Bachelor of Science – Chemistry
Programme Specific Outcome (PSO)

- Students will be able to acquire core knowledge in the key areas of Chemistry, develop written & oral communication skills in communicating chemistry-related topics.

- Design & conduct experiments, demonstrate their understanding of the scientific methods & processes.

- Develop proficiency in acquiring data using a variety of instruments, analyse & interpret the data, learn applications of numerical techniques.

- Realize & develop an understanding of the impact of Chemistry on society.

F. Y. B. Sc and S. Y. B. Sc (Semester I to IV) for Bachelor of Science (Honours) and for Bachelor of Science Programme

T. Y. B. Sc. (Semesters V & VI)
For Bachelor of Science (Honours) Programme

T. Y. B. Sc. (Semesters V & VI)
For Bachelor of Science Programme

INDUSTRIAL CHEMISTRY UNDERGRADUATE SEMESTER - I to SEMESTER – VI

Index continued…

Index continued…

$ In lieu of one of the DSE, compulsory project DSP of 4 credits is needed to be done by the students.

* On Job training of 1 credit each in Sem V and Sem VI is mandatory.

SEMESTER I

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CHC-101 **CORE COURSE**

Inorganic Chemistry& Organic Chemistry (Semester I)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To discuss Bohr's theory, Quantum theory for structure of an atom.
- To draw the radial plots, probability distribution curves.
- To generalize the rules for electronic configuration of an atom.
- To explain the general characteristics of ionic compounds and covalent compounds.
- To discuss valence bond theory, VSEPR, and molecular orbital theory for covalent compounds.

Section B

- To understand the curved arrow notations in organic reaction mechanisms.
- To understand the concept of physical effects and electronic displacement with reference to organic molecules.
- To understand the structure, shape and reactivity of organic molecules.
- To study the strength of organic acids and bases.
- To understand the aromaticity of compound.
- To understand the concept of isomerism, stereoisomerism, configuration, chirality and optical rotation.
- To understand the difference between conformational and configurational isomers.
- To draw conformations with respect to ethane, butane and cyclohexane.
- To learn the interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations.
- To understand rules for nomenclature and assigning configuration to configurational isomers.
- To understand various methods of preparation and reactions of alkanes, alkenes and alkynes.

PRACTICAL COURSE OJBECTIVE

- To estimate the metal ions by volumetric methods employing redox and acid-base titration concepts.

- To get hands on experience for the systematic qualitative analysis of the organic compounds.
- To learn the purification and separation techniques for organic compounds.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. Atomic Structure (14 H)

Review of Bohr's theory and its limitations; dual behaviour of matter and radiation; de Broglie's relation; Heisenberg Uncertainty principle; hydrogen atom spectra; need of a new approach to atomic structure; what is quantum mechanics? time independent Schrodinger equation and meaning of various terms in it; significance of ψ and ψ^2; Schrödinger equation for hydrogen atom; radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation); radial and angular nodes and their significance; radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals; quantum numbers and their significance; discovery of spin, spin quantum number(s) and magnetic spin quantum number (m_s); shapes of s, p and d atomic orbitals: nodal planes; rules for filling electrons in various orbitals; electronic configurations of the atoms; stability of half-filled and filled-orbitals; concept of exchange energy; relative energies of atomic orbitals; anomalous electronic configurations.

2. Chemical Bonding and Molecular Structure (16 H)

Ionic bonding: general characteristics of ionic bonding; energy considerations in ionic bonding; lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds; statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; polarizing power, and polarizability; Fajan's rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character. Covalent bonding: VB approach; shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements; concept of resonance and resonating structures in various inorganic and organic compounds: MO approach; rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

Section B

3. Fundamentals of Organic Chemistry (8 H)

Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms; physical effects, electronic displacements: inductive effect, electromeric effect, resonance and hyperconjugation. Cleavage of bonds: homolysis and heterolysis; structure, shape and reactivity of organic molecules: nucleophiles and electrophiles; reactive intermediates: carbocations,

carbanions and free radicals; strength of organic acids and bases: comparative study with emphasis on factors affecting pk values; aromaticity: benzenoids and Hückel's rule.

4. Stereochemistry (10 H)

Concept of isomerism; types of isomerism; stereoisomerism, conformational isomerism; conformations with respect to ethane, butane and cyclohexane; interconversion of wedge formula, Newmann, Sawhorse and Fischer representations; concept of chirality (up to two carbon atoms); configuration: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds); threo and erythro; D and L; cis – trans nomenclature; CIP Rules: R/ S (for up to 2 chiral carbon atoms) and E/Z Nomenclature (for up to two C=C systems).

5. Aliphatic Hydrocarbons (12 H)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure;

Alkanes (up to 5 carbons): preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from grignard reagent; reactions: free radical substitution: halogenation.

Alkenes (up to 5 Carbons): preparation: elimination reactions: dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration - demercuration, Hydroboration-oxidation.

Alkynes: (up to 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

PRACTICALS Number of hours: 60

Section A-(Inorganic Chemistry) (30 H)

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with standardized $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B:(Organic Chemistry) (30 H)

1. Purification of organic compounds:
   i. Solids by recrystallization process using water and ethanol as solvent. Determination of melting point.

ii. Liquids by distillation process, a) acetone b) nitrobenzene. Determination of boiling point.

2. Determination of chemical type, detection of elements, group test for any one compound.

3. Identification of unknown organic compounds.
   i. Water insoluble solids (Acid, Base, Phenol and Neutral)
   ii. Water soluble solid (Acid and Neutral)

4. Thin layer chromatographic techniques: plate preparation, spotting, Separation of mixtures by thin layer Chromatography: Measure the Rf value in each case (combination of two compounds to be given eg. Mixture of o- and p-nitroaniline).

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Interpret the atomic structure based on postulates of Bohr's theory, Quantum mechanics.
- Evaluate the stability and magnetic property based on molecular diagrams of homonuclear and heteronuclear molecules.
- Identify and use the curved arrow notations in organic reaction mechanisms.
- Explain the concept of physical effects and electronic displacement with reference to organic molecules.
- Describe structure, shape and reactivity of organic molecules.
- Interpret strength of organic acids and bases.
- Identify if the given organic compound is aromatic.
- Classify isomers giving examples.
- Discuss the concept of stereoisomerism, configuration, chirality and optical rotation.
- Distinguish between conformational and configurational isomers and also geometrical and optical isomers, giving examples.
- Draw conformations with respect to ethane butane and cyclohexane.
- Draw and interconvert Wedge Formula, Newman, Sawhorse and Fischer representations.
- Give the nomenclature and assign configuration to configurational isomers.
- Give various methods of preparation and reactions of alkanes, alkenes and alkynes.

Practical

- The students will acquire the skill and knowledge to carry out volumetric estimation of inorganic constituents.
- The students will be able to get hands on experience for the systematic qualitative analysis of the organic compounds and the purification and separation techniques for organic compounds.

REFERENCE BOOKS

Inorganic Chemistry

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

Organic Chemistry

1. Graham Solomon, T. W., Fryhle, C. B. & Dnyder, S. A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J. E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
5. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson, 2010.
7. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
8. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.
9. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
10. Jerry March, Advanced Organic Chemistry; 4th Edition, John Wiley.

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CHG-101 **GENERIC ELECTIVE**

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS-I (Semester I)

Credits: 04 (Theory: 04)

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THOERY COURSE OBJECTIVES

Section A

- To discuss Bohr's theory, Quantum theory for structure of an atom.
- To draw the radial plots, probability distribution curves.
- To generalize the rules for electronic configuration of an atom.
- To explain the general characteristics of ionic compounds and covalent compounds.
- To discuss valence bond theory, VSEPR, and molecular orbital theory for covalent compounds.

Section B

- To understand the curved arrow notations in organic reaction mechanisms.
- To understand the concept of physical effects and electronic displacement with reference to organic molecules.
- To understand the structure, shape and reactivity of organic molecules.
- To study the strength of organic acids and bases.
- To understand the aromaticity of compound.
- To understand the concept of isomerism, stereoisomerism, configuration, chirality and optical rotation.
- To understand the difference between conformational and configurational isomers.
- To draw conformations with respect to ethane, butane and cyclohexane.
- To learn the interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations.
- To understand rules for nomenclature and assigning configuration to configurational isomers.
- To understand various methods of preparation and reactions of alkanes, alkenes and alkynes.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1.. Atomic Structure (14 H)

Review of Bohr's theory and its limitations; dual behaviour of matter and radiation; de Broglie's relation; Heisenberg Uncertainty principle; hydrogen atom spectra; need of a new approach to atomic structure; what is quantum mechanics? time independent Schrodinger equation and meaning of various terms in it; significance of ψ and ψ^2; Schrödinger equation for hydrogen atom; radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation); radial and angular nodes and their significance; radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals; quantum numbers and their significance; discovery of spin, spin quantum number(s) and magnetic spin quantum number (m_s); shapes of s, p and d atomic orbitals: nodal planes; rules for filling electrons in various orbitals; electronic configurations of the atoms; stability of half-filled and filled-orbitals; concept of exchange energy; relative energies of atomic orbitals; anomalous electronic configurations.

2. Chemical Bonding and Molecular Structure (16 H)

Ionic bonding: general characteristics of ionic bonding; energy considerations in ionic bonding; lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds; statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; polarizing power, and polarizability; Fajan's rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character. Covalent bonding: VB approach; shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements; concept of resonance and resonating structures in various inorganic and organic compounds: MO approach; rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

Section B

3. Fundamentals of Organic Chemistry (8 H)

Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms; physical effects, electronic displacements: inductive effect, electromeric effect, resonance and hyperconjugation. Cleavage of bonds: homolysis and heterolysis; structure, shape and reactivity of organic molecules: nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals; strength of organic acids and bases: comparative study with emphasis on factors affecting pk values; aromaticity: benzenoids and Hückel's rule.

4. Stereochemistry (10 H)

Concept of isomerism; types of isomerism; stereoisomerism, conformational isomerism; conformations with respect to ethane, butane and cyclohexane; interconversion of wedge formula, Newmann, Sawhorse and Fischer representations; concept of chirality (up to two carbon atoms); configuration: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds); threo and erythro; D and L; cis – trans nomenclature; CIP Rules: R/ S (for up to 2 chiral carbon atoms) and E/Z Nomenclature (for up to two C=C systems).

5. Aliphatic Hydrocarbons (12 H)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure;

Alkanes (up to 5 carbons): preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from grignard reagent; reactions: free radical substitution: halogenation.

Alkenes (up to 5 Carbons): preparation: elimination reactions: dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration - demercuration, Hydroboration-oxidation.

Alkynes: (up to 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

LEARNING OUTCOMES

At the end of the course students will be able to:

- Interpret the atomic structure based on postulates of Bohr's theory, Quantum mechanics.
- Evaluate the stability and magnetic property based on molecular diagrams of homonuclear and heteronuclear molecules.
- Identify and use the curved arrow notations in organic reaction mechanisms.
- Explain the concept of physical effects and electronic displacement with reference to organic molecules.
- Describe structure, shape and reactivity of organic molecules.
- Interpret strength of organic acids and bases.
- Identify if the given organic compound is aromatic.
- Classify isomers giving examples.
- Discuss the concept of stereoisomerism, configuration, chirality and optical rotation.
- Distinguish between conformational and configurational isomers and also geometrical and optical isomers, giving examples.
- Draw conformations with respect to ethane butane and cyclohexane.
- Draw and interconvert Wedge Formula, Newman, Sawhorse and Fischer representations.
- Give the nomenclature and assign configuration to configurational isomers.

- Give various methods of preparation and reactions of alkanes, alkenes and alkynes.

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3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
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4. Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
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9. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
10. Jerry March, Advanced Organic Chemistry; 4th Edition, John Wiley.

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CHG-101 **GENERIC ELECTIVE**

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS-II (Semester I)

Credits: 04 (Theory: 03, Practical: 01)

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THOERY COURSE OBJECTIVES

Section A

- To discuss Bohr's theory, Quantum theory for structure of an atom.
- To draw the radial plots, probability distribution curves.
- To generalize the rules for electronic configuration of an atom.
- To explain the general characteristics of ionic compounds and covalent compounds.
- To discuss valence bond theory, VSEPR, and molecular orbital theory for covalent compounds.

Section B

- To understand the curved arrow notations in organic reaction mechanisms.
- To understand the concept of physical effects and electronic displacement with reference to organic molecules.
- To understand the structure, shape and reactivity of organic molecules.
- To study the strength of organic acids and bases.
- To understand the aromaticity of compound.
- To understand the concept of isomerism, stereoisomerism, configuration, chirality and optical rotation.
- To understand the difference between conformational and configurational isomers.
- To draw conformations with respect to ethane, butane and cyclohexane.
- To learn the interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations.
- To understand rules for nomenclature and assigning configuration to configurational isomers.
- To understand various methods of preparation and reactions of alkanes, alkenes and alkynes.

PRACTICALS COURSE OJBECTIVE

- To estimate the metal ions by volumetric methods employing redox and acid-base titration concepts.

- To get hands on experience for the systematic qualitative analysis of the organic compounds.
- To learn the purification and separation techniques for organic compounds.

SYLLABUS

SECTION A (INORGANIC CHEMISTRY-1)
(22 Lectures: 1.5 Credit)

1. Atomic Structure (06 H)

Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2, Significance of quantum numbers, Shapes of s, p and d atomic orbitals. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

2. Chemical Bonding and Molecular Structure (16 H)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

SECTION B ORGANIC CHEMISTRY-1
(23 Lectures: 1.5 credits)

3. Fundamentals of Organic Chemistry (7 H)

Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms. Physical Effects, Electronic Displacements: Concepts of Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation effects with one example each. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates in organic reactions, definitions and structure of carbocations, carbanions and free radicals.

4. Stereochemistry (9 H)

Concept of isomerism. Types of isomerism. Stereoisomerism, conformational isomerism. Conformations with respect to ethane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis – trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

5. Aliphatic Hydrocarbons (7 H)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Up to 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition-Mechanism)/

PRACTICALS: 30 LECTURES/30 HOURS (01 CREDIT)

SECTION A

INORGANIC CHEMISTRY 15 Hours (0.5 Credit)

Volumetric Analysis (3 x 5 = 15 Hours)

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

SECTION B

ORGANIC CHEMISTRY 15 Hours (0.5 Credit)

1. Purification of organic compounds. (2 x 4 = 08 Hours)
   - i) Solids by recrystallization process using water and ethanol as solvent. Determination of melting point.
   - ii) Liquids by distillation process, a) acetone b) nitrobenzene. Determination of boiling point.

2. Determination of chemical type, detection of elements, group test for any five compounds. (07 Hours)

LEARNING OUTCOMES

At the end of the course students will be able to:

- Interpret the atomic structure based on postulates of Bohr's theory, Quantum mechanics.
- Evaluate the stability and magnetic property based on molecular diagrams of homonuclear and heteronuclear molecules.
- Identify and use the curved arrow notations in organic reaction mechanisms.
- Explain the concept of physical effects and electronic displacement with reference to organic molecules.
- Describe structure, shape and reactivity of organic molecules.
- Interpret strength of organic acids and bases.
- Identify if the given organic compound is aromatic.
- Classify isomers giving examples.
- Discuss the concept of stereoisomerism, configuration, chirality and optical rotation.
- Distinguish between conformational and configurational isomers and also geometrical and optical isomers, giving examples.
- Draw conformations with respect to ethane butane and cyclohexane.
- Draw and interconvert Wedge Formula, Newman, Sawhorse and Fischer representations.
- Give the nomenclature and assign configuration to configurational isomers.
- Give various methods of preparation and reactions of alkanes.

REFERENCE BOOKS

Theory

Section A: Inorganic Chemistry

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F. A., Wilkinson, G. & Gaus, P. L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B. E., McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J. E., Keiter, E. A., Keiter, R. L. & Medhi, O. K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

Section B: Organic chemistry

1. Graham Solomon, T. W., Fryhle, C. B. & Dnyder, S. A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A. Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
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6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson, 2010.
7. Bahl, A. & Bahl, B. S. Advanced Organic Chemistry, S. Chand, 2010.

8. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.
9. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
10. Jerry March, Advanced Organic Chemistry; 4rd Edition, John Wiley.

Practical

Section A: Inorganic Chemistry

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

Section B: Organic Chemistry

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.

Note: Practicals of 30 Hours = 15 practicals of 2 hours each = 7.5 practicals of 4 hours each

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CHG-103 **GENERIC ELECTIVE**

Basic Chemistry and Indian Scientists (Semester I)

Credits: 04 (Theory: 04)

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THOERY COURSE OBJECTIVES

In this course, students will be able to gain knowledge on

- Various branches of science and scientists who are inspirations to the youngster generation.
- Organic chemistry and its application in daily life; carbon, nitrogen, water and oxygen cycles.
- How chemistry and industry go hand in hand.

SYLLABUS

Theory: **Number of hours: 60**

1. Importance of science in life (4 H)

Towards scientific approach, involvement of science in daily life, different branches of science: significance and applications (viz: chemistry, physics, biology, microbiology, medical science etc.).

2. Indian Scientists: who have made great contributions to science and cemented the way for others to walk on (9 H)

1) Anandibai Joshi – Physician (1865 - 1887).
2) Janaki Ammal – Botanist (1897 - 1984).
3) Kamala Sohonie – Bio-chemist (1912 – 1998).
4) Anna Mani – Physicist and meteorologist (1918- 2001).
5) Asmita Chatterjee – Chemist and Author (1917 – 2006).
6) Rajeshwari Chatterjee – Prof. and Scientist (1922-2010).
7) Darshan Ranganathan – Org. Chemist (1941 – 2001).
8) Prof. C. V. Raman – Nobel laureate (1888-1970).
9) Dr. Jagdish Chandra Bose – Physicist (1858-1937).
10) Dr. A.P. J. Abdul Kalam – Scientist (1931-2015)

3. Basic Organic Chemistry (9 H)

Different branches of chemistry, introduction to organic chemistry, classification of organic compounds and example of each. Importance of organic chemistry in day-to-day life; toothpastes, soaps, shampoos, cosmetics, drugs, dyes and paints.

4. Hydrogen and Water (8 H)

Hydrogen: chemistry of hydrogen, the hydrogen economy; water: water cycle, domestic and industrial water supplies; water as a solvent, chemical and physical test of water; hard and soft water.

5. Oxygen and Sulphur (8 H)

Air as a resource, properties of oxygen, fire triangle, combustion and respiration; sources of sulphur: volcanic regions, oil, gas and minerals; allotropes of sulphur, oxides of sulphur, use of sulphuric acid.

6. Carbon and Nitrogen (10 H)

Carbon in air, carbon cycle, removal of carbon dioxide, production of carbon dioxide, oxides of carbon, carbon monoxide, applications of carbon; nitrogen cycle, properties of nitrogen, manufacture of ammonia and nitric acid, uses of ammonia.

7. Halogens and Noble gases (6 H)

Halogens: similarities and applications; noble gases: properties and uses.

8. Chemistry & Industry (6 H)

Minerals and ores: general awareness, chemical plants: cost, environmental impact and recycling.

LEARNING OUTCOMES

At the end of this course, students will be able to understand:

- The importance of various branches of sciences
- Organic chemistry and its applications
- Contribution of some important Indian Scientists.

REFERENCE BOOKS

1) Chemistry by Richard Harwood, Cambridge University press. published 1998
2) First lady doctor of India. The Telegraph. Retrieved 2016-05-01.
3) Lilavati's Daughter's by Indian Academy of Sciences (Bangalore) 2008.
4) Organic Chemistry. Morrison, Boyd, Bhattacharjee. Seventh Edition. Pearson.
5) Wings of fire: An Autobiography by A. P. J. Abdul Kalam. Orient blackswan.
6) Jagdish Chandra Bose by Sanjay Goyal.
7) Prof. C. V. Raman: A biography by Uma Parameswaran. Ed. 2011, Penguin.

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SEMESTER II

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CHC-102 **CORE COURSE**

Physical Chemistry and Organic Chemistry (Semester II)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To define the terms and state laws involved in thermodynamics, thermochemistry and chemical equilibrium.
- To explain the concept of enthalpies of solution, buffer solutions.
- To derive the thermodynamic derivation of the law of chemical standard state, enthalpies of solution, chemical equilibrium and relationships between different equilibrium constants based on ideal gases.
- To solve numerical based on chemical energetics, chemical equilibrium and ionic equilibrium.

Section B

- To learn the preparation methods and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- To learn the various named reactions mentioned in the syllabus.
- To understand reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- To understand Benzyne mechanism with respect to aromatic nucleophilic substitution.
- To understand Pinacol-pinacolone rearrangement with mechanism.

PRACTICALS: COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory pH metry, thermochemistry.
- To understand the mechanism of reactions involved in organic preparation experiments and develop hands on experience with reference to basic laboratory techniques required for organic preparations.

SYLLABUS

Theory: **Number of hours: 60**

Section A (Physical Chemistry- I)

1. Chemical Energetics (10 H)

Need of thermodynamics and the laws of thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

2. Chemical Equilibrium (8 H)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Definition of ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

3. Ionic Equilibria (12 H)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts.

Section B (Organic Chemistry – II)

4. Aromatic hydrocarbons (8 H)

Preparation (case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (case benzene): electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

5. Alkyl and Aryl Halides (8 H)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN_1, SN_2 and SN_i) reactions. Preparation: from alkenes and alcohols; reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation; Elimination vs substitution.

Aryl Halides Preparation: (chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions; Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$); Reactivity and Relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

6. Alcohols, Phenols, Ethers and Carbonyl Compounds (14 H)

Alcohols: Preparation: Preparation of 1°, 2°and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: oxidation of diols using HIO_4. Pinacol-Pinacolone rearrangement with mechanism.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation.

Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten –Baumann Reaction.
Ethers (aliphatic and aromatic): Williamson's synthesis of ethers. Cleavage of ethers with HI.
Aldehydes and ketones (aliphatic and aromatic): (formaldehyde, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

PRACTICALS Number of hours: 60

Section A

1. Thermochemistry (Any three) (18 H)

i. Determination of heat capacity of the calorimeter.
ii. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
iii. Determination of enthalpy of ionization of acetic acid.
iv. Study of the solubility of benzoic acid in water and determination of ΔH.

2. Chemical Kinetics: (10 H)

i. To study the effect of nature of reactants on the rate of reactions
ii. Determination of relative strength between HCl and Urea hydrochloride for hydrolysis of methyl acetate Ionic equilibria.

3. pH measurements (2 H)

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using ph meter.

Section B

4. Preparations (30 H)

Mechanisms involved in the following reactions to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
Each preparation for

a. Bromination of Phenol/Aniline
b. (b) Benzoylation of amines/phenols
c. 2,4-dinitrophenylhydrazone of benzaldehyde/acetophenone
d. Nitration of acetanilide to p-nitroacetanilide.
e. (e) Oxime of Cyclohexanone
f. Chalcone from benzaldehyde and acetophenone
g. Iodoform from acetone

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Define the terms involved in chemical energetics, chemical equilibrium, ionic equilibrium and state the laws used in thermodynamics, thermochemical equilibrium .
- Describe enthalpy, buffer solutions, factors affecting ionization.
- Derive and use the equations thermochemistry, chemical equilibrium and ionic equillibria of to solve the numericals.
- Give methods of preparation and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- Identify and give the named reactions mentioned in the syllabus.
- Explain reactivity and relative strength of c-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- Explain benzyne mechanism with respect to aromatic nucleophilic substitution.

Practical

At the end of the course students will be able to

- Understand the concepts of thermochemistry, pH metry, chemical kinetics.
- Develop skills of working and set up of calorimeter.
- Solve numericals on and verify the graph of chemical kinetics
- Discuss the mechanisms involved in the organic preparation experiments.
- Develop skills of common laboratory techniques including recrystallisation, recording of melting point required for organic preparations and perform calculations for quantitative analysis.

