teacher.

BOOKS RECOMMENDED

1. Elementary Practical Organic Chemistry, Part-1, 2nd ed., Vogel.
2. Monograph on Green Chemistry by Green Chemistry Task Force Committee, DST.
3. Spectrophotometric determination of amino acid by Michail A. Alterman, Peter Hunziker, Vol. 828, Print ISBN: 978-1-61779-444-5.
4. Microwave-assisted organic synthesis, Vol. 25, D. Bogdal, Elsevier Science, 2005.
5. Laboratory experiment using microwave heating, N.E. Leadbeater and C.B. McGowan, CRC Press, 2013.
6. Experiments in green and sustainable chemistry, H.W. Roesky and D. Kennepohl, Wiley-VCH, 2009.

PATTERN OF EXAMINATION

In Semester-IV, the laboratory course has been divided in two heads:

(a) **6-credits** laboratory work of 150 marks
The daily evaluation of practical records/assignments/viva-voce, etc. shall have marks weightage of 50%. The final practical performance test along with viva-voce examination will be held at the end of semester covering 100% of the syllabus and having marks weightage of 50%.

(b) **2-credits** project work based on review of literature work on any recent research topic, the choice of which will be left to students in consultation with the concerned faculty member. This will have a weightage of 50 marks and will be evaluated by an external examiner. The three external examiners (Inorganic, Organic and Physical) shall be invited in 4th semester to evaluate the project work and also to conduct the practical examination of students of their respective specializations. The project work will be in the form of small dissertation which will be kept in the custody of the Department, once a student successfully defends his/her work.

(c) The overall marks reflected in the marks sheet will be out of 200.