REFERENCE BOOKS

Section A

1. Bahl, A. &Bahl, B.S. Advanced Physical Chemistry, S. Chand, 2010.
2. J. N. Gurtu and AayushiGurtu, Undergraduate Physical Chemistry, Vol I, Vol II and Vol III Pragati Prakashan.
3. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
4. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
5. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
6. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
7. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

Section B

1. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons, (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.

3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.
8. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
9. Jerry March, Advanced Organic Chemistry; 4rd Edition, John Wiley.
10. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
11. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
12. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.
13. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

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CHG-102 **GENERIC ELECTIVE**

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY –I
(Semester II)

Credits: 04 (Theory: 04)

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COURSE OBJECTIVES

SECTION A

- To define the terms and state laws involved in thermodynamics, thermochemistry and chemical equilibrium.
- To explain the concept of enthalpies of solution, buffer solutions.
- To derive the thermodynamic derivation of the law of chemical standard state, enthalpies of solution, chemical equilibrium and relationships between different equilibrium constants based on ideal gases.
- To solve numerical based on chemical energetics, chemical equilibrium and ionic equilibrium.

SECTION B

- To learn the preparation methods and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- To learn the various named reactions mentioned in the syllabus.
- To understand reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- To understand Benzyne mechanism with respect to aromatic nucleophilic substitution.
- To understand Pinacol-pinacolone rearrangement with mechanism.

SYLLABUS

Theory **Number of hours: 60**

SECTION A (PHYSICAL CHEMISTRY- I)

1. Chemical Energetics (10 H)

Need of thermodynamics and the laws of thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

2. Chemical Equilibrium (8 H)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Definition of ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

3. Ionic Equilibria (12 H)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts.

SECTION B (ORGANIC CHEMISTRY – II)

4. Aromatic hydrocarbons (8 H)

Preparation (case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (case benzene): electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

5. Alkyl and Aryl Halides (8 H)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN_1, SN_2 and SN_i) reactions. Preparation: from alkenes and alcohols; reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation; Elimination vs substitution.

Aryl Halides Preparation: (chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions; Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$); Reactivity and Relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

6. Alcohols, Phenols, Ethers and Carbonyl Compounds (14 H)

Alcohols: Preparation: Preparation of 1°, 2°and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: oxidation of diols using HIO_4. Pinacol-Pinacolone rearrangement with mechanism.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten –Baumann Reaction.

Ethers (aliphatic and aromatic): Williamson's synthesis of ethers. Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (formaldehyde, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's

reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

LEARNING OUTCOMES

At the end of the course students will be able to:

- Define the terms involved in chemical energetics, chemical equilibrium, ionic equilibrium and state the laws used in thermodynamics, thermochemical equilibrium.
- Describe enthalpy, buffer solutions, factors affecting ionization.
- Derive and use the equations thermochemistry, chemical equilibrium and ionic equillibria of to solve the numericals.
- Give methods of preparation and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- Identify and give the named reactions mentioned in the syllabus.
- Explain reactivity and relative strength of c-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- Explain benzyne mechanism with respect to aromatic nucleophilic substitution.

REFERENCE BOOKS

SECTION A

1. Bahl, A. &Bahl, B.S. Advanced Physical Chemistry, S. Chand, 2010.
2. J. N. Gurtu and AayushiGurtu, Undergraduate Physical Chemistry, Vol I, Vol II and Vol III Pragati Prakashan
3. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
4. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
5. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
6. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
7. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

SECTION B

1. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. Organic Chemistry, John Wiley & Sons, (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. &Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.

8. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
9. Jerry March, Advanced Organic Chemistry; 4rd Edition, John Wiley.
10. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
11. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
12. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.
13. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

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CHG-102 **GENERIC ELECTIVE**

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY –II (Semester II)

Credits: 04 (Theory: 03, Practical: 01)

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THOERY COURSE OBJECTIVES

SECTION A

- To define the terms and state laws involved in thermodynamics, thermochemistry and chemical equilibrium.
- To explain the concept of enthalpies of solution, buffer solutions.
- To derive the thermodynamic derivation of the law of chemical standard state, enthalpies of solution, chemical equilibrium and relationships between different equilibrium constants based on ideal gases.
- To solve numerical based on chemical energetics, chemical equilibrium and ionic equilibrium.

Section B

- To learn the preparation methods and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- To learn the various named reactions mentioned in the syllabus.
- To understand reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- To understand Benzyne mechanism with respect to aromatic nucleophilic substitution.
- To understand Pinacol-pinacolone rearrangement with mechanism.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory pH metry, thermochemistry.
- To understand the mechanism of reactions involved in organic preparation experiments and develop hands on experience with reference to basic laboratory techniques required for organic preparations.

SYLLABUS
THEORY Number of hours: 23

SECTION A (PHYSICAL CHEMISTRY- I)

1. Chemical Energetics (10 H)

Need of thermodynamics and the laws of thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

2. Ionic Equilibria (13 H)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts.

SECTION B (ORGANIC CHEMISTRY – II) (23 H)

3. Functional group approach for the following reactions (7 H) (preparations & reactions)

To be studied in context to their structure. Aromatic hydrocarbons. Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic aromatic substitution: Benzene to nitrobenzene, benzene sulphonic acid, chlorobenzene. Friedel Crafts alkylation to convert benzene to toluene, and Friedel Crafts acylation to convert benzene to acetophenone. Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

4. Alkyl and Aryl Halides (7 H)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN_1, SN_2 and SN_i) reactions. Preparation: from alkenes and alcohols. Reactions: Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

5. Alcohols, Phenols, Ethers and Carbonyl Compounds (8 H)

Alcohols: Preparation: Preparation of 1°, 2°and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.
Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4,). Oppeneauer oxidation Diols: Pinacol-Pinacolone rearrangement.
Phenols: (Phenol case) Preparation: from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction (Mechanism), Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. (Only reactions with application). Ethers (aliphatic and aromatic):

Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde). Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, NaHSO3, NH2-G derivatives. Iodoform test. Aldol Condensation (Mechanism), Cannizzaro's reaction, Wittig reaction, Benzoin condensation.

PRACTICALS **30 HRS**

SECTION A: PHYSICAL CHEMISTRY (15 HOURS: 0.5 CREDIT)

Thermochemistry (Any two) **2 X 4 .5 =9 hours**

1. Determination of heat capacity of calorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Study of the solubility of benzoic acid in water and determination of ΔH.

Chemical Kinetics **2 X 3= 6 hours**

1. Study the effect of nature of reactants on the rate of reactions.
2. Determination of relative strength between HCl and Urea Hydrochloride for hydrolysis of methyl acetate.

SECTION B: ORGANIC CHEMISTRY (15 HOURS: 0.5 CREDIT)

Preparations: Mechanisms involved in the following reactions to be discussed. (3 hours)

Recrystallisation, determination of melting point and calculation of quantitative yields to be done. (3 x 4 = 12hours)

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) 2,4-dinitrophenylhydrazone of benzaldehyde/acetophenone

LEARNING OUTCOMES

THEORY

At the end of the course students will be able to:

- Explain the need of thermodynamics and the Laws of Thermodynamics.
- Define the terms and state laws involved in thermodynamics and thermochemistry and understand their application.
- Describe the concept of enthalpies of solution.
- Calculate the bond energy, bond dissociation energy and resonance energy from thermochemical data.
- Discuss the variation of enthalpy of a reaction with temperature – Kirchhoff's equation.
- Explain the significance of Free energy change in a chemical reaction.
- Derive Thermodynamic derivation of the law of chemical equilibrium.
- Discuss the Le Chatelier's principle and its application.
- Derive the relationships between Kp, Kc and Kx for reactions involving ideal gases.
- Define Strong, moderate and weak electrolytes, degree of ionization and study the factors affecting degree of ionization.

- Explain the concept and solve numerical of ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, hydrolysis constant, degree of hydrolysis, Buffer solutions, solubility and solubility product of sparingly soluble salts.

PRACTICAL

At the end of the course students will be able to

- Understand the concepts of thermochemistry, pH metry, chemical kinetics.
- Develop skills of working and set up of calorimeter.
- Solve numericals on and verify the graph of chemical kinetics.
- Discuss the mechanisms involved in the organic preparation experiments.

Develop skills of common laboratory techniques including recrystallisation, recording of melting point required for organic preparations and perform calculations for quantitative analysis.

REFERENCE BOOKS

Theory

SECTION A: PHYSICAL CHEMISTRY

1. Bahl, A. & Bahl, B. S. Advanced Physical Chemistry, S. Chand, 2010.
2. J. N. Gurtu and Aayushi Gurtu, Undergraduate Physical Chemistry, Vol I, Vol II and Vol III Pragati Prakashan. Edn. 2008.
3. Barrow, G. M. Physical Chemistry Tata McGraw-Hill (2007).
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5. Kotz, J. C., Treichel, P. M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
6. Mahan, B. H. University Chemistry 3rd Ed. Narosa (1998).
7. Petrucci, R. H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
8. K. L. Kapoor, Textbook of Physical Chemistry Vol. I & II, Third Edition, Macmillan India Ltd 2004.
9. B. S. Bahl, A. Bhal, G. D. Tuli, Essentials of Physical Chemistry, S. Chand & Company Edition 2006
10. Gurudeep Raj, Advanced Physical Chemistry, Goel Publication.
11. J. N. Gurtu, Advanced Physical Chemistry, Pragati Prakashan Edition.

SECTION B: ORGANIC CHEMISTRY

1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

7. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
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10. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.
11. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
12. Jerry March, Advanced Organic Chemistry; 4rd Edition, John Wiley.

Practical

SECTION A: PHYSICAL CHEMISTRY

1. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000.
2. Sunita Rattan, Experiments in Applied Chemistry, S. K. Kataria & Sons, Second edition, 2008.
3. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, S. Chand Publication 2013.
5. O. P. Virmani, A. K. Narula, Applied Chemistry Theory and Practice, New Age International Publishers, 2000.

SECTION B: ORGANIC CHEMISTRY

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A. I., Tatchell, A. R., Furnis, B. S., Hannaford, A. J. & Smith, P. W. G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
5. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.
6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Note: Practicals of 30 Hours = 15 practicals of 2 hours each = 7.5 practicals of 4 hours each.

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CHG-104 **GENERIC ELECTIVE**

CHEMISTRY IN DAILY LIFE
(Semester II)

Credits: 04 (Theory)

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THOERY: COURSE OBJECTIVES

In this course, students will learn and understand:

- the importance of chemistry in daily life.
- various techniques to purify organic compounds.
- various medicinal compounds derived from nature and their applications.

SYLLABUS

Theory: **Number of hours: 60**

1. **Different techniques in Chemistry (5 H)**
   Introduction: Discoveries of different techniques and their applications, viz. purification techniques: distillation, recrystallization, chromatography. X-ray and radioactivity.

2. **Organic Chemistry in medical sciences (6 H)**
   introduction to Pharmaceutical chemistry, Classification of Drugs, names and uses of the following drugs with one example each: Antibiotics, Analgesics, Antihistamines, Anticonvulsant, Hypnotics and Sedatives.

3. **Medicinal plants (5 H)**
   Introduction: Importance of plant kingdom in general and medicinal plants in particular. Viz. Tulsi, Alocvera, Turmeric, Yinca rosea, Cinchona, Datura etc.
   Compounds obtained from them, their uses and applications.

4. **Cellulose and starch (4 H)**
   Cellulose: General properties, Various compounds obtained from Starch: General properties. Isolation method. Different types and uses.

5. **Acids, Bases, Salts (10 H)**
   Introduction- acids, alkalies and salts, litmus, pH scale, Ionic nature of acids and alkalies, importance of water, the chemical reaction of acids and bases- acid reactions in everyday life, alkalies and b9ses, characteristic reactions of acids, Salts and their preparations: The importance of salts, their solubility, water of crystallisation, preparation of soluble salts.

6. Corrosion (5 H)

Definition, types, react ions, EMF series, method for prevention of metal corrosion. environmental modifications, metal selection and surface conditions, Cathodic protection, Corrosion Inhibitors, Coating and Plating- Applications

7. Nanomaterials (5 H)

Overview of nanostructures, nanomaterials and nanotechnology. Classification: 1, 2, and 3 dimensional nanomaterials, nanomaterials in nature, examples: Nanotubes, fullerenes, nanowires, applications of nanostrucutres.

8. Macro and micronutrients in health sciences (10 H)

Macronutrients: Carbohydrates, Fats and Proteins w.r.t. Classification, Functions, Health and Diseases, Food Sources, Deficiencies and Excess. Micronutrients, Vitamins: Introduction and Classification w.r.t. Fat soluble Vitamins: Vitamin A, Vitamin D, Vitamin E, Vitamin K; Water soluble Vitamins: Thiamine, Riboflavin, Niacin, Pantothenic acid, Vitamin B6, Biotin, Folate, Cyanocobalamin, Ascorbic Acid.

9. Environmental Pollution (10 H)

Air Pollution: Definition of pollutant, pollution. Different sectors of atmosphere, Greenhouse effect, Green House effect, Global warming, ozone layer depletion. Different types of pollutant. Photochemical smog. Effect of CO on human system. Control Measures. Water Pollution Sources, Effects, different types of water pollutants, Entry into the food chain. Harmful effects, Control measures.

LEARNING OUTCOMES

- Importance of Chemistry in daily life.
- Medicinal importance of plants and medicinal compounds extracted from plants and their applications.
- Prevention of pollution and corrosion.

REFERENCE BOOKS

1. Chemistry, Richard Harwood, Cambridge University Press, 1st ed., (Topic 1)
2. College Inorganic Chemistry for T.Y. B. Sc. Laxmi Devi, Patel, Dhume, Turakia, Dixit, 18th revisededition, Himalaya Publishing House.(Topic 2).
3. Food Science, Nutrition and Safety, Sukhneet Suri and Anita Malhotra, Pearsons.
4. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut
5. B. S. Baliga and A. Zaveri, College Analytical Chemistry, 15th edition,Himalaya PublishingHouse, 2004; Goth's medical pharmacology, by W. G. Clark, D. C Brater, A. R. Johnson. Galgotia Publications.
6. Medicinal Chemistry by A. Kar. Wiley Eastern Limited , New Delhi.
7. Sharma O. P. Economic botany. Tata McGraw Hill publishing Com. Ltd.
8. Sambamurthy A. V. S. S. & Subramanyam N.S. 1989. A text book of Economic Botany. WileyEastern Limited, New Delhi.
9. An Introduction to Medical Botany & pharma cognosy by N. C. Kumar. Emkay

publications, Delhi.
10. Study Material for Vocational Subject by Dr. B. G. Mhatre, Dr.V. S. Narkar, and Prof. R. K.Pathak; Pharmaceutical Chemistry Organic Volume II, by G. R. Chatwal, Himalaya PublishingHouse.

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SEMESTER III

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CHC-103 **CORE COURSE**

Physical Chemistry and Organic Chemistry (Semester III)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A (Physical Chemistry)

- To understand the difference between ideal and non-ideal solutions.
- To study phase diagrams of various systems and to apply the phase rule equation.
- To study the conductance of strong and weak electrolytes.
- To study reversible and irreversible cells and measurement of EMF.
- To solve the numerical problems based on standard electrode potentials and conductance measurement of solutions.

Section B (Organic Chemistry)

- To learn the preparation/synthesis and reactions of carboxylic acids and their derivatives, amines, diazonium salts, amino acids and simple peptides.
- To understand the mechanism of reactions.
- To compare Hofmann and Saytzeff elimination.
- To learn and remember the terms involved such as zwitterion, isoelectric point, electrophoresis with examples.
- To learn the laws, the terms involved and the principles in UV –Visible spectroscopy.
- To study various electronic transitions, λmax and effect of conjugation on colour.
- To know Woodward-Fieser rules for calculation of λmax for conjugated dienes and α, β unsaturated carbonyl compounds.
- To acquire knowledge to distinguish between *cis* and *trans* isomers using UV –Visible Spectroscopy
- To know classification of carbohydrates and their general properties.
- To know the open chain and cyclic structure of Glucose and Fructose.
- To gain knowledge of determining the configuration of monosaccharides.
- To study the terms involved with examples.
- To learn the synthesis involved.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory. (phase equilibria, conductometry and potentiometry)
- To get hands on experience for the preparation of derivatives.
- To gain knowledge of analyzing organic compounds.
- To learn to perform estimations.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. **Solutions (7 H)**
   Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Azeotropes. Partial miscibility of liquids: Critical solution temperature, distillation and fractional distillation.

2. **Phase Equilibrium (8 H)**
   Phases, components and degrees of freedom of a system, criteria of phase Equilibrium. Phase diagrams of one-component systems (water, sulphur and CO_2) Component and two systems involving eutectics, congruent and incongruent melting points (Zn-Mg, NaCl-H_2O).

3. **Conductance (5 H)**
   Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Ionic mobility and factors affecting ionic mobility. Transference number and its experimental determination using moving boundary methods. Applications of conductance water, measurements: solubility and solubility products of sparingly soluble salts, ionic product of conductometric titrations (only acid-base).

4. **Electrochemistry (7 H)**
   Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using a hydrogen electrode and quinhydrone electrode.

Section B

5. **Carboxylic acids and their derivatives (10 H)**
   Carboxylic acids (aliphatic and aromatic); Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell - Volhard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversions, Reactions: Comparative study of the

nucleophilicity of acyl derivatives. Reformatsky reaction, Perkin condensation (mechanism).

6. Amines and Diazonium Salts (6 H)

Amines (aliphatic and aromatic): (upto 5 carbons) Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (Hofmann rearrangement).

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann reaction. Electrophilic substitution (case aniline): nitration,bromination, sulphonation.

Diazonium salts: Preparation from aromatic amines, conversion to benzene, phenol, dyes.

7. Amino Acids and Peptides (6 H)

Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis.

Terms: Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: Ester of – COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

8. UV –Visible Spectroscopy in Organic Chemistry (6 H)

Introduction to spectroscopy:

UV Spectroscopy: Beer-Lambert's law, Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption.

Visible Spectroscopy: Effect of conjugation on colour. Application of Woodward - Fieser rules for calculation of λmax for the following systems: α, β unsaturated aldehydes, ketones. Conjugated dienes: alicyclic, homoannular and heteroannular, extended conjugated systems (aldehydes, ketones and dienes). Distinction between cis and trans isomers.

9. Carbohydrates (8 H)

Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, Osazone formation, Killiani Fischer synthesis.

PRACTICALS Number of hours: 60

Section A (PHYSICAL CHEMISTRY)

Phase Equilibria (10 H)

1. To draw the phase diagram of the binary system - diphenyl amine and α – Naphthol and find the eutectic temperature.
2. Study the mutual solubility of phenol and water at various temperatures and hence determine the critical solution temperature.

3. Study the effect of addition of NaCl on critical solution temperature of phenol water system and study of the effect of impurities on it.

Conductance (8 H)

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base

Potentiometry (12 H)

Potentiometric titrations
1. Strong acid vs. strong base (Quinhydrone method)
2. Potassium dichromate vs. Ferrous Ammonium sulphate

Section B (ORGANIC CHEMISTRY)

1. **Systematic Qualitative Organic Analysis (12 H)**
   Analysis of Organic Compounds possessing monofunctional groups (carboxylic, aldehyde, ketone, amide, nitro, amines) and preparation of one derivative of each group. (Analysis of single compound and its derivative preparation) ethylacetoacetate.

2. **Organic Preparations: (14 H)**
   Synthesis, yield, recrystallisation and Melting Point.
   A. Hippuric acid from glycine (Benzoylation-Schotten Baumann reaction) (4 Hours)
   B. Osazone from Glucose (Nucleophilic addition) (2 Hours)
   C. Phthalic acid to Phthalic Anhydride to Phthalimide (4 Hours)
   D. Preparation of Azo dye (4 Hours)

3. **Organic Estimations: (**Any 2**) (4 H)**
   A. Estimation of glycine by formylation method (2 Hours)
   B. Estimation of Glucose by oxidation (2 Hours)
   C. Estimation of Acetamide by hydrolysis

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:
- Define the terms involved in Phase Equilibria, Solutions, Conductance and Electrochemistry.
- State the Raoult's Law and the Kohlrausch's law of independent migration of ions.
- Draw the schematic diagrams of instruments used in Conductance and Electrochemistry.

- Interpret the graphs based on Raoult;s law and in Conductometric titrations.
- Define and explain the terms involved giving examples.
- Describe the preparation of various compounds involved.
- Classify carbohydrates.
- Draw the structures of carbohydrates.
- Predict and compare the mechanism of reactions involved.
- Explain and propose the mechanism of similar reactions.
- Predict the products, intermediates, reactants and reaction conditions for a given chemical reaction.
- State the laws involved in UV –Visible Spectroscopy and will be able to distinguish between cis and trans isomers.
- Calculate λmax for Conjugated dienes and α, β unsaturated carbonyl compounds using Woodward–Fieser rules which will help them to predict the structure of organic compound with the help of other spectroscopic data.

Practicals

At the end of the course students will be able to

- Understand the concepts of phase equilibria, conductometric titration and potentiometric
- Develop skills of working and carrying out conductometric and potentiometric titrations.
- Draw Phase equilibria curve, Conductometric and Potentiometric titration curves.
- Perform reactions and prepare derivatives.
- Develop skills of identification and analysis of organic compounds at microscale level.
- Carry out organic estimations by formylation, oxidation and hydrolysis.

REFERENCE BOOKS

Theory

1. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
2. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009)
3. Undergraduate Physical Chemistry, Vol II, J.N. Gurtu, Pragati Prakashan.
4. Advanced Physical Chemistry, Gurtu and Gurtu, Pragati Prakashan
5. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
6. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York
7. (1985).
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9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
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12. Berg, J. M., Tymoczko, J.L. &Stryer, L. Biochemistry, W.H. Freeman, 2002.Kemp,
13. W. Organic Spectroscopy, Palgrave.
14. Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India

15. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.

Practical

Physical Chemistry

1. Systematic experimental physical Chemistry by S.W. Rajbhoj, Dr. T. K. Chondhekar, Anjali Publication, Aurangabad.
2. Practical Chemistry by O.P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication
3. Khosla, B. D., Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Organic Chemistry

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

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CHS-101 **SKILL INHANCEMENT COURSE**

Natural Resources and Analysis
(Semester III)

Credits:04 (Theory: 03 & Practical: 01)

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THOERY: COURSE OBJECTIVES

- To define renewable, non-renewable and alternative energy sources.
- To define fuel, calorific value and the characteristics of a good fuel.
- To understand composition and uses of coal gas, producer gas and water gas.
- To study coal gasification (Hydrogasification and Catalytic gasification), coal liquefaction and solvent refining.
- To study different types of petroleum products and their applications.
- To understand idea about food processing and food preservation and adulteration.
- To understand the concept of pH and pH measurement with respect different types of soils...
- To study the use of different indicators for mapping various soil characteristics to improve soil fertility.
- To find out the sources responsible for contaminating water, study water sampling methods and methods employed for the purification of water.

PRACTICALS: COURSE OBJECTIVES

- To understand the different methods employed for the determination of various physico-chemical parameters of water.
- To understand the method of determination of soil pH.

SYLLABUS

Theory: **Number of hours: 45**

1. **Review of energy sources (renewable and non-renewable) (2 H)**
   Classification of fuels and their calorific value.

2. **Coal (10 H)**
   Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, Producer gas and Water gas—composition and uses. Fractionation of coal tar, uses of coal tar, requisites of a good metallurgical coke, coal gasification (Hydrogasification and Catalytic gasification), coal liquefaction and solvent refining.

3. Petroleum and Petrochemical Industry (10 H)

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), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its Derivatives.

4. Analysis of food products (10 H)

Nutritional value of foods, idea about food processing and food preservation and adulteration.

a) Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder, pulses etc.

b) Analysis of preservatives and colouring matter.

5. Analysis of soil (7 H)

Composition of soil, Concept of pH and pH measurement, complexometric titrations, chelation, chelating agents, use of indicators.

6. Analysis of water (8 H)

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

PRACTICALS Number of hours: 30

1. Determination of pH of soil samples.
2. Determination of pH of water samples.
3. Estimation of Calcium and Magnesium ions as calcium carbonate by complexometric titration.
4. Determination of dissolved oxygen (DO) in a given water sample.
5. Determination of acidity of a water sample.
6. Determination of alkalinity in a given water sample
7. Measurement of dissolved CO_2.
8. Percentage of available chlorine in bleaching powder.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Define the terms renewable, non-renewable and alternative energy sources.
- Define fuel, its calorific value and know the properties of fuels.
- Understand production of coal gas, producer gas and water gas and their uses.
- Explain composition of crude petroleum, Refining and different types of petroleum products and their applications.
- Define Nutritional value of foods, idea about food processing and food preservation and adulteration.
- Apply the concept of pH to understand reactions in soil.

- Define chelate, chelating agent and know the method of preserving important cations in soil.
- Use different types of indicators for soil mapping to understand soil fertility.
- Identify various sources of water pollution and understand the use of water sampling methods to sample water.

Practical

At the end of the course students will be able to

- To determine various physico-Chemical parameters of water.
- To determine pH of any soil sample.

REFERENCE BOOKS

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
4. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
5. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
6. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
7. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
8. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India
9. Jain, P.C. & Jain, M. Engineering Chemistry.

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CHS-106 **SKILL INHANCEMENT COURSE**

PHARMACEUTICAL CHEMISTRY & INTELLECTUAL PROPERTY RIGHTS (Semester III)

Credits:04 (Theory: 03 & Practical: 01)

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THOERY: COURSE OBJECTIVES

- To study the importance of pharmaceutical chemistry
- To study the various ways of naming drugs.
- To introduce the students the concept of Structure Activity Relationship with examples.
- To introduce various representative classes of drugs with examples.
- To introduce the students to mechanism of action of selected drugs
- To introduce the students to intellectual property rights.

PRACTICALS: COURSE OBJECTIVES

- Adopt hands-on practical training in performing assay of drugs.
- To give an overview of intellectual property rights, that include patent filing procedures and prior art patent search.

SYLLABUS

Theory: **Number of hours: 45**

1. **Pharmaceutical Chemistry: History and Introduction (6 H)**
   Pharmaceutical Chemistry-Historical background of Drug discovery, design and development. Pharmacophore and Concept of structure-activity relationship. Main Classes of drugs with examples: anti-infective agents, cardiovascular agents, central nervous system agents, analgesics and anti-inflammatory agents, antibiotics and anti-HIV drugs

2. **IUPAC names, Synthesis and uses of representative drugs (10 H)**
   Synthesis of Aspirin, paracetamol, lbuprofen, Sulphacetamide, Acyclovir, Clotrimazole, Phenobarbital, Glyceryl trinitrate, Dapsone, metronidazole.

3. **Mechanism of Action of representative drugs (6 H)**
   Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides, antiamoebic (metronidazole), Central nervous depressant (Phenobarbital)

4. Structure Activity Relationship of representative drugs (6 H)

Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides (suphacetamide), antiamoebic (metronidazole)

5. Introduction to Intellectual Property (12 H)

Historical Perspective, Different Types of IP, Importance of protecting IP.

Copyrights: Introduction, How to obtain, Differences from Patents. Trade Marks: Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, Trade names, etc. Differences from Designs.

Patents: Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

Geographical Indications: Definition, rules for registration, prevention of illegal exploitation, importance to India.

Industrial Designs: Definition, How to obtain, features, International design registration. Importance for pharmaceutical industry.

Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

6. Different International Agreements

World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade related Services (GATS)

(iii) Madrid Protocol

(iv) Berne Convention

(v) Budapest Treaty. **(3 Hours)**

Indian Patent Act: Prior Art search for patents with an illustration. **(2 Hours)**

PRACTICALS Number of hours: 30

I) Preparations (Each practical for four hours) (Any four) (4x4=16 Hours)

1) Aspirin
2) Benzimidazole
3) 2,4-diphenyl Quinoxaline
4) Benzocaine
5) Sulphacetamide

II) Titrimetric Assay (Each practical for three hours) (3x2=06 Hours)

1. Assay of Aspirin
2) Assay of Ibuprofen

III) Patent filing application procedures with two exercises (2x2=4 Hours)

IV) Patent Prior Art search on pharmaceutical patent (4 Hours)

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Explain different classes of drugs.
- Write the synthesis and naming of drugs.
- Apply the concept of structure activity relationship in studies of drug bioactivity.
- Explain the mechanism of action of drugs.
- Understand the intellectual property rights.
- Write prior art patent search.
- Write patent filing procedures.

Practical

At the end of the course students will be able to

- To perform synthesis of drugs.
- To understand the concept of assay of drugs and find the purity of drugs.
- To write patent filing application procedures.
- To perform prior art patent search.

REFERENCE BOOKS

Theory

1. **G**.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.
4. Wilson, Gisvold and Doerge Textbook of Organic, Medicinal and Pharmaceutical Chemistry.
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6. Medicinal Chemistry, D. Shriram, P. Yogeshwari, Pearson Education, 2007.
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8. Medicinal Chemistry, Chatwal, Himalaya Publishing house, 2002.
9. N.K. Acharya: Textbook on intellectual property rights, Asia Law House (2001).
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11. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).
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13. Jayashree Watal, Intellectual property rights in the WTO and developing countries, Oxford University Press, Oxford.

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SEMESTER IV

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CHC-104 **CORE CORSE**

Physical Chemistry and Inorganic Chemistry (Semester IV)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A –Physical Chemistry

- To study the postulates of kinetic theory of gases and understand the deviations of real gases from ideal behaviour.
- To understand properties of liquids such as surface tension and viscosity and the methods to measure them.
- To study the structures of cubic crystals and the laws explaining their structure.
- To understand rates of chemical reactions of zero, first and second orders.
- To apply reaction rate theories for chemical reactions.

Section B-Inorganic Chemistry

- To understand electronic configuration, variable valency, color, magnetic and catalytic properties of 3d series.
- To understand the complexing ability and stability of various oxidation states (Latimer diagrams) for Mn, Fe, and Cu.
- To understand electronic configurations, oxidation states, color, magnetic properties of lanthanides.
- To explain lanthanide contraction, separation of lanthanides (ion exchange method only).
- To understand the IUPAC system of nomenclature for coordination compounds.
- To understand the bonding in complexes using valence bond theory.
- To study the different types of isomerism's associated with coordination compounds.
- To understand the factors affecting the magnitude of 10Dq.
- To study the effect of strong field and weak field ligands on CFSE.
- To study crystal field splitting in tetrahedral and octahedral complexes and to calculate CFSE.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory.
- To systematically analyse the cations and anions in a given mixture.

- To quantitatively estimate several metal ions using the gravimetric and volumetric techniques.
- To determine the concentration of coloured compounds using the colorimetric technique.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. Kinetic Theory of Gases (8H)

Postulates of Kinetic Theory of Gases, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrew's isotherms for CO2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation), collision number, collision frequency, collision diameter and mean free path of molecules.

2. Liquids (6 H)

Surface tension and its determination using stalagmometer. Effect of temperature on surface tension. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer and factors affecting viscosity.

3. Solids (8 H)

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice. Laws of crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices, X–Ray diffraction by crystals, Bragg's law. Particle size determination using powder method. Structures of NaCl, KCl and CsCl (qualitative treatment only)

4. Chemical Kinetics (8 H)

The concept of reaction rates. Effect of temperature, pressure and catalyst on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions.

Section B

5. Transition Elements (10 H)

General characteristic properties of 3d series with special reference to electronic configuration, variable valency, color, magnetic and catalytic properties. Ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe, and Cu. Lanthanides: Electronic configurations, oxidation states, color, magnetic properties,

lanthanide contraction, separation of lanthanides (ion exchange method only). Actinides: Electronic configuration and general characteristics.

6. Coordination Chemistry (10 H)

IUPAC system of nomenclature. Bonding in complexes based on Valence Bond Theory (VBT), Inner and outer orbital complexes of Cr, Fe, Co, Ni, and Cu (coordination numbers 4 and 6). Different types of structural and stereo-isomerism including optical isomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT.

7. Crystal Field Theory (10 H)

Crystal field splitting in octahedral complexes. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Spectrochemical series. Crystal Field Splitting in Tetrahedral complexes. Calculation of CFSE. Comparison of CFSE for Oh and Td complexes. Factors affecting the magnitude of 10Dq. Merits and Demerits of Crystal Field Theory.

PRACTICALS Number of hours: 60

Section A (Physical Chemistry)

1. Surface Tension measurement (4 H)

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

II. Solutions of Solids in Liquids (4 H)

Determine solubility curve for KCl from 25^0C to 50^0C.

III. Viscosity measurement (10 H)

a. Determination of the viscosity of a liquid or dilute solution using an Ostwald's viscometer.
b. Study of the variation of viscosity of an aqueous solution with concentration of solute.

IV. Chemical Kinetics (12 H)

a. To determine the rate constant and order of reaction between KI and $K_2S_2O_8$.
b. Study of saponification of ethyl acetate with sodium hydroxide at equal concentration of ester and alkali.
c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Section B (Inorganic Chemistry)

I. Semi-micro qualitative analysis: not more than four ionic species (two anions and two cations): (4 Mixtures) (12 H)

Cations: NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+.

Anions: CO_3^{2-}, S^{2-}, SO^{2-}, SO_4^{2-}, NO_3^-, Cl^-, Br^-, I^-, NO_2^-, PO_4^{3-}, F^-

II. Gravimetric/Volumetric (12 H)

1. Estimate the amount of Nickel present in a given solution as bis (dimethylglyoximato) Nickel(II) gravimetrically by counterpoise filter paper.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. To estimate the amount of Bismuth present in the given solution of $Bi(NO_3)_2.3H_2O$ by complexometric titration.
4. To estimate the amount of Nitrite present in the given $NaNO_2$ solution by titrating v/s Ceric ammonium sulphate /Ceric sulphate.

III. Colorimetric Experiments (6 H)

1. Draw calibration curve (absorbance at λ_{max} v/s concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
2. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.

LEARNING OUTCOMES

Theory

Section A: Physical Chemistry

At the end of the course students will be able to:

- Define the terms involved in Kinetic Theory of Gases, Liquids, Solids, and Chemical Kinetics.
- Draw the schematic diagrams of stalagmometer, Ostwald viscometer and cubic crystal structures.
- Draw the graphs for first order and second order reactions.
- Explain the terms involved like unit cell, space lattice, activation enery, surface tension, viscosity, average velocity, root mean square velocity.

Section B: Inorganic Chemistry

- Explain general characteristics and electronic configuration of 3d Lanthanide and Actinide elements.
- Explain oxidation states, colour, and magnetic properties of 3d and lanthanide elements.
- Understand the Latimer diagram for Mn, Fe, and Cu.
- Name coordination compounds using IUPAC nomenclature.
- Explain inner and outer orbital complexes.
- Identify the different types of isomerism's associated with coordination complexes.
- Calculate crystal field stabilization energy of coordination complexes. Understand the effect of strong field and weak field ligands on the crystal field splitting of coordination complexes.

Practical

At the end of the course, students will be able to:

- Understand the concepts of surface tension, viscosity, and solubility.

- Develop skills for doing chemical kinetics titrations.
- Draw graphs and determine order of reactions.
- Understand on how to use a stalagmometer and Ostwald's viscometer.
- Develop skills in the identification and analysis of cations and anions.
- Perform gravimetric, volumetric and colorimetric experiments for quantitative interpretation of substances/metal ions.
- Carry out quantitative estimations of various metal ions.

REFERENCE BOOKS

Section A: Physical Chemistry

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R.
3. Chand & Co.: New Delhi (2011).
4. Systematic experimental physical Chemistry by S.W. Rajbhoj, Dr. T. K. Chondhekar, Anjali Publication.
5. Practical Chemistry by O.P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication.
6. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg, A. Gulati, R. Chand & Comp, New-Delhi.

Section B: Inorganic Chemistry

1. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
2. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
3. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
4. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd.,2008.
5. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
6. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
7. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
8. Principles of Inorganic chemistry by B.R. Puri, S. Sharma, and Kalia, Vallabh Publication.
9. Inorganic Chemistry Principles of Structure and Reactivity James E Huheey, Ellen A. Keiter, Richard L.Keiter, Okhil K Medhi

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CHS-102 **SKILL ENHANCEMENT CORSE**

Chemistry of Cosmetics and Perfumes (Semester IV)

Credits: 04 (Theory: 03 & Practical: 01)

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THOERY COURSE OBJECTIVES

- To explain the term cosmeticology.
- To give examples of marketed products and describe the preparation formulation and packaging of various cosmetic products.
- To define herb and other terms involved.
- To describe the preparation of herbal drug.
- To classify herbal cosmetics.
- To describe the development of Ayurvedic and Herbal formulations and their evaluation by physical methods, chemical methods and microscopical techniques.
- To describe the formulation and preparation of Herbal cosmetics for skin care and hair care products.
- To define the terms involved in perfumes and flavours.
- To understand the classification of perfumes and categorise as per the ingredients.
- To understand the importance of essential oils in cosmetic industries.
- To describe the general methods of obtaining volatile oils from plants. To describe the composition of volatile oils.

PRACTICALS COURSE OBJECTIVES

- To understand the concept of cosmetics and develop preparation and skills of working and preparation of various cosmetic products.

SYLLABUS

Theory: **Number of hours: 45**

1. **Cosmetic Formulation, principles and preparations (15 H)**
   Introduction to cosmeticology. Definition of cosmetics as per EU and Indian guidelines. Cleansing and care needs for face, eye lids, lips, hands, feet, nail, scalp, neck, body, and underarms. Examples of marketed products. A general study including preparation and uses of the following: Hair dye, hair spray, sunscreen lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving), Formulation, preparation and packaging of cosmetics for hair - Shampoo and conditioners. Examples from marketed products.

2. Herbal Cosmetics (15 H)

Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation. Classification of herbal cosmetics. Development of Ayurvedic and Herbal formulations and their evaluation by physical methods, chemical methods and microscopical techniques. Herbal cosmetics for skin care (lotions, vanishing cream, foundation creams, anti sunburn preparations, face packs, lipsticks, face powders, soaps). Herbal cosmetics for hair care: Henna and Hibiscus.

3. Perfumes and Flavors (15 H)

Classification of perfumes. Perfume ingredients listed as allergens. Deodorants, antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone. Volatile Oils: General methods of obtaining volatile oils from plants; Study of volatile oils of Mentha, Lemon peel, Orange peel, Lemon grass, Eucalyptus, Musk, Sandal wood.

PRACTICALS Number of hours: 30

1) Demonstration/Practicals
2) Preparation of talcum powder.
3) Preparation of shampoo.
4) Preparation of enamels.
5) Preparation of hair remover.
6) Preparation of cold cream.
7) Preparation of nail polish and nail polish remover.
8) Preparation of vanishing cream.
9) Preparation of shaving cream.
10) Herbal preparations and evaluations of lotions.
11) Herbal preparations and evaluations of face packs.
12) Herbal preparations and evaluations of soaps.
13) Extraction of volatile oil from lemon peel.
14) Extraction of volatile oil from lemon grass.
15) Extraction of volatile oil from orange peel.

LEARNING OUTCOMES

THEORY

At the end of the course students will be able to

- Define cosmetics as per EU and Indian guidelines
- Describe the preparation and uses of various cosmetic products mentioned.
- Describe the formulation and packaging of cosmetics for hair - Shampoo and conditioners.
- Classify herbal cosmetics.
- Explain the terms herbal medicine and herbal medicinal products.
- Describe the preparation of herbal drug.
- Describe the development of Ayurvedic and Herbal formulations and their evaluation by physical methods, chemical methods and microscopical techniques.

- Describe the formulation and preparation of Herbal cosmetics for skin care and hair care.
- Classify the perfumes and categorize the perfume ingredients.
- Explain the importance of essential oil in cosmetic industries.
- Describe the composition of different volatile oils and methods of obtaining them.

PRACTICAL

At the end of the course students will be able to:

- Understand the concepts various cosmetic products.
- Prepare various cosmetic products.

REFERENCE BOOKS

1. E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
4. G.L. Patrick: Introduction to *Medicinal Chemistry, Oxford University* Press, UK. 65.
5. Hakishan, V.K. Kapoor: *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi.
6. Keith Wilson and John Walker: Practical Biochemistry.
7. Thomas M. Devlin: Textbook of Biochemistry.
8. Talwar, G.P. &Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed.PHI Learning.
9. Textbook of herbal cosmetics by Vimaladevi M. CBS Publishing 1st Ed. 2015.
10. The complete technology book on herbal beauty products with formulation and processes by H. Panda, Asia pacific business press Inc. 2005.
11. Essential oils: A practical guide by John Gordon, Aetheric publishing.

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CHS-107 **SKILL ENHANCEMENT COURSE**

Advances in Energy Technology
(Semester IV)

Credits: 04 (Theory 03 + Practical 01)

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THEORY COURSE OBJECTIVES

- To learn about various available natural energy resources and discuss about future energy resources.
- To study different energy conversion processes including chemical as well as electrochemical energy systems.
- To study fundamental and applications of various energy systems especially battery, fuel cells, solar cells etc.
- To learn about mechanism involved in Photochemical and photo galvanic conversion along with other miscellaneous Sources of energy like tidal Energy and geothermal Energy.

PRACTICAL COURSE OBJECTIVES

- To learn about designing of basic electrochemical energy conversion electrochemical cell.
- To study synthesis methods for preparation of good electrochemical support material for electrodes in fuel cells as well as batteries.
- To experimentally evaluate the adsorption property of the synthesized material.
- To study the kinetics of photochemical reactions.
- To evaluate moisture content, sulphur and ash content of the synthesized adsorbent.

SYLLABUS

Theory **No. of hours: 45**

1. INTRODUCTION (5 H)

1.1 Man, and Energy.

1.2 Chemical Energy System, Electrochemical energy system.

1.3 Resources and energy: natural resources- energy environment triangle, energy problem, World energy resources, Energy conversion, Energy conversion processes.

1.4 Future Energy Resources.

2. CHEMICAL ENERGY SOURCES (16 H)

2.1 Petroleum: Origin, nature of sources of material for crude oil, composition of petroleum, refining of petroleum, products derived from petroleum.

2.2 Natural gas: Occurrence, natural gas liquid.

2.3 Coal: Origin, constitution of coal, coal gasification, and indirect liquification, purification of synthesis gas. Water gas shift process, indirect liquification, direct liquification, coal combustion, chemical obtained from coal.

2.4 Nuclear Fission: Power from nuclear fission, light water reactors (LWR), heavy water reactor (HWRs), Gas cooled reactors (GCRs), fast breeder reactors (FBRs)

2.5 Nuclear Fusion: Cold fusion

3. ELECTROCHEMICAL ENERGY SYSTEM (12 H)

3.1 Introduction, fundamentals of batteries, choice of materials, classification of batteries, sizes of batteries.

3.2 Some common batteries: Button cells, Portable equipment batteries, SLI batteries, Vehicle traction batteries, Stationary batteries, Battery characteristic power density.

3.3 Primary batteries: Combination of materials for a primary battery, alkaline MnO_2 batteries performance and advantages, secondary batteries.

3.4 Types and classification, sealed storage batteries, metal hydride electrode.

3.5 Reserve Batteries: Introduction, classification, liquid activated, water activated Batteries, gas activated batteries, heat activated batteries, and Lithium based conducting polymer batteries, Lithium batteries and heart pacers.

4. FUEL CELLS (7 H)

4.1 Introduction, Classification, Choice of electrolyte. Electrodes and requirement of Electrocatalysis.

4.2 Biochemical Fuel cells. Characteristic, Classification, Mechanisms and Application.

4.3 Use of carbon in fuel cells, Fuel cells using Carbon nano materials.

5. SOLAR ENERGY (5 H)

5.1 Photochemical and photogalvanic conversion.

5.2 Hydrogen energy: Merits of hydrogen fuel cell, Hydrogen economy concept, Photo assisted electrolysis of water.

5.3 Biomass: Resources, Wood- a measure renewable resource and Biochemical routes.

5.4 Gasohol, Hydrogen storage by Metal alloys.

5.5 Miscellaneous Sources: Tidal Energy, Geothermal Energy.

PRACTICALS

A. Electrochemical Energy

1. Construct a Daniel cell and determine the voltage of the cell at varying concentration. (**4 H**)
2. Determination of electrochemical equivalent of copper. (**4 H**)

B. Supports for Electro-catalyst

1. Preparation of Carbon (from Coconut shell) and determination of surface area using volumetric method. (**4 H**)

2. Verification of Freundlich adsorption isotherm of Coconut shell Carbon. (**4 H**)

C. Photochemical Energy

1. Extraction of photosynthetic pigments from different parts of the plants and its identification from absorption wavelength (2 samples to be studied). (**4 H**)
2. Kinetics of photochemical reactions between iodine and oxalate using visible light (Colorimetrically). (**4 H**)

D. Sources of Chemical Energy

1. Determination of moisture content in the sample of coal/ charcoal. (**2 H**)
2. Determination of Sulphur and ash content in the sample of Coal/Charcoal. (**4 H**)

LEARNING OUTCOMES

Theory

- This course will help strengthen knowledge regarding various available natural energy resources and future energy resources.
- Different energy conversion processes like chemical and electrochemical energy systems will be studied in detail.
- It focusses on fundamental as well as applications of batteries, fuel cells and solar energy systems.
- It will also cover Photochemical and photo galvanic conversion along with other miscellaneous Sources of energy like tidal Energy and geothermal Energy.

Practical

- Will be able to understand basics in designing a electrochemical cell.
- Various synthetic strategies for preparation of good electrochemical support material for electrodes in fuel cells as well as batteries will be undertaken.
- Will learn to evaluate the adsorption properties of the various materials.
- Kinetics of photochemical reactions will be studied
- Parameters like moisture content, Sulphur and ash content of the adsorbent will be evaluated.

REFERENCES

Textbooks **THEORY**

1. R. Narayan and B. Viswanathan, Chemical and Electrochemical Energy Systems, University Press, 1998.

2. C. Vincent and B. Scrosati, Modern Batteries, An introduction to Electrochemical Power Sources, Arnold, 1997.

3. M. Sharon and M. Sharon, Nano Forms of Carbon and its Application, Monad Nano Tech, Mumbai, 2007.
4. R. Probstein and R. Hicks, Synthetic Fuels, Mc Graw Hill, 1985.
5. International Journal of Hydrogen Energy 16, 35-45 (1991)
6. S. Manahan, Fundamentals of Environmental Chemistry, Lewis Publication, New York, 1993.
7. S. P. Sukhatme, Solar Energy Principles of Thermal Collection and Storage, Tata McGraw Hill, 2006

PRACTICAL

1. O. P. Virmani and A.K. Narula, Applied Chemistry theory and Practice, New Age, International Publishers, IInd Edition.
2. Robert Bruce Thompson, Illustrated Guide to Home Chemistry Experiments O'Reilly Media. Inc.
3. S. W. Rajbhoj and Dr. T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication Aurangabad.

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SEMESTER V

Bachelor of Science (Honours) Programme

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Bachelor of Science (Honours) Programme

CHC-105 **CORE COURSE**

Physical Chemistry
(Semester V)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A & B

- To study the mathematical concepts (integration, derivation, exponential trigonometric function.)
- To solve the numerical wrt Nernst equation, to study electrochemical series and applications.
- To study optical activity, polarization, dipole moment and methods of determination of dipole moments and structure of molecules
- To classify different nuclides. Binding energy and nuclear forces. To study nuclear models, radioactivity.
- To study emf and its measurements. To study concentration cell, its measurements, applications,
- To study decomposition potential, overvoltage and factors affecting them.
- Molecular structure and molecular spectra
- To define the principles, hypothesis, postulates of quantum mechanics in Quantum chemistry.
- To apply the basic mathematical concepts in quantum chemistry.
- To draw the wave functions, orbital diagrams and the graphs involved.
- To solve the numerical, explain and interpret the wave functions.
- To study the electromagnetic spectrum, terms, principles involved. To study Rotational spectra of diatomic molecules, determination of bond lengths and qualitative description
- To study counters used in measurement of radioactivity

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory (potentiometry, pH metry, Solubility, Chemical kinetics)

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Nuclear Chemistry I (10 H)

Composition of the nucleus, nuclear binding forces and energy, nuclear stability, nucleon –nucleon forces and their equality, characteristics and theory of nuclear forces, nuclear models, radioactive disintegration, decay constant, half- life and average life, units of radioactivity, artificial radioactivity, detection and measurement of radioactivity, GM counter, semiconductor and proportional counter, Scintillation counter, characteristics of suitable scintillator. (numericals to be solved)

2. Electrochemistry I (20 H)

Ion-selective electrodes: Fixed-site membrane, mobile-site membrane, site-free membrane, construction of ion selective electrodes, applications of ion selective electrodes. Decomposition potential, experimental determination of decomposition potential, application of decomposition potential, overvoltage and overpotential, theory of overvoltage, experimental determination of overvoltage, factors affecting overvoltage, hydrogen overvoltage, oxygen overvoltage, metal overvoltage. Fuel cells; H_2-O_2, Molten Carbonate Fuel cell, Proton exchange membrane fuel cell, Solid Oxide Fuel cell, Electrochemical Sensors; sensors, Principle, advantages and applications.

SECTION B

3. Quantum Chemistry I (16 H)

Mathematical Concepts: Derivatives and integrations, trigonometric functions, exponential functions, second derivatives of the functions. De-Broglie hypothesis, Heisenberg Uncertainty principle, sinusoidal wave function, terms involved in Quantum mechanics: Normalisation, orthogonality, observables, operators, stationary states, and variables. Schrodinger equation and its application to free particle and "particle in a box" (rigorous treatment) quantisation of energy levels, zero – point energy, Schrodinger equation in Cartesian and spherical polar (derivation not required), Extension to two- and three-dimensional boxes, separation of variables, degeneracy. Operators (Hermitian, non-Hermitian), eigen value and eigen functions, physical significance of wave function, examples of operators, Hamiltonian operators, Quantum mechanical operators and commutation rules Postulates of quantum mechanics, wave functions, probability distribution functions, nodal properties.

4. Molecular Spectroscopy I (14 H)

Interaction of electromagnetic radiation with molecules and various types of spectra, Born Oppenheimer approximation. Rotational Spectroscopy: selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degree of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration –rotation spectroscopy: Diatomic vibrating rotator, P, Q, R branches Raman spectroscopy: Qualitative treatment of Rotational Raman effect, Vibrational Raman spectra, Raman effect, Stokes and Anti-stokes lines, their intensity difference, Quantum and Classical theories of Raman effect rule of mutual exclusion principle.

PRACTICALS Number of hours: 60

1. To study the kinetics of iodine clock reactions.
2. To determine the strength of mixture containing weak acid and salt of weak base by titrating against standard 0.1N NaOH solution conductometrically.
3. To determine the dissociation constant of a weak monobasic acid using pH metry.
4. To determine the percentage composition and amount of halides from a mixture (any two halide) using standard 0.1N $AgNO_3$ solution.
5. To study the adsorption of Acetic acid by charcoal and to verify Freundlich adsorption isotherm.
6. To determine the energy of activation of hydrolysis of ethyl acetate (unequal concentration)
7. To determine degree of hydrolysis and hydrolysis constant of CH_3COONa/ NH_4Cl.

Minor Experiments

1) Using vibrational-rotational spectra of HCl molecule;
   (A) Assign the rotational lines to various transitions.
   (B) Calculate
      (I) The value of B0 and B1, for R and P branches of spectra.
      (II) Vibrational frequency and
      (III) Inter nuclear distance

2) Using vibrational-rotational spectra of HBr molecule:
   (A) Assign the rotational lines to various transitions.
   (B) Calculate
      (I) The value of B0 and B1, for R and P branches of spectra.
      (II) Vibrational frequency and
      (III) Inter nuclear distance

3) To determine Standard Reduction Potential of Zn++/Zn.
4) To determine Standard Reduction Potential of Cu++/Cu.
5) To determine the solubility product of AgCl of 0.1 M $AgNO_3$.
6) To determine the solubility product of AgCl of 0.05 M $AgNO_3$.
7) To determine the solubility product of AgCl of 0.01 M $AgNO_3$.

LEARNING OUTCOMES:

THEORY

At the end of the course students will be able to

- Define the terms involved in Quantum chemistry, electrochemistry, molecular structure and nuclear chemistry.
- State the laws, principles of quantum chemistry, electrochemistry, molecular structure and nuclear chemistry. postulates of quantum mechanics
- Draw the schematic diagrams, diagrams of instruments, wave functions, orbital diagrams and the graphs involved.
- Distinguish between types of nuclear forces, types of polarisations.

- Explain the terms involved in quantum chemistry, electrochemistry, molecular structure and nuclear chemistry with suitable examples, interpret the graph of binding energy, neutron energy.
- Explain classification of electrochemical cells, nuclear models, working of counters used in measurement of radioactivity, electrodes used in electrochemical cells.
- Derive and use the equations to solve the numerical in quantum chemistry, electrochemistry, molecular structure and nuclear chemistry.
- Interpret the wave function, compare the various methods involved in measurement of dipole moment.
- To solve the numerical in quantum chemistry using basic mathematical concepts (definite integrals, derivatives, trigonometric functions and exponential functions.)

PRACTICAL

At the end of the course students will be able to
- Understand the concepts of adsorption isotherms and activation energy solubility product.
- Develop skills of working and set up of electrochemical cells (potentiometry and pH-metry, coductometry).
- Solve numericals on standard electrode potential and verify the graph of adsorption isotherms.

REFERENCE BOOKS

Textbooks

1. J. N. Gurtu, Physical Chemistry Vol-III, A Pragati edition.
2. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan.
3. P. C. Jain, Monica Jain, Engineering Chemistry 15th Edition, Dhanpat Rai Publishing Co.

Reference Books

1. Barnwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th Ed. Tata McGraw Hill, New Delhi (2006)
2. U. N. Dash, Nuclear Chemistry, S. Chand Publication
3. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, 4th Revised Edition
4. Gurdeep Raj, Advanced Physical Chemistry Goel Publication.
5. Chandra, A.K., Introductory Quantum Chemistry, Tata McGraw –Hill (2001).
6. House., J.E., Fundamentals of Quantum Chemistry, 2ND Ed. Elsevier: USA (2004)
7. Lowe. J.P. & Peterson., K., Quantum Chemistry, Academic Press (2005)
8. Kakkar., R., Atomic and Molecular Spectroscopy, Cambridge University Press (2015)
9. Ira N. Levine, Quantum Chemistry, Seventh Edition, Pearson
10. Chemistry for degree students Semester V and VI by R. L. Madan, S. Chand Publication
11. Quantum Chemistry by Donald A McQuarrie, viva student edition

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Bachelor of Science (Honours) Programme

CHC-106 **CORE COURSE**

Inorganic Chemistry
(SEMESTER V)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To define the various periodic properties like atomic and ionic radii, electron affinity and electronegativity and determine the trends of the periodic properties in the groups and the periods of the periodic table.
- To define the terms, Interhalogens, Oxyacids of Halogens, Polyhalides and Pseudo halogens and generalize their properties.
- To evaluate the structure and bonding in Interhalogens, Oxyacids of Halogens, Polyhalides and Pseudohalogens.
- To discuss the occurrence and general properties of Noble gases.
- To discuss the uses and hydrates and Clathrates of Noble gases.
- To interpret the structure and bonding in various xenon compounds.
- To introduce concept of defects in solids, define Schottky and Frenkel defects, Color center, extended defects and Non-stoichiometry.
- To introduce basic synthesis concepts of solid-state chemistry and to provide introductory knowledge on concept of band gap and classification of materials based on it.

Section B

- To define Primary valency, Secondary valency, Chelate effect, Stability of Complexes.
- To generalize Werner's Co-ordination Theory, Ligand field Theory and Molecular Orbital Theory (σ as well as π bonding).
- To draw molecular orbital diagrams and to discuss the evidences for Covalent bonding in Complexes and factors affecting stability of complexes.
- To define the basic concepts of oxidation and reduction and the study of electrochemical series.
- To define and draw Frost, latimer and Pourbaix diagrams for various types of reactions and to study the principles involved in extraction of elements
- To introduce Nano chemistry and explain nano particles, their properties and applications
- To know the classification of elements as essential or trace and their uses in biological processes.
- To study the roles of myoglobin and hemoglobin and to define and study metalloenzymes

PRACTICALS: COURSE OBJECTIVES

- To understand and to get hands on experience on the various steps involved in gravimetry for quantitative estimations of desire metal ions in the presence of other interfering ions in the mixture of salt solutions by precipitating method and preparation of some inorganic complexes.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Periodicity of Elements (10 H)

Detailed discussion of the following:

Properties of the elements with their trends in the periodic table.

a. Atomic radii (van der Waals)

b. Ionic radii and Covalent radii.

c. Effective nuclear charge, shielding or screening effect, Slater rules.

d. Ionization Energy, Successive ionization energies and factors affecting ionization energy.

e. Electron Affinity.

f. Electronegativity, Pauling's/ Mulliken's/Alfred and Rochow's. Calculation of Electronegativity (Pauling's Method), Factors affecting Electronegativity.

2. Chemistry of halogens (8 H)

General methods of preparation, structure, bonding and chemical properties of: i) Interhalogens ii) Polyhalides ions iii) Oxoacids of halogens in different oxidation states iv) Pseudo halogens.

3. Noble Gases (4 H)

Occurrence and uses, inertness of noble gases, Clathrates; preparation properties and structure (VSEPR) of XeF_2, XeF_4 and XeF_6.

4. Inorganic Solid-State Chemistry (8 H)

Defects in solids, Point defects; Schottky and Frenkel defects, Colour Centre, Extended defects and Non-stoichiometry. Band Theory of solids: Band gaps, Metals, Insulators and Semi-conductors.

SECTION B

5. Bonding in Co-ordination Compounds (12 H)

Werner's theory and its experimental verification Evidences for Covalent bonding in complexes; Stereochemistry of Co-ordination Compounds with different co-ordination Numbers

A. Ligand Field Theory (Adjusted Crystal Field Theory) –Brief Introduction; Comparison of the CFT and MOT.

B. Molecular Orbital Theory as applied to Octahedral Complexes. Stability of complexes and factors affecting stability.

C. Molecular orbitals diagrams of $[Ti(H_2O)_6]^{+3}$, $[Fe(CN)_6]^{-3}$, $[FeF_6]^{-3}$ and $[Co(NH_3)_6]^{+3}$ Complexes. Effect of π - bonding on splitting parameter.

6. Oxidation and Reduction (8 H)

Oxidation number, single electrode potential, Standard electrode potential and Electrochemical series. Energy cycle for electrode potential. Application of Electrochemical series to check feasibility of reaction. Hydrogen overvoltage and Oxygen overvoltage. The use of reduction potentials, redox cycle, redox stability in water. The diagrammatic presentation of potential data - Frost, Latimer and Pourbaix diagrams. Principles involved in the extraction of the elements.

7. Selected Topics

A) Nano chemistry (5 H)

Introduction to Nano particles, their properties, carbon nanotubes, SWCNT, MWCNT, different types of nanomaterials and their applications.

B) Bio-inorganic Chemistry (5 H)

Overview, essential and trace elements in biological processes, Metalloporphyrins with special reference to haemoglobin and myoglobin. The role of Model systems, The alkali and alkaline earth metals, Metalloenzymes, Nitrogen fixation: Bacterial nitrogenase system (The biological nitrogen cycle).

PRACTICALS Number of hours: 60

Gravimetric Estimations

1. To estimate the amount of Al as Al_2O_3 in the given solution of aluminum sulphate.

2. To estimate the amount of Fe as Fe_2O_3 in the given solution of ferric chloride containing barium chloride and free HCl.

3. To estimate the amount of nickel as Ni-DMG in the solution of nickel chloride containing copper chloride and free HCl.

4. To estimate the amount of barium as $BaCrO_4$ in the solution of barium chloride containing ferric chloride and free HCl.

5. To estimate the amount of Zinc as $Zn_2P_2O_7$ in the given solution of zinc sulphate containing copper sulphate and free H_2SO_4.

Inorganic Preparations

1. Preparation Potassium trioxalatoferrate (III).
2. Preparation of potassium trioxalatoaluminate (III).
3. Preparation of Tristhioureacopper (I) sulphate.
4. Guignet's green (hydrated chromium oxide).
5. Cobalt blue (azure).

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Define the terms involved in the chapter Periodic Properties, derive the equations for the various periodic properties and follow the trends within groups and periods of the various periodic properties.
- Discuss the general properties and evaluate bonding in different compounds of halogens like Interhalogens, Oxyacids, Pseudohalogens and Polyhalides.
- Understand the reactivity of Noble gas elements and their compound formation.
- Define and differentiate different types of defects.
- Explain non-molecular solids and their preparation methods.
- To understand the Werner's Co-ordination Theory, Ligand field Theory and Molecular Orbital Theory to interpret the properties, bonding and stability in Co-ordination Compounds.
- Define the concepts of oxidation and reduction and draw Frost, Latimer and Pourbaix diagrams and apply them for various reactions
- Describe nanomaterials, their properties and applications
- To study the roles of myoglobin and hemoglobin with respect to the transfer and storage of oxygen in biological systems and the process of respiration.
- Define the roles metalloenzymes in biological systems.

Practical

- Understand the methods to quantitatively estimate with precision the desired amount of the precipitate..
- Understand the various conditions to be undertaken to acquire the desired yield.
- Understand various methods to estimate inorganic complexes of various ions.

REFERENCE BOOKS

Textbooks

1. J. D. Lee, *Concise Inorganic* Chemistry, 5th Edn. Wiley India.
2. B. R. Puri, L. R. Sharma, and K. C. Kalia, *Principles of Inorganic Chemistry,* 33rd Edn.

Reference books

1. F. Albert Cotton, Geoffrey Wilkinson, and Paul L. Gaus, *Basic inorganic chem.* 3rd Edn. Wiley India
2. James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, *Inorganic Chemistry, Principles of Structure and Reactivity*. 4th Edn. Pearsons
3. K. V. S. Laxmi Devi, N. C. Patel, S.S. Dhume, A. Venkatachalam, S. P. Turakhia, Chhaya Dixit and R. A. Mirji, College Inorganic Chemistry for T.Y. B. Sc. 21st Edn, Himalaya Publishing House.
4. Solid State Chemistry, Third edition By- Lesley E. Smart, Elaine A. Moore, Pub- Taylor and Francis.
5. Shriver, P.W. Atkins and C.H. Langford, *Inorganic Chemistry*, Oxford.

6. G.D. Tuli, S. K. Basu and R.D. Madan, Advance inorganic chemistry, Satya Prakash, S. Chand Publication.
7. F. A. Cotton, Chemical Applications of Group Theory, Wiley India
8. P.K Bhattacharya, Group Theory and its Chemical Applications Himalaya Publications.

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Bachelor of Science (Honours) Programme

CHC-107 **CORE COURSE**

Organic Chemistry
(Semester V)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To understand the concept of aromaticity.
- To understand mechanistic aspects of electrophilic and nucleophilic aromatic substitution.
- To understand the concept related to reactivity and orientation of activating and deactivating groups.
- To study methods for structure elucidation of Nicotine, Papaverine and Hygrine.
- To learn the synthesis of Nicotine from Succinimide, synthesis of Papaverine using Bischler-Napieralski reaction and synthesis of Hygrine from Pyrrole.
- To understand important concepts in IR, NMR and Mass spectroscopic methods.
- To learn interpretation of IR, NMR and MS spectra.

Section B

- To study heterocyclic compounds and bicyclic heterocycles with examples.
- To learn classification with examples of oxygen, sulphur and nitrogen containing heterocycles (up to 6 membered).
- To understand structure, resonance, stability and reactivity of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline and also learn about their industrial source and preparation methods.
- To study structure elucidation of Vitamin A, Vitamin C , Thyroxine and Adrenaline and also learn their synthesis from β-ionone, xylose, tyrosine and catechol respectively.
- To learn classification of dyes with one example and structure of each class.
- To understand reasons for colour of some molecules.
- To learn synthesis and understand chemistry of phenolphthalein, congo-red, crystal violet and methyl orange.

PRACTICAL COURSE OBJECTIVES

- To understand theoretical concepts required for experiments and develop hands on experience with reference to basic laboratory techniques required for organic preparations, estimations and identification and separation of organic binary mixtures.

- To learn the interpretation of Infra-Red and proton NMR spectra by applying the concepts studied in theory.

SYLLABUS

Theory: Number of hours: 60

Section A

1. Aromaticity, Aromatic hydrocarbons and Reactivity (6 H)

Huckel's rule of Aromaticity (4n+2) Rule, 4n Rule for antiaromaticity, Electrophilic Aromatic substitution (w.r.t Benzene): Mechanism of Nitration, Sulphonation, Halogenation, Friedel – Crafts alkylation and acylation. Reactivity and orientation of activating, deactivating groups (ortho, para and meta effects). Nucleophilic aromatic substitution of Aryl halides (SNAr mechanism)

2. **Alkaloids (6 H)**

Ziesel's Method, Herzig-Meyer's method, Hoffman's exhaustive methylation method. Structure elucidation of Nicotine, Papaverine and Hygrine. Synthesis of Nicotine from Succinimide. Synthesis of Papaverine using Bischler-Napieralski reaction. Synthesis of Hygrine from Pyrrole.

3. Spectroscopic methods in Organic Chemistry (18 H)

Infra-Red Spectroscopy: Principle of I.R Spectroscopy (Hooke's law), types of molecular vibrations (Stretching and bending). Source, instrumentation and working of I.R spectrophotometer. Functional group region and Fingerprint region. Applications of I. R. Spectroscopy: Functional group analysis, detection of purity of sample, establishing the identity of an unknown molecule, Effect of H-bonding, conjugation, resonance and ring size on IR absorptions. To study the progress of a reaction. Problems based on I.R. spectroscopy (ketone, aldehyde, ester, acid & alcohol).

Nuclear Magnetic Resonance Spectroscopy:

Basic Principles of 1H NMR spectroscopy, Number of signals (Homotopic, Enantiotopic, diastereotopic protons). Position of signals, Chemical shift: Reference standard, Solvent effect, Shielding and de-shielding effect, anisotropic effects in alkenes, alkynes, aldehydes, aromatic compounds, factors affecting chemical shift. Intensity of signals: Peak area and proton counting. Spin-Spin coupling: Coupling constant (J). Interpretation of NMR spectra of simple compounds. (acetone, acetaldehyde, toluene, ethyl bromide, anisole, acetic acid, t-butylbenzene, 2-butanone, propene). Simple problems based on NMR spectral data for identification of molecule. Carbon-13 Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry: Principle of 13C spectroscopy. Number of signals: Proton coupled and decoupled spectra (off-resonance). Position of signals. Factors affecting position of signals (hybridisation). Problems based on ^{13}C spectroscopy. Principle, theory, instrumentation of Mass spectrometry. Base Peak, Molecular ion, Metastable ion. Fragmentation pattern for alkanes. Fragmentation pattern of ketones: αcleavage and McLafferty rearrangement. Isotopic effect of alkyl halides.

Section B

4. Chemistry of Heterocyclic Compounds (18 H)

Definition of heterocyclic compounds: Organic compounds containing oxygen, sulphur, nitrogen. Classification with examples for three, four, five and six membered heterocycles. Structure, resonance, stability and industrial source of furan, pyrrole, thiophene and pyridine. Preparation of furan, pyrrole and thiophene using Paal Knorr Synthesis. Reactivity of furan, pyrrole and thiophene: Electrophilic substitution at 2/5 position. Preparation of pyridine using Hantzsch synthesis. Reactivity of pyridine: Electrophilic substitution at 3 position, Nucleophilic substitution at 2 and 4 position. Definition of bicyclic heterocycles with examples. Structure, resonance, stability and industrial source of indole, quinoline, isoquinoline. Preparation of indole using Fischer indole synthesis. Reactivity of Indole: Electrophilic substitution at 3 position. Skraup synthesis of quinoline and Bischler Napieralski synthesis of isoquinoline. Reactivity of quinoline and isoquinoline: Electrophilic substitution at 5/8 position, Nucleophilic substitution at 2 and 4 position. Oxidation and Reduction of quinoline and Isoquinoline.

5. Vitamins and Hormones (6 H)

Structure elucidation of Vitamin A, Vitamin C, Thyroxine and Adrenaline. Synthesis :Vitamin A from β-ionone ,Vitamin C from xylose , Adrenaline from Catechol and thyroxine from tyrosine.

6. Dyes (6 H)

Classification of dyes: Acidic, basic, azo, reactive, Vat, mordant, direct, disperse with one example and structure of each class. Reasons for colour of some molecules: Resonance effect in p-nitroaniline and nitrobenzene, conjugation effect in β-carotene and graphite. Synthesis and chemistry of phenolphthalein, congo-red, crystal violet, methyl orange.

PRACTICALS Number of hours: 60

1. Organic Preparations (Two steps): (Any 5)
   Synthesis, yield, recrystallisation and Melting Point.
   i) Nitrobenzene to m-nitroaniline
   ii) Phthalimide to 2-iodobenzoic acid
   iii) Acetanilide to p-nitroaniline
   iv) Benzamide to m-nitrobenzoic acid
   v) Benzoin to benzilic acid
   vi) Acetophenone to acetanilide
   vii)Benzophenone to benzanilide

2. Organic Estimations (Any 3)
   a) Acid+ Amide
   b) Acid + Ester
   c) Estimation of the number of acetyl groups in an acetyl ester. (Triacetyl glycerol, Hexaacetyl mannitol or Pentaacetyl glucose) (Any one) .
   d) Estimation of nitro group by reduction using stannous chloride

3. Synthesis of dyes
   a) Diazoaminobenzene
   b) Picric acid

4. Interpretation of Infra-Red, and proton NMR spectra
   a) IR spectra of the following: aldehyde, alcohol, ketone, carboxylic acid, amine, nitrile.
   b) Proton NMR of simple organic compounds (6 compounds)

5. Identification and Separation of following Organic binary mixtures
   Water insoluble –water insoluble (Acid-Base, Acid-Phenol, Base-Neutral, Acid-Neutral, Phenol-Base, Phenol-Neutral), Water soluble- water insoluble (Acid-Acid, Acid-Neutral, Neutral-Neutral), Liquid-Liquid (2 mixtures), Solid-liquid (2 mixtures).

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Explain the concept of aromaticity and distinguish between aromatic and anti-aromatic compounds.
- Explain the mechanism of electrophilic and nucleophilic aromatic substitution.
- Explain the concept related to reactivity and orientation of activating and deactivating groups.
- Explain structure elucidation of nicotine, papaverine and hygrine using suitable methods and give their synthesis.
- Explain important concepts in IR, NMR and mass spectroscopic methods.
- Identify functional group based on IR spectra.
- Predict the structure of simple organic compounds based on IR, NMR, MS data.
- Define and classify oxygen, sulphur and nitrogen containing heterocyclic compounds with examples.
- Explain structure, resonance, stability and reactivity of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline and give their industrial source and preparation methods.
- Explain structure elucidation of vitamin a , vitamin c , thyroxine and adrenaline and also give their synthesis from β-ionone, xylose, tyrosine and catechol respectively.
- Classify dyes, giving one example and structure of each class.
- Explain reasons for colour of some molecules.
- Give synthesis and explain the chemistry of phenolphthalein, congo-red, crystal violet and methyl orange.

Practical

At the end of the course students will be able to

- Discuss the theory behind experiments.
- Understand stoichiometric requirements during organic preparations.
- Develop skills of common laboratory techniques including reflux, recrystallisation, recording of melting point, distillation, titration and chemical analysis.
- Identify the separation technique for binary mixture separation and perform chemical nature analysis.
- Perform calculations for quantitative analysis.
- To interpret infra-red and proton NMR spectra of simple organic compounds.

REFERENCE BOOKS

Theory

Textbooks

1. I.L.Finar, Organic Chemistry Vols I and II, Orient Longman.
2. Morrison and Boyd, Organic Chemistry; 6th Edn. Prentice Hall India.
3. J. March, Advanced Organic Chemistry: Reaction, Mechanism and Structure, Wiley, 2010, 4th Ed.
4. P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.

Reference books

1. Francis Carey, Organic Chemistry, 10th Edition.
2. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edn. Pearson Education Asia.
3. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.
4. J. Clayden, N. Greeves, S. Warren & Wothers, Organic Chemistry, Oxford University Press, 2012, 2nd Ed.
5. I.L. Finar Stereochemistry and Chemistry of Natural products, ELBS, Longmans, 1963, Vol. 2, 3rd Ed.
6. E.S. Gould et al., Mechanism and structure in Organic Chemistry, 1965.
7. F. A. Carey, Organic Chemistry, 2000, 4th Ed.
8. S.H. Pine, Organic Chemistry, McGraw-Hill International Edn. 2010, 5thEd.
9. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry, Part A and Part B. Plenum Press, Springer, 1977.
10. J. M. Harris & C.C. Wamser, Fundamentals of Organic Reaction Mechanisms, John Wiley & Sons. Inc. 1976.
11. F.M. Menger, D.J. Goldsmith & L. Mendell, Organic Chemistry, A concise approach, 1975, 2nd Ed.
12. J. R. Dyer, Applications of Absorption Spectroscopy of Organic compounds, Prentice Hall of India, 1987.
13. V.M. Parikh, Absorption spectroscopy of organic Molecules, Addison Wesley Longman Publishing Co., 1974.
14. D.H Williams & I. Fleming, Spectroscopic methods in organic chemistry, 6th Ed., Tata Mcgraw Hill Education, 2011.
15. William Kemp, Organic spectroscopy, 3rd Ed., Palgrave Macmillan, 1991.
16. R. O. C. Norman and J. M. Coxon, Principles of Organic Syntheses, 3rd Ed., CRC Press Inc, 1993.
17. J A Joule and G F Smith, Heterocyclic Chemistry, ELBS, Advances in Heterocyclic Chemistry, Edited by A R Katritzky etal, Vol. 1 to 50, Academic Press.
18. Gurdeep Chatwaal, Synthetic dyes, Himalaya Publishers.

Practical

Textbooks

1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011.
2. F G Mann and B C Saunders, Practical organic chemistry, Orient Longman, 4th ed.

Reference Books

1. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, 1st Ed., Prentice Hall, 1991.
2. L. F. Fieser, K. L. Williamson "Organic Experiments" 7th edition D. C. Heath, 1992.
3. K. L. Williamson, K.M. Masters, Macroscale and Microscale Organic Experiments, 6th Edition, Cengage Learning, 2010
4. R.K. Bansal, Laboratory Manual in Organic Chemistry, New Age International, 5th Edition, 2016.
5. Morrison and Boyd, Organic Chemistry,6th Edition, Prentice Hall, India.
6. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
7. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.
8. S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.

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Bachelor of Science (Honours) Programme

CHD-101 **Discipline Specific Elective**

Basic Topics in Analytical Chemistry (SEMESTER V)

Credits: 04 (Theory: 03 & Practical: 01)

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THOERY COURSE OBJECTIVES

- To define the terms involved in analytical chemistry, sampling techniques, data handling, chromatographic Techniques and electroanalytical methods.
- To explain scope and importance of analytical chemistry, different types of sampling and the types of solvent extractions.
- To classify different types of chromatographic techniques and errors with examples.
- To study the principles of volumetric analysis and gravimetric analysis and the basic principles of instrumentation of electrogravimetry, coulometry and polarographic analysis.
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments of electroanalytical methods.
- To draw the schematic diagrams of different electroanalytical methods.
- To solve numericals of evaluation of data and solvent extractions.
- To discuss the applications of different chromatographic techniques and electroanalytical methods.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory (ion exchange chromatography, colorimetry, statistical data).

SYLLABUS

Theory: **Number of hours: 60**

1. Introduction (3 H)

Scope and importance of analytical chemistry, chemical analysis and analytical chemistry.

Classification of instrumental methods, analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results.

2. Quantitative analysis (8 H)

A. Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations.

B. Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition.

3. Sampling Techniques (4 H)

Terms encountered in sampling: the population or the universe, Sample, Sampling unit, increment, the gross sample, the sub sample, Analysis sample, Bulk ratio, Size to weight ratio, Random sampling, Systematic sampling, Multistage sampling, Sequential sampling. Sampling of Gases, Liquids and Solids. Preservation, storage and preparation of sample solution.

4. Evaluation of analytical data (10 H)

Significant figures and rounding off, accuracy and precision Errors: determinate and indeterminate error, constant and proportionate errors, minimization of errors. Measures of central tendency and dispersion. Standard deviation, Gaussian distribution curve and its characteristics, Histogram and Frequency polygon. Confidence limit. Test of significance: Students t, F test, Rejection of the results: 2.5d & 4d rule and Q test. Linear least squares and Method of averages (Numerical problems are expected to be solved)

5. Solvent Extraction (4 H)

Basic Principle, percentage extraction, role of complexing agents in solvent extraction, separation factor, types of extraction (continuous, batch) (Numerical problems are to be solved)

6. Chromatography (7 H)

Principles Classification of chromatographic techniques

1. Column chromatography: Principle, experimental details, theory of development, factors affecting column efficiency and applications.
2. Paper and thin layer chromatography: Principles, techniques and applications of paper and thin layer chromatography.
3. Ion exchange chromatography: Principles, classification of ion exchange materials, Nature of exchanging ions, Ion exchange capacity, applications in analytical chemistry.

7. Electroanalytical methods (9 H)

Electro gravimetric analysis: Introduction, principles, instrumentation, Electrolysis at constant current, apparatus, determination of copper by constant current electrolysis. Coulometry: Introduction, constant Current measuring device, Hydrogen-Oxygen coulometer, Silver coulometer. General characteristics of coulometric method, applications of coulometry in Neutralization, complexation, precipitation and redox titrations. Polarography: Introduction, Basic principles of instrumentation, Deposition potential, Dissolution potential, Polarization of electrode, Polarographic wave, Ilkovic equation, Supporting electrolytes, Interference of oxygen, Applications of polarography – inorganic and organic.

PRACTICALS Number of hours: 60

1. Determination of iron by salicylic acid by colorimetry.
2. Determination of nitrite in water by colorimetry.
3. Separation of organic compounds by TLC. (Demonstration)
4. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Magnesium with standard EDTA.
5. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Zinc with standard EDTA.
6. Estimation of Na^{+} in NaCl by cation exchange resin using standard NaOH.
7. Estimation of Ca in calcium tablet by oxalate method and titration with $KMnO_4$.
8. Determination of hardness of water by EDTA i.e. estimate Ca as $CaCO_3$ and report analysis in ppm. (The candidate should record more than 5 observations and carry out statistical analysis to find out mean, median, range, standard deviation, absolute error, relative error and possibly Q test.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Define the terms, state the laws and principles involved in involved in sampling techniques, data handling, chromatographic techniques, solvent extractions, volumetric analysis and gravimetric analysis.
- Explain sampling of liquid, solid and gases, different types of tests related to data handling, scope and importance of analytical chemistry.
- Draw and describe the basic components of instruments of electroanalytical methods.
- Classify and explain different types of errors, sampling and chromatographic techniques.
- Derive and use the equations of linear least squares and method of averages and solvent extraction to solve numerical.
- Interpret steps involved in chemical analysis.
- To discuss the applications of different chromatographic techniques and electroanalytical methods

Practical

At the end of the course students will be able to

- Understand the concepts based on ion exchange chromatography, colorimetry and to estimate acidic and basic radicals quantitatively.
- Develop skills to prepare different plates of thin layer chromatography.
- Solve numericals based on statistical data obtained from experimental results.

REFERENCE BOOKS

Textbooks

1. Baliga and Shetty, College Analytical Chemistry, 15th edition, Himalaya Publishing House, 2004
2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, 5th Edn., Sheth Publishers Pvt. Ltd.

Reference Books:

1. G. D. Christan Analytical Chemistry by, 5th edition Wiley publications.
2. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis 5th edition (reprint 2003), Himalaya publication.
3. Vogels Textbook of Quantitative Inorganic Analysis 4th edition ELBS.
4. Willard, Meritt and Dean. Instrumental Methods of Analysis
5. Skoog and Leary, Principles of Analytical Chemistry 4th International edition.
6. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut
7. Mendham, J. Vogel's Quantitative Chemical Analysis (6th Edition) Pearson.

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Bachelor of Science (Honours) Programme

CHD-104 **Discipline Specific Elective**

ESSENTIALS IN PHARMACEUTICAL CHEMISTRY (Semester V)

(4 Credits: Theory-03, Practicals-01)

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THOERY COURSE OBJECTIVES

- To study the importance of chemistry in pharmacy.
- To bridge the gap between chemistry and pharmacy by learning drug product formulation.
- To study the various ways of naming drugs.
- To introduce the students the concept of drug designing.
- To introduce various representative classes of drugs with examples.

PRACTICALS COURSE OBJECTIVES

- To perform experiments as given in monographs to understand drug analysis.
- To use UV-spectrophotometer and perform assay of drugs.
- To introduce the principle of thin layer chromatography in performing drug identification experiments.
- To improve practical hands for synthesis of drugs.

SYLLABUS

Theory: **Number of hours: 45**

1. General Introduction to Pharmaceutical Chemistry: (6 H)

Importance of Chemistry in Pharmacy. Important terminologies: Pharmaceutical Chemistry, Pharmacokinetics, Pharmacodynamics, Pharmacophore, Pharmacopoeia, Pharmacognosy, Toxicology, Materia Medica, Drug. Drug Product formulation, drug dosage forms, routes of drug administration: Oral, Parenteral, Enemal, Topical (Advantages and Disadvantages). Assay of drugs. Chemical Assay (Titrimetric and Instrumental methods), Biological assay: Principles of bioassay, methods of bioassay, Invitro and Invivo assay.

2. Physicochemical properties of drugs and drug metabolism (5 H)

Effect of solubility, partition coefficient, ionisation constant, hydrogen bonding, chelation, electronic effect, steric effect, surface activity and cis-trans isomerism on the pharmacological action of drugs. Drug Metabolism: Definition, Phase I drug metabolism: Oxidation, Reduction and Hydrolysis. Phase II drug metabolism: Conjugation reactions. Factors on which drug metabolism depends.

3. Nomenclature of drugs and structure activity relationship (4 H)

Drugs -Nomenclature, Naming of drugs: code number, chemical name, brand name/trade name/optical name/common name, synonyms. Examples Aspirin, Ibuprofen, Chloroquine, Mebendazole, Caffeine, Propranolol, Methyl Dopa. Effect of various functional groups on the chemical activity of drugs (acidic, hydroxyl, amino, aldehyde, cyano, halogen,)

4. Introduction to Drug Design (5 H)

Development of new drugs: Introduction, procedure followed in drug design, the search for lead compounds, molecular modification of lead compounds, prodrugs and soft drugs, prodrug; introduction, multiple prodrug formation; Design of Enzyme Inhibitors, 9-alkylpurines, 9-mercaptopurines and allopurines.

5. Definition and Classification with structure of the following drugs: Anti Infective agents: (6 H)

Antiseptics and Disinfectants: Alcohols, substituted phenols, DDT, p-hydroxy-benzoic acid esters, Chloramine-T, 8-hydroxy quinoline derivatives, Bromopal, Halazone. Synthesis, use and side effects of DDT and Halazone.

Antimycobacterial agents (Antitubercular and Antileprotic drugs) Aminosalicylic acid, Isoniazid, Pyrazinamide, Ethambutol, Dapsone, Synthesis, use and side effects of Isoniazid and Ethambutol.

Antimalarials: Life cycle of parasite, drug acting on different stages- Quinine, Mefloquine, Chloroquines, Trimethoprim. Antiamoebics: Metronidazoles, Diloxanides, Anthelmintics: Niclosamide, Mebendazoles, Synthesis, use and side effects of Metronidazole and Niclosamide.

Antifungal: Antibiotics like Clotrimazoles. Antivirals including drugs acting on HIV: Idoxuridiness, Amantadine Hydrochlorides. Synthesis, use and side effects of Clotrimazole and Idoxuridiness.

6. Antineoplastics, Sulfonamides, Hypoglycemics, Diagnostic agents and Diuretics (4 H)

6-Mercaptopurines, Thiotepa, Doxorubicin, Cis-platin, Sulfacetamide, Sulfamethoxazoles,: Insulin and various sulfonyl ureas like tolbutamide, Metformin, Saccharin. Iodoxyls, aminohippuric acid. Sulfonamides – Acetazolamides, Hydrochlorthiazide, Ethacrynic acid, Theophylline. Synthesis, use and side effects of sulphacetamide, thiotepa.

7. Analgesic, antipyretics, anti-inflammatory and antibiotic drugs (4 H)

Definition and Classification with structure of the following drugs: Aspirin, Acetaminophen, Ibuprofen, Naproxen, Diclofenac. Narcotic analgesic agents: Morphine. Non-narcotic analgesic agents: Dextropropoxyphene. Antibiotics: Penicillin, Chloramphenicol, Synthesis, use and side effects of Aspirin, Ibuprofen.

8. Cardiovascular and Parkinsonism drugs (4 H)

Antianginal drugs: Angina pectoris condition-Isosorbide dinitrate, Vasodilators: Cylandelate, Antiarrythmic agents: Cardiac Arrythmia condition Verapamil, Antihypertensive agents: Methyl dopa, Coagulants and Anticoagulants: Vitamin K, Coumarin derivatives like Warfarin, Dicoumarol. Antilipidemics: Atherosclerosis condition, Clofibrates, Nicotinic acid, Drugs used in Parkinsonism: Levodopa, Drugs for Alzheimer's iseases: Velnacrine. Synthesis, use and side effects of Methyl Dopa and Warfarin.

9. Central Nervous System Drugs (3 H)

Local anaesthetics: Benzocaines, Lidocaine. General Anaesthetics: Ether, Nitrous oxide, Halothane, Ultra short acting Barbiturates-Thiopental sodium. Drugs acting on the central nervous system: a] Hypnotics and sedatives: Phenobarbital, b] Drugs acting as anticonvulsants: Phenytoin, Phenobarbital, c] Psychotherapeutic agents: Phenothiazines such as Chloropromazine, Diazepam. d] CNS stimulants: Nikethamide, Caffeine. Synthesis, use and side effects of Phenytoin, Nikethamide.

10. Drugs acting on cholinergic and adrenergic nervous system (2 H)

Drugs acting on cholinergic nervous system Methacholine, Tropicamide. Drugs acting on adrenergic nervous system: Epinephrine, Propanalol, Metoprolol. Synthesis, use and side effects of Bethanechol and Propranolol.

11. Antihistaminics and antiemitics and antiulcer drugs (2 H)

Chloropheniramine, Cyclizine, Promethazine, Synthesis, use and side effects of Chloropheniramine, Promethazine.

PRACTICALS — Number of hours: 30

1. Indian Pharmacopoeia Monograph of Aspirin and Purified water. (Any One)
2. Spectrophotometric assay of Metformin hydrochloride and Albendazole.
3. Synthesis of Sulphacetamide, Dilantin, Paracetamol, 7-hydroxy-4-methyl coumarin. (any 3)
4. TLC identification of analgesic drugs comparison of bulk drugs with branded drugs

LEARNING OUTCOMES

Theory

At the end of this course students will be able to:

- Explain terminologies in pharmaceutical chemistry.
- Explain the nomenclature, structure activity relationship and physicochemical properties of drugs.
- Apply the concept of drug designing.
- Classify various drugs.
- Understand the synthesis of drugs.

Practical

At the end of this course students will be able to:

- Refer Pharmacopoiea and perform monograph experiments.
- Use UV-spectrophotometer and improve their analytical skills performing drug assay experiments.
- Perform TLC experiment in identification of analgesic drugs.
- Handle chemicals and follow procedure for synthesis of drugs.

REFERENCE BOOKS

Theory

Textbooks:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 8th edition Edited by Robert F. Doerge, J. B. Lippincott Company, Philadelphia, USA.
2. Harikishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. Medicinal Chemistry, D. Shriram, P. Yogeshwari, Pearson Education, 2007.
4. Medicinal Chemistry, Chatwal, Himalaya Publishing house, 2002.
5. Textbook of Pharmaceutical Chemistry by Jayshree Ghosh, S. Chand & company Ltd.
6. Pharmaceutical Chemistry by Dr. S. Lakshmi, Sultan chand & Sons.

References books:

1. G. L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. William O. Foye, Thomas L., Lemke, David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.
3. Lednicer and Meischer, Organic Chemistry of Drug Synthesis. Vol. I to III. John Wiley & Sons, 2005.
4. Burger's Medicinal Chemistry, Part I and II, 4th edition, Edited by M. E. Wolff, John Wiley.
5. Principles of Medicinal Chemistry, W. O. Foye, 3rd edition, K. M. Varghese and Co., Bombay.
6. Burgers Medicinal Chemistry and Drug Discovery, Vol. I, 6th edition, Edited by Donald J. Abraham, John Wiley and Sons, New Jersey, 2003.

Practical

Reference books:

1. Indian Pharmacopoeia, Latest edition.
2. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011.

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Bachelor of Science (Honours) Programme

CHD-102 **Discipline Specific Elective**

Green Methods and Safety Aspects in Chemistry (Semester V)

04 Credits (4 + 0)

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COURSE OBJECTIVES

Section A

- To understand the need of Green Chemistry.
- To know the 12 principles of Green Chemistry and their importance in Green chemistry.
- To know the Green chemistry institutes and organizations in the world.
- To study green techniques in chemistry including the use of greener solvents, solvent-free reactions, grinding technique, ball milling techniques, use of various catalysts, microwave, and ultrasound techniques.
- To understand the mechanism of Phase Transfer Catalysis.
- To learn the green methods of preparation of metallophthalocyanine complexes, Grignard reagent, Schiff's base, 1-acetylferrocene, and bis(acetylacetanato) copper (II).
- To study the real-world cases in chemistry.

Section B

- To study the various risks and hazards involved in a chemical laboratory.
- To study the personnel protective equipment and emergency equipment to be used in a chemical laboratory.
- To understand the risks and hazards associated with a specific chemical.
- To distinguish between SDS and MSDS
- To study the toxic hazards involved in a chemical laboratory
- To study the types and working of fire extinguishers.
- To study the different types of waste and their hazards associated in a chemical laboratory.
- To study the precautions to be taken while working with water-dependent, electrical, and heating devices.
- To study the handling of solid waste.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. Green Chemistry (10 H)

Introduction. Why there is a need for green chemistry? A brief overview of twelve green chemistry principles as proposed by Paul Anastas and John Warner. Explanation with examples, with special emphasis on atom economy, designing of less hazardous substances, reducing toxicity, use of greener solvents, catalysis, Energy efficiency, alternative sources of energy, accident prevention, and green Chemistry for better sustainability. Brief on green chemistry institutes and organizations in the world.

2. Green techniques in Chemistry (10 H)

Greener solvents: Water as solvent-Diels Alder Reaction, supercritical liquids-extraction of D-limonene from orange pill, ionic liquids and deep eutectic solvents-properties- one application. Solvent free reaction: Grinding techniques - Aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone. and Ball milling techniques in synthesis. Catalysts: Definition: Solid supported reagents- $NaBH_4$-Alumina and PCC-silica. natural catalysts-Thiamine hydrochloride, L-Proline. Phase transfer catalysis: Phase Transfer catalyst, Mechanism of PTC, Advantages and application in Chemistry-Using 18-crown-6 ether or ammonium salt. Microwave and Ultrasound techniques: Principles and advantages, Green synthesis of metallophthalocyanine complexes by Microwave method. Preparation of Grignard reagent by ultrasonication method. Solid-solid synthesis of Schiff's base. (p-toluidine and o-vanillin). Green preparation of 1-acetylferrocene and bis(acetylacetanato) copper (II).

3. Real world Cases in Green Chemistry (10 H)

Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Right fit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn. Greening of acetic acid manufacture, EPDM rubbers and Vitamin C. Eco-friendly pesticides.

Section B

4. Introduction to Laboratory Safety (10 H)

Risks in a Chemical Laboratory, Health Effects Due to "Hazardous" Chemical Exposure (How Does One Determine the Hazards Associated with Specific Chemicals? ; Exposure Routes, Toxicity Risk Assessment), Personal Protective Equipment (PPE) Proper Attire (Eye/Face Protection, Lab Coats, Gloves, Respirators, Disposal/Removal of PPE), Emergency Equipment Safety Showers/Eye Washes.

5. Laboratory Emergencies (10 H)

Spills and Fires, Handling the Accidental Release of Hazardous Materials, Spill Containment, and Clean-up, Leaking Gas Cylinders, Fires. Fire Extinguisher (how they work, types), Risk Assessment. Chemical Hazards, The New Safety Data Sheets (SDS) versus the Old Material Safety Data Sheets (MSDS), Assessment of Chemical Toxicity, Toxic Hazards (Dose, Risk Assessment, Types of Toxins, Flammable Hazards, Flammability Characteristics, Flammability Classes, Causes of Ignition, Reactive Hazards, Explosives).

6. Waste Handling and Laboratory equipment (10 H)

Characterization of Waste, Collection, and Storage (Lids, Leaks, Labels, Location, Containers). Consequences of Mixing Incompatibles. Solid Wastes (Chemicals, Broken Glass, Sharps, Cylinders, Pick-up). Special Cases. Hazardous Waste Minimization. Laboratory Equipment. Working with Electricity, Working with Water (liquid)-dependent Equipment (Hazards, Proper Use, Heating Baths), Working with High Pressure/Vacuum, Working with Vacuum Pumps, Working with Stirring and Mixing devices, Working with Heating Devices (Variacs, Oil, Salt, Sand baths, Microwave Oven).

LEARNING OUTCOMES

At the end of the course, students will be able to

Section A

- Explain concepts in Green Chemistry.
- State and explain the principles of Green Chemistry.
- Name the Green chemistry institutes and organizations in the world.
- Explain green techniques in chemistry including the use of greener solvents, solvent-free reactions, grinding technique, ball milling technique, use of various catalysts, microwave, and ultrasound techniques.
- Explain the mechanism of Phase Transfer Catalysis.
- Give and discuss the green methods of preparation of metallophthalocyanine complexes, Grignard reagent, Schiff's base, 1-acetylferrocene and bis(acetylacetanato) copper (II).
- Describe the real-world cases in chemistry.

Section B

- Identify the various risks involved in a chemical laboratory.
- Identify the Hazards Associated with Specific Chemicals.
- Understand the various personnel protective equipment and emergency equipment to be used in a chemical laboratory.
- Explain the working and types of fire extinguishers.
- Understand about the Flammable Hazards, Flammability Classes, and causes of ignition.
- Explain how New Safety Data Sheets are different from the Old Material Safety Data Sheets.
- Explain the hazards associated with water-dependent, pressure-dependent equipment, and heating devices.
- Explain the collection, storage, and minimization of hazardous waste chemicals.

REFERENCE BOOKS

Textbooks

1. Vogel's textbook of Practical Organic Chemistry, ELBS Publishers,1996.

2. Anastas, P.T. & Warner, J.K. Green Chemistry- Theory and Practical, Oxford University Press (1998).
3. Sharma, R. K.; Sidhwani, I. T. & Chaudhari, M. K. Green Chemistry Experiments: A monograph I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore.
4. Green Chemistry: Environmentally Benign Reactions, V. K. Ahluwalia, Anne Books India, New Delhi, 2006.

Reference Books

1. Cann, M. C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
2. Phase Transfer Catalysis, Waber and Gokel, springer-verlag, 1977.
3. Organic Synthesis-Special Techniques, V.K. Ahluwalia and R. Aggarwal, Narosa Publishing House, New Delhi, 2001.
4. Kappe, C. O. & Stadler, A. Microwaves in Organic and Medicinal Chemistry (Wiley-VCH, Weinheim) 2005.
5. New trends in Green Chemistry, V. K. Ahluwalia and M. Kidwai, Kluwer Academic Publishers, 2004.
6. Laboratory Safety for Chemistry students, Robert H. Hill, David C Finster, Wiley, July, 2010.
7. Laboratory safety: Theory and Practice, 1st Edition, Elseviers.

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Bachelor of Science (Honours) Programme

CHD 105 **Discipline Specific Elective**

Properties and Processes of Molecular Chemistry
(Semester V)

Credits: 04 (Theory: 04)

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COURSE OBJECTIVES

- To learn electrical and magnetic properties of materials and their applications.
- Understanding photochemistry and photoelectron spectroscopy.
- Evaluation of properties and applications of liquid crystals.
- Use of colloidal properties and macromolecules.
- Concept of electrophoresis in understanding various molecular processes.

SYLLABUS

Theory **No. of hours: 60**

SECTION A

1. **Electrical properties (10 H)**
   Polar and non-polar molecules, Dipole moment, Units of dipole moment, Distortion or Induced polarisation, Orientation polarisation. Determination of dipole moment: Vapour Temperature Method, Refraction Method. Applications of dipole moment. Ferroelectricity: Ferroelectric, anti-ferroelectric and ferrielectric effect, Pyroelectricity, Piezoelectricity and their applications.

2. **Magnetic properties (8 H)**
   Definitions and Units: Magnetic Permeability, Magnetic Susceptibility, Types of Magnetic substances, Measurement of magnetic susceptibility by Quincke's method. Langevin's theory of diamagnetism and Paramagnetism. Interpretation of paramagnetic property of oxygen molecule and nitric oxide molecule.

3. **Photochemistry (12 H)**
   Introduction, Laws of photochemistry: Grothus-Draper law, Stark-Einstein law. Quantum yield or efficiency, factors affecting quantum efficiency, reasons for low and high quantum efficiency, experimental determination of quantum yield. Primary and secondary processes. Potential energy curves for primary photochemical processes, Photochemical reactions. Non radiative and radiative transitions, Jablonski diagram. Photosensitization: luminescence, fluorescence, phosphorescence and Chemiluminescence. Laser amplifier

principle, Ruby laser, Helium-Neon laser, applications of laser, Photo Electron spectroscopy, types of photoelectron spectroscopy and applications.

SECTION B

4. Liquid crystals (10 H)

Liquid crystals, Vapour pressure-temperature diagram, thermography, classification of liquid crystals: thermographic and lyotropic liquid crystals, theory of liquid crystals, molecular arrangement of liquid crystals, chemical properties of liquid crystals, pressure induced mesomorphism, applications of liquid crystals display, thermometers, and research. Importance of lyotropic liquid crystals: soap, foam, and liquid crystals in biological systems.

5. Colloids and Macromolecules (12 H)

Introduction, properties of colloids, origin of charge on colloidal particles, electrical double layer. Electro kinetic phenomenon: Electrophoresis, Osmosis, Osmotic behaviour of cells, osmoregulation, Electro osmosis, streaming potential. Donnan membrane equilibrium. Colloidal electrolytes.

Macromolecules. Methods of determining molecular weight of macromolecules, Sedimentation method, Osmotic Pressure method and Light Scattering method.

6. Electrophoresis (8 H)

Migration of an ion in an electric field, Factors affecting electrophoretic mobility. Types of electrophoresis: free electrophoresis, Zone electrophoresis, Gel electrophoresis, Principles of Electrophoresis, Isoelectric focusing, two-dimensional gel electrophoresis and DNA foot printing.

LEARNING OUTCOMES

- Students will be able to identify polar and non-polar molecules.
- Applications of dipole moment in elucidation of molecular structure.
- Understanding magnetism and their applications in recent technology.
- Use of photochemical reactions towards environmental prospects.
- Implementation of electrical properties of materials in development of smart materials.
- Behavior macromolecules in designing and learning various processes.

REFERENCE BOOKS

Textbooks

1. Concepts in physical chemistry T. Y. B. Sc. by N. B. Laxmeshwar, S. A. Malushte A. S. Mule, V. N. Kulkarni, Chetana Prakashan.
2. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania. Vishal publishing company 2015.
3. Engineering Chemistry by P. C. Jain and M. Jain Dhanpat Raj publishing company Ltd.

2012.

Reference Books

1. College Physical Chemistry T. Y. B. Sc., Himalaya Publishing house, by K. B. Baliga, S. A. Zaveri, Dr. S. Raghupathy.
2. Biophysical Chemistry Principles and Techniques, Himalaya Publishing house by Upadhyay, Upadhyay and Nath.
3. Advanced Physical Chemistry by Goel Publishing house, Meerut by Gurdeep Raj.
4. Basic Principles in Physical Chemistry F. Y. B. Sc. by Sheth Publishers K. Raghuraman, D. V. Prachi, S. J. Gary, C. S. Prabhu, P. A. Sathe.
5. Solid State Chemistry by Anthony West, John Wiley and sons inc. 2009.

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SEMESTER VI

Bachelor of Science (Honours) Programme

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Bachelor of Science (Honours) Programme

CHC-108 **CORE COURSE**

Physical Chemistry
(Semester VI)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section I

- To study the molecular orbital theory diagrams and the graphs involved.
- To interpret the physical picture of bonding and antibonding wavefuction.
- To define terms involved in electrochemistry, pH, poH, pKa, pKb. Buffer solution, buffer capacity. Measurement of pH using different electrodes by potentiometric methods.
- To describe the mechanism of buffer action.
- To derive and solve numerical on Henderson's equation.
- To study energy released in nuclear fission, fission products.
- To classify various nuclear reactors. To describe the working of reactors and its parts.
- To know nuclear reactors in India.
- To define the terms and laws involved in photochemistry.
- To draw and interpret Jablonski diagrams.
- To study photochemical and photosensitized reactions with examples

Section II

- To describe types of theories in corrosion
- To explain the types of energy sources
- To study vibrational spectroscopy, IR, harmonic and anharmonic oscillator, Raman spectroscopy.
- Define terms, force constants, bond energy, polarizability.
- To study stokes and antistock lines, Raman shift and selection rules involved.
- Chain reactions, terms involved and units of radioactivity, applications of radioactive isotopes Biological effects of radiations.

PRACTICAL COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory.

SYLLABUS

Theory: Number of hours: 60

SECTION A

1. Quantum chemistry II (20 H)

Qualitative treatment of hydrogen atom and hydrogen – like ions/harmonic oscillator; setting up of Schrodinger equation in spherical polar co-ordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrodinger equation for many-electron atoms (He, Li) Need for approximation methods. Statement of variation theorem and application to simple systems. Chemical Bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H2+ Bonding and antibonding orbitals, qualitative extension to H_2.

2. Nuclear Chemistry II (10 H)

Nuclear Fission, discovery, energy released in fission, fission products, neutron emitted in fission, nuclear reactors, classification of reactors, Breeder reactor, nuclear reactors in India, chain Reactions & its control, reprocessing of spent fuels Units of radiation energy, applications of radio-isotopes, radioisotopes as tracers, biological effects of radiation.

SECTION B

3. Electrochemistry II (12 H)

Definition of pH, pOH, pKa, and pKb, Determination of pH using glass electrodes by potentiometric method, Buffer solution, types, buffer action, buffer capacity, mechanics of buffer action, Henderson equation for acidic and basic buffer, amphoteric electrolyte, existence of dipolar ions, isoelectric point, strong electrolytes, Debye Huckel theory of strong electrolytes. Variation of activity coefficient with concentration, ionic strength, Debye Huckel limiting law. Energy sources: Primary and Secondary batteries. Acid and Alkaline battery, Ni-Cd cell, solar cells. Construction, working, advantages and CdS solar Cell.

4. Molecular Spectroscopy II (18 H)

Electronic Spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Armor precession, Chemical shift and low-resolution spectra, different scales (Delta and T), Spin–spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Principle, hyperfine structure, ESR of simple radicals.

PRACTICALS Number of hours: 60

1. Conductometric titration of Lead Nitrate against Sodium Sulphate and to determine the solubility of Lead Sulphate.
2. To investigate the influence of Ionic strength on the rate constants between Potassium Persulphate and Potassium Iodide.
3. To determine the dissociation constant of a weak dibasic acid using pH metry.
4. To study the Kinetics of ethyl acetate by NaOH at two different temperatures and hence determine the energy of activation.
5. To determine the percentage concentration and strength of a strong acid and weak acid present in a mixture by potentiometric titration.
6. Preparation of aniline hydrochloride and to determine hydrolysis and hydrolysis constant of aniline hydrochloride.
7. Adsorption of Oxalic acid by charcoal and verifying Freundlich adsorption isotherm.
8. Verification of Debye-Huckel-Onsager equation to dilute solutions of KCl by conductometric method.
9. To determine composition of Zinc Ferrocyanide complex by potentiometric titration.

Minor Experiments

1. Using vibrational-rotational spectra of NO molecule:
   a. Assign the rotational lines to various transitions.
   b. Calculate
      i) the value of B_0 and B_1, for R and P branches of spectra.
      ii) Vibrational frequency and
      iii) Inter nuclear distance

2. Using vibrational-rotational spectra of CO molecule.
   a. Assign the rotational lines to various transitions.
   b. Calculate
      i. The value of B_0 and B_1, for R and P branches of spectra.
      ii. Vibrational frequency and
      iii. Inter nuclear distance

3. To Calculate ionic strength at different concentration of potassium persulphate and potassium iodide.

4. Calculate the potentials by supplying the values of pH using the equation $pH = 0.457 – E_{cell}/0.0592$ and plot the graph.

5. Calculate the rate constants and energy of activation by using the given titre values.

6. Determine the hydrolysis and hydrolysis constant of aniline hydrochloride at any two concentrations, given the conductance values at these concentrations.

7. Provide any five values for log x/m and log Ce and plot a graph of log x/m against log Ce and determine the constant values n and k.

LEARNING OUTCOMES

THEORY

At the end of the course students will be able to

- Define the terms involved in Quantum chemistry, electrochemistry, spectroscopy and nuclear chemistry.
- Derive Schrodinger's equation in spherical polar coordinates.
- Apply Schrödinger equation to many electron system apply the concept in valence bond chemical bond and molecular orbital.
- Draw the schematic diagrams, diagrams of reactors, energy sources, molecular orbital diagrams and the graphs involved.
- Describe the working of reactors, electrochemical cells and energy sources.
- Explain the terms involved giving examples, classify the types of nuclear reactors, energy sources and corrosion types.
- Derive and use the equations to solve the numerical in electrochemistry, spectroscopy,
- Interpret the physical picture of bonding and antibonding wave function.
- Discuss the principles involved in electronic spectroscopy (NMR PMR ESR)

PRACTICAL

At the end of the course students will be able to

- Understand the concepts of conductance adsorption isotherms and activation energy solubility product.
- Develop skills of working and set up of electrochemical cells and electrodes.
- Solve numericals on and verify the graph of adsorption isotherms.
- Interpret vibrational spectra of NO CO molecule.
- Determine potential with respect to pH.

REFERENCE BOOKS

Textbooks

1. J. N. Gurtu, Physical Chemistry Vol-III, A Pragati edition.
2. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan.
3. P. C. Jain, Monica Jain, Engineering Chemistry 15th Edition, Dhanpat Rai Publishing Co.

Reference Books

1. Barnwell, C. N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th Ed. Tata McGraw Hill, New Delhi (2006)
2. U. N. Dash, Nuclear Chemistry, S. Chand Publication
3. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, 4th Revised Edition
4. Gurdeep Raj, Advanced Physical Chemistry Goel Publication.

5. Chandra, A. K., Introductory Quantum Chemistry, Tata McGraw –Hill (2001).
6. House., J. E., Fundamentals of Quantum Chemistry, 2ND Ed. Elsevier: USA (2004)
7. Lowe. J. P. & Peterson., K., Quantum Chemistry, Academic Press (2005)
8. Kakkar., R., Atomic and Molecular Spectroscopy, Cambridge University Press (2015)
9. Ira N. Levine, Quantum Chemistry, Seventh Edition, Pearson
10. Chemistry for degree students Semester V and VI by R. L. Madan, S. Chand Publication
11. Quantum Chemistry by Donald A McQuarrie, viva student edition.

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Bachelor of Science (Honours) Programme

CHC-109 **CORE COURSE**

Inorganic Chemistry
(Semester VI)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To define the terms Organometallic compounds, mononuclear, polynuclear metal carbonyls.
- To state the Effective atomic number rule, 18 electron rule for metal carbonyls and organometallic compounds.
- To discuss the IUPAC nomenclature, of metal carbonyls and organometallic compounds.
- To discuss the methods of preparation, properties and bonding in metal carbonyls and Ferrocene.
- To study the different types of magnetic behavior
- To discuss the measurement of magnetic susceptibility.
- Calculate the magnetic moments of transition metal complexes.
- To prepare by various methods alkyls and aryls of Li, Al, Hg and Ti.
- To study the effect of crystal field splitting on magnetic and spectral properties of octahedral complexes
- To study the types of electronic transitions like d-d , charge transfer and ligand-ligand.
- To study the selection rules for transitions to take place like Laporte, Orbital and Spin selection rules.
- To study the applications to determine ligand field strength, color of complexes, Cis-trans isomerism and Geometry of complexes.

Section B

- To study stability constants of reactions in terms of thermodynamic and kinetic stability.
- To study the substitution reaction mechanisms of octahedral complexes and the trans effect observed in square planar complexes.
- To define various acid -base theories.
- To know the several types of solvents and their typical characteristics.
- To explain the distinct types of reactions occurring in liquid ammonia and liquid Sulphur dioxide solvents.

- To introduce concept of Symmetry elements: Centre of symmetry, Rotation axis, Mirror plane, rotation – reflection axis and Identity To apply concepts of symmetry and point groups to different molecules.

PRACTICAL COURSE OBJECTIVES

- To estimate the metal ions by volumetric methods employing redox, argentometric and complexometric titration concepts.
- To prepare complexes and estimate the metal ion by volumetric analysis.
- To determine the alkalinity of water samples.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. **Organometallic chemistry (15 H)**

Definition, nomenclature and classification of organometallic compounds, EAN rule, 18 electron rule.

(A) Mononuclear metal carbonyls: Preparation, properties, structure and bonding of $Ni(CO)_4$, $Fe(CO)_5$ and $Cr(CO)_6$ (Orbital diagram not expected)

(B) Polynuclear metal carbonyl: Preparation and structures of $Mn_2(CO)_{10}$, $Co_2(CO)_8$ $Fe_2(CO)_9$ and $Fe_3(CO)_{12}$ (Orbital diagram not expected)

(C) Sandwich compounds like Ferrocene: preparation, properties, reactions, structure and Bonding (MOT).

(D) Preparation and properties of alkyl and aryls of Li, Al, Hg and Ti.

2. Spectra and Magnetic properties (15 H)

A) Effect of Crystal Field Splitting on properties of Octahedral Complexes: Magnetic, Spectral. Measurement of 10 Dq for $[Ti(H_20)_6]^{+3}$ Complex.

B) Determination of ground state term for d1 to d10 metal ions

C) Electronic Spectra of transition Metal Complexes. Introduction, Types of Electronic transitions. The d-d transitions (d1/d9 and d2/d8), Charge transfer transitions and Ligand- Ligand transitions. Selection Rules (LaPorte Orbitals and Spin). Applications: Ligand field strength, Colour of complexes, Cis – Trans isomerism and Geometry of complexes.

D) Types of magnetic behaviour, Methods of determining magnetic susceptibility (Gouy's method); Spin only formula; application of magnetic moment data for 3d – Metal complexes.

SECTION B

3. Reaction Kinetics and Mechanism (10 H)

A brief outline of thermodynamic stability of metal complexes and factors affecting the stability. Thermodynamic and Kinetic stability, Lability and inertness of octahedral complexes, Taube's classification. Kinetics of octahedral complexes: Electrophilic and Nucleophilic substitution. Mechanism of ligand substitution in octahedral complexes: acid hydrolysis, base hydrolysis and annation reaction. Trans- effect with respect to square planar Platinum complexes.

4. Acid Bases and Non-aqueous Solvents (12 H)

Bronsted theory, Lux – Flood Solvent systems and Lewis concept of Acids and Bases. Classification and physical properties of solvents, their general characteristics and levelling effect. Reactions in non-aqueous solvents with respect to liquid NH_3, liquid SO_2 and liquid HF.

5. Symmetry and Term Symbols (8 H)

Symmetry elements like Centre of symmetry, Rotation axis. Mirror Plane, Rotation Reflection Axis, Identity. Determination of Point group and its application to H_2O, Ethylene, Trans dichloro ethylene, NH_3, BCl_3, $[PtCl_4]^{-2}$, $SiCl_4$, Benzene, SF_6.

PRACTICALS Number of hours: 60

Volumetric Exercise

1. Volumetric estimation of Nitrite in the given solution of sodium nitrite using $KMnO_4$.
2. Estimation of Fe(III) by dichromate method in the given solution of ferric alum by using $SnCl_2$.
3. Preparation of Tetraamine copper(II) sulphate complex and estimate the amount of copper from Tetraamine copper(II) sulphate complex by iodometry.
4. Preparation of Trisethylenediaminenickel(II) chloride complex and estimate the amount of Ni by EDTA.
5. Estimate volumetrically the amount of cobalt in $CoCl_2$. H_2O by EDTA method using hexamine indicator.
6. To estimate amount of ferrous(Fe^{2+}) and ferric(Fe^{3+}) ions in the given solution containing ferric chloride and ferrous sulphate by using potassium dichromate.
7. To estimate aluminum by back titration using zinc sulphate.
8. Estimation of manganese in presence of iron in ferromanganese by EDTA titration.
9. Determine the strength in grams per litre of a given $AgNO_3$ solution being provided N/30 NaCl solution by Mohr's Method.
10. Determination of alkalinity of a given mixture of OH- and CO_3^{-2} using phenolphthalein and methyl orange indicator.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- To interpret the stability of metal carbonyls and organometallic compounds. To generalise the methods of preparation, properties and bonding in organometallic compounds.
- To study the different types of magnetic behaviour.
- Discuss the measurement of magnetic Susceptibility.
- Calculate the magnetic moments of transition metal complexes.
- Define stability constants of reactions in terms of thermodynamic and kinetic stability.
- Know the various factors affecting the stability constants of complexes.
- Know the types of substitution reaction mechanisms of octahedral complexes and understand the trans effect to apply it to square planar complexes.
- Define and understand various acid-base theories with various examples
- Understand the behaviour of non- aqueous solvents like liquid ammonia and liquid Sulphur dioxide with the help of the distinct reactions taking place in these solvents.
- Explain Symmetry elements: Centre of symmetry, Rotation axis, Mirror plane, rotation – reflection axis and
- Identify symmetry elements in various molecules and assign them to different point groups.

Practical

- The students will acquire the skill to effectively prepare complexes and carry out their quantitative analysis.
- Acquire skills to effectively prepare complexes and carry out their quantitative analysis.
- Learn methodology to determine the alkalinity of water samples.

REFERENCE BOOKS

Theory

Textbooks

1) J. D. Lee, Concise Inorganic Chemistry, 5th Edn. Wiley India.
2) B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, 3rd Edn.

Reference books

1) F. Albert Cottton, Geoffrey Wilkinson and Paul L. Gaus, Basic inorganic chem. 3rd Edn. Wiley India
2) James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, Inorganic Chemistry, Principles of Structure and Reactivity. 4th Edn. Pearsons
3) K. V. S. Laxmi Devi, N. C. Patel, S.S. Dhume, A. Venkatachalam, S. P. Turakhia, Chhaya Dixit and R. A. Mirji, College Inorganic Chemistry for T.Y. B. Sc. 21st Edn, Himalaya Publishing House.
4) Solid State Chemistry, Third edition By- Lesley E. Smart, Elaine A. Moore, Pub- Taylor and Francis.
5) D. E. Shriver, P. W. Atkins and C.H. Langford, Inorganic Chemistry, Oxford.
6) G. D. Tuli, S. K. Basu and R.D. Madan, Advance inorganic chemistry, Satya Prakash, S. Chand Publication.

7) F. A. Cotton, Chemical Applications of Group Theory, Wiley India
8) P. K. Bhattacharya, Group Theory and its Chemical Applications Himalaya Publications.

Practical

Textbooks

1) G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn. ELBS.

Reference books:

1. J. Mendham, R. C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson
2. S. Ratan, Experiments in Applied Chemistry, 3rd Edn. S.K. Kataria & Sons
3. O. P. Pandey, D. N. Bajpai and S. Giri, Practical Chemistry, Revised Edn. S. Chand.

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Bachelor of Science (Honours) Programme

CHC-110 **CORE COURSE**

Organic Chemistry
(Semester VI)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To understand the reactions and mechanism of name reactions and rearrangements mentioned in the syllabus.
- To know the definition of the enolate ion and understand the concept of acidity and pka values of carbonyl compounds.
- To understand the generation of enolate ions and their use in synthetic organic chemistry.
- To study Keto-enol tautomerism of ethylacetoacetate.
- To study Jablonskii diagram and understand fluorescence, phosphorescence, intersystem crossing, and vibrational relaxation.
- To learn and understand photochemical reactions.

Section B

- To learn the structure elucidation of terpenes.
- To learn the synthesis of terpenes.
- To understand the reactions of glucose and determination of ring size of Glucose and sucrose.
- To understand the open chain reactions of sucrose and inversion of cane sugar.
- To know the evidence of presence of glucose and fructose unit in sucrose.
- To understand the stereospecific and stereoselective reactions.
- To understand the mechanistic aspects of addition, substitution and elimination reactions.

PRACTICALS COURSE OBJECTIVES

- To get hands on experience for the preparation of derivatives using the reactions learnt in theory and binary mixture separation followed by analysis of individual compound.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Name Reactions and Rearrangements (18 H)

Reaction and mechanism of the following: Benzoin, Aldol, Knoevanagel, Wittig and Darzens Glycidic ester. Rearrangement with mechanism: Beckmann, Wolff Rearrangement and Hofmann. Only Reaction and applications (2) of the following: Baeyer Villiger, Appel, Diekmann and Stobbe. Rearrangements: Schmidt, Claisen, Favorskii ,Curtius. Comparison of Clemmensen reduction and Wolff Kishner reduction.

2. Chemistry of Enolates (8 H)

Definition of enolate ion, acidity of carbonyl compounds, pka values, generation of enolate ion, role of bases in enolate ion formation, alkylation of carbonyl compounds with reference to cyclohexanone, acetone, ethylacetoacetate, malonic ester. Claisen condensation for preparation of ethylacetoacetate (reaction and mechanism). Keto-enol tautomerism of ethylacetoacetate. Malonic ester synthesis of carboxylic acids, ethylacetoacetate synthesis of ketones. Alkylation of 1,3-dithianes. Alkylation via enamine synthesis. Michael addition reaction.

3. Photochemistry (4 H)

Jablonski diagram, fluorescence, phosphorescence, intersystem crossing and vibrational relaxation. Norrish Type I and Type II cleavage reactions of ketones. Paterno Buchi and Barton reaction.

SECTION B

4. Terpenes (16 H)

Structure elucidation of Citral, α-Terpineol, α-Pinene and Camphor. Synthesis of Methylheptenone, Terebic acid and terpenylic acid. Synthesis of Citral from Methylheptenone. Synthesis of α –Terpineol from p-toluic acid. Synthesis of Norpinic acid, camphoric acid, camphoronic acid. Commercial synthesis of camphor.

5. Carbohydrates (6 H)

Open chain reactions of Glucose, Ruff degradation, determination of ring size of Glucose (pyranose and furanose using methylation method). Open chain reactions of sucrose, inversion of canesugar, Evidence of presence of glucose and fructose unit in sucrose. Determination of ring size of Sucrose. (using methylation method).

6. Stereochemistry (6 H)

Stereospecific and stereoselective reactions. Addition of bromine to 3-Hexene with mechanism. Addition of hydrogen halides to alkenes: Markownikoff's and anti-Markownikoff's addition rule. Substitution reactions: SN1, SN2, SNi reactions with mechanisms. Elimination reactions: E1, E2, E1cb reactions with mechanism.

PRACTICALS Number of hours: 60

1. Preparation of Derivatives (any 4)
   i. Oxime derivative of Benzophenone.
   ii. Acetyl derivative of Salicylic acid
   iii. Osazone of Fructose
   iv. Aldol derivative (using benzaldehyde and acetone to give dibenzalpropanone)
   v. Benzoyl derivative of p-nitroaniline
   vi. Demonstration of Knoevanagel condensation between Salicylaldehyde and ethylacetoacetate.

2. Binary mixture separation and analysis (Microscale)
   (Any 10 Mixtures to be analysed)
   i) Water insoluble –water insoluble (4 mixtures)
   (Acid-Base, Acid-Phenol, Base-Neutral, Acid-Neutral, Phenol-Base, Phenol-Neutral.
   ii) Water soluble –water insoluble (2 mixtures) (Acid-Acid, Acid-Neutral, Neutral-Neutral).
   iii) Liquid-Liquid (2 mixtures)
   iv) Solid-liquid mixture. (2 mixtures)

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Explain and give the reactions and mechanism of reactions mentioned in the syllabus.
- Draw Jablonskii diagram and explain various processes.
- Discuss and illustrate photochemical reactions.
- Define enolate ion.
- Explain the acidity of carbonyl compounds, pk_a values, Keto-enol tautomerism.
- Describe the use of enolate ion in organic synthesis
- Elucidate the structure of terpenes.
- Describe the synthesis of terpenes.
- Illustrate the reactions of glucose, open chain reactions of sucrose and determination of ring size of Glucose and sucrose.
- Give the evidence of presence of glucose and fructose unit in sucrose.
- Describe stereospecific and stereoselective reactions and mechanism w.r.t. addition, substitution and elimination reactions.

Practical

At the end of the course students will be able to

- Perform reactions and prepare derivatives.
- Develop skills of separation of binary mixture and the analysis of separated compound at microscale level.

REFERENCE BOOKS

THEORY

Textbooks

1. I. L. Finar, Organic Chemistry Vols I and II, Orient Longman
2. Morrison and Boyd, Organic Chemistry; 6th Edn. Prentice Hall India
3. J. March, Advanced Organic Chemistry: Reaction, Mechanism and Structure, Wiley, 2010, 4th Ed.
4. I. L. Finar, Stereochemistry and Chemistry of Natural products, ELBS, Longmans, 1963, Vol. 2, 3rd Ed.
5. P. S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.Press.

Reference books

1. Francis Carey, Organic Chemistry, 10th Edition.
2. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edn., Pearson Education Asia
3. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.
4. P Sykes, A guidebook to mechanisms in organic chemistry, 6th Ed., Pearson Edu., 1996.
5. J. Clayden, N. Greeves, S. Warren & Wothers, Organic Chemistry, Oxford University Press, 2012, 2nd Ed.
6. E. S. Gould et al., Mechanism and structure in Organic Chemistry, 1965
7. F. A. Carey, Organic Chemistry, 2000, 4th Ed.
8. S. H. Pine, Organic Chemistry, McGraw-Hill International Edn., 2010, 5thEd.
9. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Vol. I & II. Plenum Press, 1977.
10. D. Nasipuri, Stereochemistry of Organic compounds - Principles and Application, Wiley Eastern Limited, 2013, 4th Ed. Kent, [England]: New Academic Science Limited, 2013.
11. E. L. Eliel, Stereochemistry of carbon compounds, Tata Mac Graw Hill Publishing Company Ltd. (1990)
12. V. M. Potapov, Stereochemistry, MIR Publishers, Moscow, 1979
13. Organic Photochemistry- A Visual Approach, J Kopecky, VCH Pub., 1992.
14. Applications of Absorption Spectroscopy of Organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
15. V. M. Parikh, Absorption spectroscopy of organic Molecules, Addison Wesley Longman Publishing Co., 1974.
16. D. H Williams & I. Fleming, Spectroscopic methods in organic chemistry, 6th Ed., Tata Mcgraw Hill Education, 2011.
17. William Kemp, Organic spectroscopy, 3rd Ed., Palgrave Macmillan, 1991.
18. R. O. C. Norman and J. M. Coxon, Principles of Organic Syntheses, 3rd Ed., CRC Press Inc, 1993.
19. R. Bruckner, Advanced Organic Chemistry – Reaction Mechanisms, San Diego, CA: Harcourt /Academic Press, San Diego, 2002.
20. M. B. Smith, Organic Synthesis, McGraw – HILL International Edition, NewYork,1994.
21. W. Caruthers, Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, 2004.
22. Heterocyclic Chemistry, J A Joule and G F Smith, ELBS, Advances in Heterocyclic Chemistry, Edited by A R Katritzky et al., Vol. 1 to 50, Academic P.

PRACTICAL

Textbooks

1. A.I. Vogel, A.R. Tatchell, B. S. Furniss, A.J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011.
2. Practical organic chemistry, F G Mann and B C Saunders, Orient Longman, 4th ed.
3. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

Reference books

1. D. Pasto, C. Johnson and M. Miller, Experiments and Techniques in Organic Chemistry, 1st Ed., Prentice Hall, 1991.
2. L. F. Fieser, K.L. Williamson "Organic Experiments" 7th edition D. C. Heath, 1992.
3. K. L. Williamson, K.M. Masters, Macroscale and Microscale Organic Experiments, 6th Edition, Cengage Learning, 2010
4. R. K. Bansal, Laboratory Manual in Organic Chemistry, New Age International, 5th Edition, 2016.

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Bachelor of Science (Honours) Programme

CHD-103 **Discipline Specific Elective**

Selected Instrumentation in Chemistry (Semester VI)

Credits: 04

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THOERY: COURSE OBJECTIVES

- To define the terms involved in chromatographic techniques and spectroscopic methods.
- To explain working of chromatographic techniques and detectors, spectrophotometer, Atomic spectroscopy, DTA, DSC.
- To classify different types of chromatographic methods.
- To study the principles of GC, HPLC,
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments.
- To draw the schematic diagrams of different instruments.
- To solve numerical on chromatographic techniques
- To discuss the applications of different chromatographic techniques and spectroscopic methods.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Introduction (4 H)

Overview of instruments in chemical analysis, Basic components of instruments for analysis: Signal generators, detectors (input transducers) Signal processors, read out devices, circuits & electrical devices in the instruments, advantages of instruments interfaced with computers.

2. Chromatographic techniques (12 H)

Classification of chromatography methods. Gas chromatography: Basic principles of GSC and GLC. Terms involved: Distribution equilibria, rate of travel, retention time, retention volume, relative retention, Height Equivalent to a Theoretical Plate(HETP), Van Deemter equation. Instrumentation: carrier gas, column, injections systems,

explanations of factors affecting separation, thermal conductivity and flame ionization detectors. Qualitative and Quantitative analysis: internal standards, determination of peak area. HPLC: Instrumentation, description of pumps, detector choice (UV absorption and refractive index detectors), columns, injection system, packing materials, applications. Introduction to hyphenated techniques: Basic principles of GC-MS and LC-MS. (Numerical problems are to be solved)

3. Mass spectrometry (8 H)

Introduction, theory, making the gaseous molecule into an ion (electron impact, chemical ionization), making liquids and solids into ions (electro spray, electrical discharge), separation of ions on basis of mass to charge ratio. Instrumentation: schematic diagram of single and double focusing. Advantages of Quadrupole Mass Spectrometer, sample introduction, sample purity, spectrum resolution. Applications of mass spectrometry in structure elucidation. Peak matching.

4. X-ray diffraction methods (6 H)

Introduction to X-ray absorption and emission methods, Bragg's law, Diffraction of X-rays, production and detection of X-rays, sample preparation, identification of powder diffraction patterns of ZnO, NiO and $MgAl_2O_4$.

SECTION B

5. UV-Visible Spectroscopy (10 H)

Interaction of electromagnetic radiation with matter, Quantitative calculations- Beer's and Lambert's law, derivation of Beer-Lambert's law, deviations from Beer's law. Principles of instrumentation: Sources, monochromators, cells. Types of instruments: Photoelectric colorimeters and Spectrophotometers: Single & Double beam; comparison between colorimeter and spectrophotometer; applications: qualitative control of purity, quantative analysis; identification of structural groups in a molecule; study of co-ordination compound, cis-trans isomerism; chemical kinetics. Photometric titrations (numerical problems are expected to be solved).

6. Atomic spectrometric methods (14 H)

Atomic absorption Spectroscopy: Introduction, principle, instrumentation, applications, limitations. Flame photometry and introduction, principle, instrumentation, applications, limitations. Differences between flame photometry and atomic absorption spectroscopy. Fluorimetry: principles of fluorescence, chemical structure and fluorescence. Relationship between concentration & fluorescence intensity, instrumentation & applications. (numerical problems are expected to be solved)

7. Analysis of drug in solid state (6 H)

Concepts of particle size, size distribution shown as cumulative undersize curve. Thermal methods of analysis: Basic principles of differential thermal analysis (DTA) and Differential Scanning Calorimetry (DSC), Differential Thermal Analysis - apparatus and methodology, factors affecting DTA results, quantitative DTA, interpretation of results.

Applications to detect polymorphism and pseudo polymorphism in pharmaceuticals by DSC or DTA.

LEARNING OUTCOMES

At the end of the course students will be able to

- Discuss the principles behind the basic components of instruments (signal generators processors and detectors) and their advantages interfaced with computers.
- Define the terms, and principles involved in involved gas chromatography (GC) liquid chromatography (HPLC).GC-MS, LC-MS and solve the numericals with reference to the techniques.
- Explain sampling and working of X ray absorption and emission techniques.
- Describe the working and principles in photoelectric colorimeters and spectrophotometers and its application in isomerism photometric titrations and chemical kinetics.
- Explain principles, instrumentation, applications and limitations of AAS, flourimetry, flame photometry and solve the numerical with reference to the technique.
- Interpret steps involved in thermal methods of analysis- DTA, DSC and its applications in pharmaceuticals.
- To discuss the applications of advantages of different chromatographic techniques and spectroscopic methods.

REFERENCE BOOKS

Textbooks:

1. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut.
2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, Basic principles in Analytical Chemistry, 5th edition, Shet Publications Pvt. Ltd.

Reference books:

1. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, 5th edition (reprint 2003), Himalaya publication.
2. Willard, Meritt and Dean. Instrumental Methods of Analysis.
3. Skoog and Leary, Principles of Instrumental analysis, Saunders College Publication.

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Bachelor of Science (Honours) Programme

CHD-106 **Discipline Specific Elective**

Pharmaceutical Chemistry and Analysis (Semester VI)

Credits: 04 (Theory: 04)

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THOERY: COURSE OBJECTIVES

Students will gain knowledge and understanding of

- pharmaceutical inorganic compounds.
- structure, synthesis and use of some selected drugs.
- Current good manufacturing practices.
- Radiopharmaceuticals, medicinal chemistry of herbs and Pharmaceutical unit processes

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Pharmaceutical Inorganic compounds (5 H)

Pure chemical compound, sources of impurities, Limit tests for chloride and sulphate.
Official compounds of Iron: Ferrous Fumarate and Ferrous Gluconate,
Official compounds of Iodine: Tincture of Iodine, Aqueous Iodine solution.
Official compounds of Calcium: Calcium Gluconate, Calcium acetate.

2. Structure, Synthesis and use of Selected Drugs (5 H)

Benzocaine, Pyrazinamide, Mefenamic acid, Naproxen, Phenobarbital, Atenolol and Theophylline.

3. Current Good Manufacturing Practice (5 H)

Standards for Current Good Manufacturing Practice, CGMP for Finished Pharmaceuticals: General Provisions, Organization and Personnel, Buildings and facilities, Equipments, Controls of components containers and closures, Production and process control, packaging and labelling control, holding and distribution, laboratory controls, records and reports, returned and salvaged drug products, Information technology and automation.

4. Radiopharmaceuticals (5 H)

Introduction, Isotopes and Radioisotopes, Radiochemistry of Fluorine, Indium and Iodine.

5. Medicinal Chemistry of Herbs (5 H)

Structure and name of an active component and its uses.

Garlic (Allicin), Capsicum (Capsaicin), Chamomile (-)-alpha-Bisabolol, Tulsi (Eugenol, Methyl Eugenol), Turmeric (Curcumin), Adulsa (Vasicinone), Coriander (Coriandrol), Ajwain (Thymol), Aloes (Aloesin) and Gokhru (Harman).

Extraction of Clove oil and Cinnamon oil.

6. Pharmaceutical unit processes (5 H)

a. Nitration: Importance of Nitro group in Medicines. Introduction, Nitrating agents, Aromatic nitration, Kinetics and mechanism of Aromatic nitration, Industrial Nitration process: continuous nitration of benzene with HNO_3 - fortified spent acid

b. Halogenation: Importance of halogenated compounds in drugs, Introduction, Chlorination of propane.

c. Fermentation: Aerobic and anaerobic fermentation. Production of Penicillin Vitamin B12.

SECTION B

6. Instruments of analysis (3 H)

Overview of instruments for chemical analysis, Basic components of instruments for analysis: Signal generators, detectors (input transducers) Signal processors, read out devices, advantages of instruments interfaced with computers.

7. Separation methods (10 H)

(A) Solvent Extractions: Principles, determination of the salts of organic acids and bases, extraction using equal and unequal volumes of solvents, choice of solvent, determination of alkaloids in crude drugs and galenicals, general method for liquid galenicals,

(B) Chromatography: Adsorption and partition mechanism of separation. Theory of chromatographic separation: Distribution equilibrium, rate of travel, retention time, retention volume, Height Equivalent to a Theoretical Plate (HETP). Gas chromatography: Principle, instrumentation, factors affecting separation, thermal conductivity and flame ionization detectors. Qualitative and Quantitative analysis: determination of peak area and applications. HPLC: Principle, instrumentation - description of pumps, columns -packing materials, injection system, detector choice and applications. (Numerical problems are to be solved)

8. Mass spectrometry (4 H)

Introduction, theory, instrumentation of single, double and Quadrupole Mass Spectrometer, advantages Quadrupole MS, sample introduction, sample purity, spectrum resolution. Applications of MS in structure elucidation, Peak matching.

9. UV-Visible Spectroscopy (8 H)

Electromagnetic radiation: wavelength, frequency, wave number, units, different regions of electromagnetic radiations.

Interaction of radiation with matter: atomic absorption and atomic emission.
Quantitative calculations- Beer's and Lambert's law, derivation of Beer-Lambert's law and deviations.
Instrumentation: Light sources, Filters and Monochromators, Cells, Detectors; photo emissive, barrier layer, photomultiplier tube. Single & double beam photoelectric colorimeters and spectrophotometers, Principles, comparison between colorimeter and spectrophotometer; applications in
i) qualitative control of purity,
ii) identification of a structural group in a molecule,
iii) study of co-ordination compounds, photometric titrations. (Numerical problems are to be solved)

10. Analysis of drug in solid state (5 H)

Concepts of particle size, size distribution shown as cumulative under size curve.
Thermal methods of analysis: Basic principles of differential thermal analysis (DTA) and Differential Scanning Calorimetry (DSC), Differential Thermal Analysis - apparatus and methodology, factors affecting DTA results, quantitative DTA, interpretation of results.
Applications to detect polymorphism and pseudopolymorphism in pharmaceuticals by DSC or DTA.

LEARNING OUTCOMES

Students will be able to learn of the contribution of inorganic compounds in pharmacy.

- They will learn to synthesise important drugs.
- Students will learn about the good manufacturing practice in pharmaceutical industry before they start working in the same.
- Students will learn about radioactive compounds used in therapy.
- Students will learn about the organic compounds present in herbs and their therapeutic effect.
- students will be better equipped to handle unit processes called out in pharmaceutical industry.

REFERENCE BOOKS

Textbooks

1. G. R. Chatwal Pharmaceutical Chemistry-Inorganic, Himalaya Publications.
2. Ashutosh Kar, Medicinal Chemistry, Newage International Publishers.
3. Wilson and Gisvold's textbook of Organic Medicinal and Pharmaceutical chemistry, Twelfth Edition, Wolters Kluwer
4. K. Raghuraman, D. V. Prabhu et al., Basic Principles in Analytical Chemistry, Shet Publishers.
5. H. Beckett and J. B. Stenlake, Practical Pharmaceutical Chemistry - Part One and Two, 4th ed. CBS Publishers and Distributors, N. D.

Reference Books

1. Wilson and Gisvold Organic Medicinal and Pharmaceutical Chemistry, Seventh Edition
2. Foye's Principles of Medicinal Chemistry, fifth edition.
3. L. E. Casida JR, Industrial Microbiology, New age International Publishers
4. Graham L. Patrick, Introduction to Medicinal chemistry, Fourth edition, Oxford university Press
5. P.H. Groggins, Unit Processes in Organic synthesis, Fifth Edition, Tata McGraw Hill.
6. C. K. Kokate and A. P. Purohit, Pharmacognosy, Nirali Publications
7 P. Yogeshwari, D. Shriram, Medicinal Chemistry, Pearson Education,2007.
8 Lednicer and Meischer, Organic Chemistry of Drug Synthesis Volume I to III, John Wiley and Sons,2005.
7. Howard C. Ansel, Loyd V. Allen Jr, Nicholas G. Popovich Pharmaceutical dosage forms and drug delivery systems
8. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut
9. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, 5th edition (reprint 2003), Himalaya publication

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Bachelor of Science (Honours) Programme

CHP-101 **PROJECT**

(Semester VI)

Credits: 04

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PROJECT COURSE OBJECTIVES

Students will gain knowledge and understanding of

- **Basic research:** The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.
- **Applied research**: Applied research is aimed at gaining knowledge or understanding to determine how a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

This Project course is in lieu of one of the DSE course. The project work is to be started in the beginning of semester V and to be completed at the end of semester VI.

LEARNING OUTCOMES

Students will be able to learn the following:

- Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. Majors to be certified by the American Chemical Society will have extensive laboratory work and knowledge of Biological Chemistry.
- Students will be able to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will be able to clearly communicate the results of scientific work in oral, written, and electronic formats to both scientists and the public at large.
- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

- Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
- Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
- Students will be able to function as a member of an interdisciplinary problem-solving team.

NOTE: Project to be started in semester V and completed at the end of semester VI.

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SEMESTER V

Bachelor of Science Programme

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Bachelor of Science Programme

CHS-103 **SKILL ENHANCEMENT COURSE**

Chemistry of Materials
(Semester V)

Credits: 04 (Theory: 03, Practical: 01)

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THOERY COURSE OBJECTIVES

- This Course introduces materials of industrial importance such as polymers, plastics, fires and rubber, effect of processes such as corrosion, adsorption and catalysis.
- It gives a basic knowledge on the preparation and properties of industrial materials and indepth study of the processes.
- Finally the course gives a brief overview of the applications of industrial materials and processes.

PRACTICALSCOURSE OJBECTIVE

- Industrial materials such as polymers can be better understood by performing the practical on polymerization. The processes like corrosion and adsorption can be better studied by performing practical on these processes.

SYLLABUS

Theory **No. of hours: 45**

1. Industrial Materials (15 H)

Polymers: Types of polymerization (Chain and step growth) Plastics: Thermoplastic and thermo setting resins, Compounding and fabrication of plastics Preparation, properties, engineering applications of PVC, Teflon, and Bakelite.

Fibers: Characteristics of fibers – Preparation, properties and use of Nylon 6,6 and Decron Fiber reinforced Plastics (FRP) applications.

Rubbers: Natural and its vulcanization, Elastomers- Buna -S, butyl rubber, Thiokol rubber.

Conducting polymers: Polyacetylene, Polyaniline, Mechanism of conduction, doping, applications of conducting polymers.

Biodegradable Polymers: Preparations and applications of Poly vinyl acetate and poly acetic acid. Cement: Composition of Portland cement, setting and hardening of cement (reactions) Lubricants: Classification with examples, Characteristics of a good lubricants and mechanism of lubrication (thick film, thin film and extreme pressures, Properties of lubricants, Viscosity, cloud point, flash and fire point.

Nanomaterials: Introduction, preparation by sol -gel, chemical and vapour deposition methods.

2. Corrosion and its control (15 H)

Causes and effects of corrosion, theories of corrosion- chemical and electrochemical corrosion, types of corrosion (Galvanic, Pitting, and inter-granular, factors affecting rate of corrosion – nature of metal and nature of environment. Corrosion control methods: Cathodic protection sacrificial anodic and impressed current Surface coatings: metallic coatings and methods of applications of metallic coatings – hot dipping (galvanizing and tinning). Cementation, cladding, electroplating (copper plating), electro-less Plating (Ni plating), Organic plating, Paints.

3. Adsorption and Catalysis (15 H)

Adsorption, classification of adsorption, differences between physical adsorption and chemical adsorption, adsorption of gases on solids, adsorption for solutions, applications of adsorption, Langmuir's theory of adsorption, Freundlich theory, B.E.T adsorption isotherm. Colloidal state, Types of colloidal solution, macromolecular and associated colloids, preparation of colloidal solutions, characteristics of colloidal solutions, origin of charge on colloids, stability of colloids, emulsions, gels, applications of colloids. Introduction to catalysis, characteristics of catalyst, types of catalyst, kinetics of homogenous and heterogeneous catalysts, enzyme catalysis, Michealis-Menten equation, application of catalysts.

PRACTICALS **30 Hours (01 Credit)**

1. To determine the rate of corrosion on different metallic plates (Iron, Aluminium) in various concentrations of HCl. Ref: 1.
2. To determine the effect of temperature on rate of corrosion in acidic medium. Ref: 1.
3. 3. To determine the rate of corrosion on a metallic plate in acidic medium. Ref: 1
4. To determine the rate of corrosion on a Aluminium plate in basic medium. Ref: 1
5. To study Aniline polymerisation using chemical method. Ref: 1
6. To study Synthesis of Nylon 6,6 by Hexamethylene diamine and Adipic acid. Ref: 2
7. To determine the adsorption behaviour of oxalic acid on charcoal and to verify Langmuir adsorption Isotherm. Ref: 3.
8. Determination of Total Dissolved Solids (TDS) of Magnesium Sulphate. Ref: 4

LEARNING OUTCOMES

Theory

- By the end of the course the student will be able to
- Distinguish between the different types of industrial materials and use them selectively or in combination for different purposes.
- Use the processes for a greener environment.

Practical

- Chalk out a plan to decrease the rate of corrosion.
- Reduce the amount of waste for adsorption and catalysis.

REFERENCE BOOKS

Theory

Textbooks

1. Engineering Chemistry by P.C. Jain and Monica Jain, Dhanpatrai Publishing company. (2008).

Reference books

1. Engineering Chemistry by R. P. Mani, K.N. Mishra, B. Rama Devi, CENGAGE learning.
2. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan.

Practical

Reference books

1. Analytical Chemistry by Gary D. Christian 6^{th} edition Wiley publication.
2. Organic synthesis by N. K. Vishnoi, Vikas Publisher, Third Edition.
3. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg, Adarsh Gulati, R Chand and Co.
4. Applied Chemistry Theory and Practice, O.P. Virmani, A.K. Narula. New Age International Publishers, 2^{nd} Edition.

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Bachelor of Science Programme

CHS-104 **SKILL ENHANCEMENT COURSE**

Inorganic Materials of Industrial Importance (Semester V)

Credits: 04 (Theory: 03, Practical: 01)

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THOERY COURSE OBJECTIVES

- To elucidate the properties of inorganic material of industrial importance such as glass, refractories, ceramic, cement, chemical explosives etc.
- To describe the raw materials and manufacturing processes involved in preparation of various inorganic material of industrial importance.
- To understand and discuss the classifications and types of inorganic materials.
- To explain the uses and applications of inorganic materials.
- To learn the methods of application of metal coatings.

PRACTICALS COURSE OJBECTIVE

- To estimate the inorganic materials, ions and element by volumetric and gravimetric method respectively.
- To develop hands on experience with respect to techniques required in preparations of inorganic materials.
- To study the method of electroless metallic coating on inorganic materials.

SYLLABUS

Theory: **Number of hours: 45**

1. **Glass (5 H)**
   Introduction, physical & chemical properties, raw materials, chemical reactions, manufacturing steps: melting, forming & shaping, annealing, finishing. Composition and properties of the following types of glasses: soda lime glass, lead glass, safety glass, borosilicate glass, coloured glass, photosensitive glass, glass laminates, vitreosil glass, optical or crookes glass

2. **Ceramics (6 H)**
   Introduction to ceramic, groups of ceramic materials and wares: structural ceramics, facing ceramics, special ceramics. Basic raw materials: clay, feldspar, sand & flint. Plasticity of clays, Manufacturing: Grinding of raw materials, mixing or preparation of body, kneading, jollying, slip casting, pressing, extrusion, turning, drying, firing and glazing.

3. **Refractories** (**4 H)**
Classification, properties, manufacture of refractories: composition, properties and uses of some special refractories: fire clay refractories, high alumina refractories, super refractories, carbon & graphite refractories and enamels.

4. **Cement**s **(6 H)**
Raw materials of cements and their role. Manufacture: dry & wet processes.Types of cements: (i) portland cement, (ii) white cement, (iii) coloured cement, (iv) pozzolan cement. Setting and hardening, heat of hydration. Concrete & RCC.

5. **Fertilizers (6 H)**
Classifications of fertilizers: direct, indirect and mixed fertilizers. Sources of fertilizers. Manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; triple phosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

6. **Pigments & paints (7 H)**
(**A**) **Pigments**: Introduction, types of pigments.Manufacture and uses of:
(i) White pigments: white lead by Dutch process, TiO_2 by modern chlorine method.
(ii) Blue pigments: iron blue by precipitation method.
(iii) Chrome pigments: chrome green by calcination method
(iv) Yellow pigments: chrome yellow from $Pb(NO_3)_2$/$Pb(CH_3COO)_2$
(**B**) **Paints:** Introduction, constituents of paints: pigments, extenders of fillers, film forming materials, driers, thinners or diluents, anti-skinning agents, plasticizers, resins, binders.Types of paints: emulsion paints, luminescent paint, heat resistant paint, fire retardant paints
(C) Varnishes: Introduction. Types of varnishes: spirit & oleoresinous varnishes.

7. **Surface Coatings (5 H)**
Metallic coatings: anodic coatings, cathodic coatings.Methods of application of metal coatings Hot dipping: (a) Galvanising (b) Tinning, Metal cladding Electroplating or electrodeposition. Objectives of electroplating on metals & nonmetal

8. **Chemical Explosives (6 H)**
Introduction**,** origin of explosive properties in organic compounds.
Classification: primary, low & high explosives. Preparation and explosive properties of lead azide, PETN, cyclonite or RDX [$(CH_2)_3N_3(NO_2)_3$]. Rocket propellants: characteristics of good propellent, types of propellents. Fireworks & flares.

Practical (30 Hrs- 01 credits)

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of calcium in calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Determination of % sulphur in ammonium sulphate by gravimetric analysis.
5. Preparation of Malachite [$CuCO_3.Cu(OH)_2$]. Estimation of copper(II) ions iodometrically using $Na_2S_2O_3$.
6. Preparation of Chrome Yellow ($PbCrO_4$).
7. Preparation of Prussian blue.

8. Electroless metallic coating on plastic and ceramic materials.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

1. Describe the properties of inorganic material of industrial importance such as glass, refractories, ceramic, cement, chemical explosives etc.
2. Explain the raw materials and manufacturing processes involved in preparation of various inorganic material of industrial importance.
3. Discuss the classifications and types of inorganic materials with their uses and applications.
4. Give and explain the methods of application of metal coatings.

Practical

At the end of the course students will be able to:

1. The students will acquire the skill and knowledge to carry out volumetric and gravimetric estimations.
2. The students will be able to get hands on experience in preparations of inorganic materials.
3. Develop the skill in the electroless metallic coating on inorganic materials.

REFERENCES

Theory

Textbook

1. Sharma, B.K.: Industrial Chemistry (including Chemical Engineering), Goel Publishing House, Meerut, 21st Edition, 2018.

Reference books

1. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
2. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic chemistry, Milestone Publishers.
4. Shriver and Atkins Inorganic chemistry, 4th edition.

Practical

Textbook

1. G.H Jefeery, J Bassett, J Mendham, R C Denney, Vogel's Textbook of Quantitative Chemical Analysis, 5th edition.

Reference books

1. Sharma, B.K., *Industrial Chemistry (including chemical Engineering),* Goel Publishing House, Meerut, 21st Edition, 2018.

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Bachelor of Science Programme

CHD-101 **Discipline Specific Elective**

Basic Topics in Analytical Chemistry (SEMESTER V)

Credits: 04 (Theory: 03 & Practical: 01)

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THOERY COURSE OBJECTIVES

- To define the terms involved in analytical chemistry, sampling techniques, data handling, chromatographic Techniques and electroanalytical methods.
- To explain scope and importance of analytical chemistry, different types of sampling and the types of solvent extractions.
- To classify different types of chromatographic techniques and errors with examples.
- To study the principles of volumetric analysis and gravimetric analysis and the basic principles of instrumentation of electrogravimetry, coulometry and polarographic analysis.
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments of electroanalytical methods.
- To draw the schematic diagrams of different electroanalytical methods.
- To solve numericals of evaluation of data and solvent extractions.
- To discuss the applications of different chromatographic techniques and electroanalytical methods.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory (ion exchange chromatography, colorimetry, statistical data).

SYLLABUS

Theory: **Number of hours: 60**

1. Introduction (3 H)

Scope and importance of analytical chemistry, chemical analysis and analytical chemistry.

Classification of instrumental methods, analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results.

2. Quantitative analysis (8 H)

A. Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations.

B. Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition.

3. Sampling Techniques (4 H)

Terms encountered in sampling: the population or the universe, Sample, Sampling unit, increment, the gross sample, the sub sample, Analysis sample, Bulk ratio, Size to weight ratio, Random sampling, Systematic sampling, Multistage sampling, Sequential sampling. Sampling of Gases, Liquids and Solids. Preservation, storage and preparation of sample solution.

4. Evaluation of analytical data (10 H)

Significant figures and rounding off, accuracy and precision Errors: determinate and indeterminate error, constant and proportionate errors, minimization of errors. Measures of central tendency and dispersion. Standard deviation, Gaussian distribution curve and its characteristics, Histogram and Frequency polygon. Confidence limit. Test of significance: Students t, F test, Rejection of the results: 2.5d & 4d rule and Q test. Linear least squares and Method of averages (Numerical problems are expected to be solved)

5. Solvent Extraction (4 H)

Basic Principle, percentage extraction, role of complexing agents in solvent extraction, separation factor, types of extraction (continuous, batch) (Numerical problems are to be solved)

6. Chromatography (7 H)

Principles Classification of chromatographic techniques

1. Column chromatography: Principle, experimental details, theory of development, factors affecting column efficiency and applications.
2. Paper and thin layer chromatography: Principles, techniques and applications of paper and thin layer chromatography.
3. Ion exchange chromatography: Principles, classification of ion exchange materials, Nature of exchanging ions, Ion exchange capacity, applications in analytical chemistry.

7. Electroanalytical methods (9 H)

Electro gravimetric analysis: Introduction, principles, instrumentation, Electrolysis at constant current, apparatus, determination of copper by constant current electrolysis. Coulometry: Introduction, constant Current measuring device, Hydrogen-Oxygen coulometer, Silver coulometer. General characteristics of coulometric method, applications of coulometry in Neutralization, complexation, precipitation and redox titrations. Polarography: Introduction, Basic principles of instrumentation, Deposition potential, Dissolution potential, Polarization of electrode, Polarographic wave, Ilkovic equation, Supporting electrolytes, Interference of oxygen, Applications of polarography – inorganic and organic.

PRACTICALS Number of hours: 60

1. Determination of iron by salicylic acid by colorimetry.
2. Determination of nitrite in water by colorimetry.
3. Separation of organic compounds by TLC. (Demonstration)
4. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Magnesium with standard EDTA.
5. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Zinc with standard EDTA.
6. Estimation of Na^{+} in NaCl by cation exchange resin using standard NaOH.
7. Estimation of Ca in calcium tablet by oxalate method and titration with $KMnO_4$.
8. Determination of hardness of water by EDTA i.e. estimate Ca as $CaCO_3$ and report analysis in ppm. (The candidate should record more than 5 observations and carry out statistical analysis to find out mean, median, range, standard deviation, absolute error, relative error and possibly Q test.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Define the terms, state the laws and principles involved in involved in sampling techniques, data handling, chromatographic techniques, solvent extractions, volumetric analysis and gravimetric analysis.
- Explain sampling of liquid, solid and gases, different types of tests related to data handling, scope and importance of analytical chemistry.
- Draw and describe the basic components of instruments of electroanalytical methods.
- Classify and explain different types of errors, sampling and chromatographic techniques.
- Derive and use the equations of linear least squares and method of averages and solvent extraction to solve numerical.
- Interpret steps involved in chemical analysis.
- To discuss the applications of different chromatographic techniques and electroanalytical methods

Practical

At the end of the course students will be able to

- Understand the concepts based on ion exchange chromatography, colorimetry and to estimate acidic and basic radicals quantitatively.
- Develop skills to prepare different plates of thin layer chromatography.
- Solve numericals based on statistical data obtained from experimental results.

REFERENCE BOOKS

Textbooks

1. Baliga and Shetty, College Analytical Chemistry, 15th edition, Himalaya Publishing House, 2004
2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, 5th Edn., Sheth Publishers Pvt. Ltd.

Reference Books:

1. G. D. Christan Analytical Chemistry by, 5th edition Wiley publications.
2. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis 5th edition (reprint 2003), Himalaya publication.
3. Vogels Textbook of Quantitative Inorganic Analysis 4th edition ELBS.
4. Willard, Meritt and Dean. Instrumental Methods of Analysis
5. Skoog and Leary, Principles of Analytical Chemistry 4th International edition.
6. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut
7. Mendham, J. Vogel's Quantitative Chemical Analysis (6th Edition) Pearson.

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Bachelor of Science Programme

CHD-104 **Discipline Specific Elective**

ESSENTIALS IN PHARMACEUTICAL CHEMISTRY (Semester V)

(4 Credits: Theory-03, Practicals-01)

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THOERY COURSE OBJECTIVES

- To study the importance of chemistry in pharmacy.
- To bridge the gap between chemistry and pharmacy by learning drug product formulation.
- To study the various ways of naming drugs.
- To introduce the students the concept of drug designing.
- To introduce various representative classes of drugs with examples.

PRACTICALS COURSE OBJECTIVES

- To perform experiments as given in monographs to understand drug analysis.
- To use UV-spectrophotometer and perform assay of drugs.
- To introduce the principle of thin layer chromatography in performing drug identification experiments.
- To improve practical hands for synthesis of drugs.

SYLLABUS

Theory: **Number of hours: 45**

1. **General Introduction to Pharmaceutical Chemistry: (6 H)**
   Importance of Chemistry in Pharmacy. Important terminologies: Pharmaceutical Chemistry, Pharmacokinetics, Pharmacodynamics, Pharmacophore, Pharmacopoeia, Pharmacognosy, Toxicology, Materia Medica, Drug. Drug Product formulation, drug dosage forms, routes of drug administration: Oral, Parenteral, Enemal, Topical (Advantages and Disadvantages). Assay of drugs. Chemical Assay (Titrimetric and Instrumental methods), Biological assay: Principles of bioassay, methods of bioassay, Invitro and Invivo assay.

2. Physicochemical properties of drugs and drug metabolism (5 H)

Effect of solubility, partition coefficient, ionisation constant, hydrogen bonding, chelation, electronic effect, steric effect, surface activity and cis-trans isomerism on the pharmacological action of drugs. Drug Metabolism: Definition, Phase I drug metabolism: Oxidation, Reduction and Hydrolysis. Phase II drug metabolism: Conjugation reactions. Factors on which drug metabolism depends.

3. Nomenclature of drugs and structure activity relationship (4 H)

Drugs -Nomenclature, Naming of drugs: code number, chemical name, brand name/trade name/optical name/common name, synonyms. Examples Aspirin, Ibuprofen, Chloroquine, Mebendazole, Caffeine, Propranolol, Methyl Dopa. Effect of various functional groups on the chemical activity of drugs (acidic, hydroxyl, amino, aldehyde, cyano, halogen,)

4. Introduction to Drug Design (5 H)

Development of new drugs: Introduction, procedure followed in drug design, the search for lead compounds, molecular modification of lead compounds, prodrugs and soft drugs, prodrug; introduction, multiple prodrug formation; Design of Enzyme Inhibitors, 9-alkylpurines, 9-mercaptopurines and allopurines.

5. Definition and Classification with structure of the following drugs: Anti Infective agents: (6 H)

Antiseptics and Disinfectants: Alcohols, substituted phenols, DDT, p-hydroxy-benzoic acid esters, Chloramine-T, 8-hydroxy quinoline derivatives, Bromopal, Halazone. Synthesis, use and side effects of DDT and Halazone.

Antimycobacterial agents (Antitubercular and Antileprotic drugs) Aminosalicylic acid, Isoniazid, Pyrazinamide, Ethambutol, Dapsone, Synthesis, use and side effects of Isoniazid and Ethambutol.

Antimalarials: Life cycle of parasite, drug acting on different stages- Quinine, Mefloquine, Chloroquines, Trimethoprim. Antiamoebics: Metronidazoles, Diloxanides, Anthelmintics: Niclosamide, Mebendazoles, Synthesis, use and side effects of Metronidazole and Niclosamide.

Antifungal: Antibiotics like Clotrimazoles. Antivirals including drugs acting on HIV: Idoxuridiness, Amantadine Hydrochlorides. Synthesis, use and side effects of Clotrimazole and Idoxuridiness.

6. Antineoplastics, Sulfonamides, Hypoglycemics, Diagnostic agents and Diuretics (4 H)

6-Mercaptopurines, Thiotepa, Doxorubicin, Cis-platin, Sulfacetamide, Sulfamethoxazoles,: Insulin and various sulfonyl ureas like tolbutamide, Metformin, Saccharin. Iodoxyls, aminohippuric acid. Sulfonamides – Acetazolamides, Hydrochlorthiazide, Ethacrynic acid, Theophylline. Synthesis, use and side effects of sulphacetamide, thiotepa.

7. Analgesic, antipyretics, anti-inflammatory and antibiotic drugs (4 H)

Definition and Classification with structure of the following drugs: Aspirin, Acetaminophen, Ibuprofen, Naproxen, Diclofenac. Narcotic analgesic agents: Morphine. Non-narcotic analgesic agents: Dextropropoxyphene. Antibiotics: Penicillin, Chloramphenicol, Synthesis, use and side effects of Aspirin, Ibuprofen.

8. Cardiovascular and Parkinsonism drugs (4 H)

Antianginal drugs: Angina pectoris condition-Isosorbide dinitrate, Vasodilators: Cylandelate, Antiarrythmic agents: Cardiac Arrythmia condition Verapamil, Antihypertensive agents: Methyl dopa, Coagulants and Anticoagulants: Vitamin K, Coumarin derivatives like Warfarin, Dicoumarol. Antilipidemics: Atherosclerosis condition, Clofibrates, Nicotinic acid, Drugs used in Parkinsonism: Levodopa, Drugs for Alzheimer's iseases: Velnacrine. Synthesis, use and side effects of Methyl Dopa and Warfarin.

9. Central Nervous System Drugs (3 H)

Local anaesthetics: Benzocaines, Lidocaine. General Anaesthetics: Ether, Nitrous oxide, Halothane, Ultra short acting Barbiturates-Thiopental sodium. Drugs acting on the central nervous system: a] Hypnotics and sedatives: Phenobarbital, b] Drugs acting as anticonvulsants: Phenytoin, Phenobarbital, c] Psychotherapeutic agents: Phenothiazines such as Chloropromazine, Diazepam. d] CNS stimulants: Nikethamide, Caffeine. Synthesis, use and side effects of Phenytoin, Nikethamide.

10. Drugs acting on cholinergic and adrenergic nervous system (2 H)

Drugs acting on cholinergic nervous system Methacholine, Tropicamide. Drugs acting on adrenergic nervous system: Epinephrine, Propanalol, Metoprolol. Synthesis, use and side effects of Bethanechol and Propranolol.

11. Antihistaminics and antiemitics and antiulcer drugs (2 H)

Chloropheniramine, Cyclizine, Promethazine, Synthesis, use and side effects of Chloropheniramine, Promethazine.

PRACTICALS — Number of hours: 30

1. Indian Pharmacopoeia Monograph of Aspirin and Purified water. (Any One)
2. Spectrophotometric assay of Metformin hydrochloride and Albendazole.
3. Synthesis of Sulphacetamide, Dilantin, Paracetamol, 7-hydroxy-4-methyl coumarin. (any 3)
4. TLC identification of analgesic drugs comparison of bulk drugs with branded drugs

LEARNING OUTCOMES

Theory

At the end of this course students will be able to:

- Explain terminologies in pharmaceutical chemistry.
- Explain the nomenclature, structure activity relationship and physicochemical properties of drugs.
- Apply the concept of drug designing.
- Classify various drugs.
- Understand the synthesis of drugs.

Practical

At the end of this course students will be able to:

- Refer Pharmacopoiea and perform monograph experiments.
- Use UV-spectrophotometer and improve their analytical skills performing drug assay experiments.
- Perform TLC experiment in identification of analgesic drugs.
- Handle chemicals and follow procedure for synthesis of drugs.

REFERENCE BOOKS

Theory

Textbooks:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 8th edition Edited by Robert F. Doerge, J. B. Lippincott Company, Philadelphia, USA.
2. Harikishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. Medicinal Chemistry, D. Shriram, P. Yogeshwari, Pearson Education, 2007.
4. Medicinal Chemistry, Chatwal, Himalaya Publishing house, 2002.
5. Textbook of Pharmaceutical Chemistry by Jayshree Ghosh, S. Chand & company Ltd.
6. Pharmaceutical Chemistry by Dr. S. Lakshmi, Sultan chand & Sons.

References books:

1. G. L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. William O. Foye, Thomas L., Lemke, David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.
3. Lednicer and Meischer, Organic Chemistry of Drug Synthesis. Vol. I to III. John Wiley & Sons, 2005.
4. Burger's Medicinal Chemistry, Part I and II, 4th edition, Edited by M. E. Wolff, John Wiley.
5. Principles of Medicinal Chemistry, W. O. Foye, 3rd edition, K. M. Varghese and Co., Bombay.
6. Burgers Medicinal Chemistry and Drug Discovery, Vol. I, 6th edition, Edited by Donald J. Abraham, John Wiley and Sons, New Jersey, 2003.

Practical

Reference books:

1. Indian Pharmacopoeia, Latest edition.
2. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011.

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SEMESTER VI

Bachelor of Science Programme

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Bachelor of Science Programme

CHS-105 **SKILL ENHANCEMENT COURSE**

Molecules of Life
(Semester VI)

Credits: 04 (Theory: 03, Practical: 01)

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THOERY COURSE OBJECTIVES

Students will gain knowledge and understanding of;

- The Chemistry of carbohydrates.
- The chemistry of Amino acids, Peptides and Proteins.
- Enzymes and correlation with drug action
- Nucleic acid
- Lipids
- Spectroscopic analysis in structure elucidation of molecules of life.

PRACTICAL COURSE OJBECTIVE

Students will:

- Gain skills in carrying out various estimations/experiments.
- Be able to determine the various parameters of oil/fat.
- Will be trained in interpreting IR and NMR spectra of various compounds related to molecules of life.

SYLLABUS

Theory: **Number of hours: 45**

1. **Carbohydrates (6 H)**Introduction to Carbohydrates. Open chain reactions of Glucose, Ruff degradation, determination of ring size of Glucose (pyranose and furanose using methylation method). Open chain reactions of sucrose, inversion of cane sugar, Evidence of presence of glucose and fructose unit in sucrose. Determination of ring size of Sucrose. (using methylation method). Measuring the blood Glucose levels of Diabetics (reaction with amino group of haemoglobin) Some naturally occurring products derived from Carbohydrates, Carbohydrates on cell surfaces, Synthetic sweeteners.

2. **Amino Acids, Peptides and Proteins (10 Hours)**
Introduction to Amino acids, peptides and proteins. Separation of Amino acids using Paper chromatography and Ion Exchange Chromatography. Overview of Primary,

Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides (amino acid sequence), determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (Benzoxycarbonyl and di-tertbutyl dicarbonate) & C-activating group (Dicyclohexylcarbodiimide) (DCC) .

3. Enzymes and correlation with drug action (4 H)

Mechanism of enzyme action, factors affecting enzyme action, Enzyme inhibitors and their importance, phenomenon of inhibition (Competitive and Noncompetitive inhibition including allosteric inhibition). Drug action-receptor theory.

4. Nucleic Acids (7 H)

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

5. Lipids (6 H)

Introduction to lipids, classification.Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number and Acid value.Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

6. Spectroscopic analysis (12 H)

Infra Red Spectroscopy

Principle of I.R Spectroscopy (Hooke's law), types of molecular vibrations (Stretching and Bending) Functional group region and Fingerprint region. Applications of I. R. Spectroscopy: Functional group analysis, detection of purity of sample, establishing the identity of an unknown molecule, Effect of H-bonding.

Nuclear Magnetic Resonance Spectroscopy

Basic Principles of 1H NMR spectroscopy, Number of signals, Position of signals, Chemical shift: Reference standard, Shielding and deshielding effect, anisotropic effects in aldehydes, Intensity of signals: Peak area and proton counting. Spin-Spin coupling: Coupling constant (J). Interpretation of NMR spectra of simple compounds. (acetone, acetaldehyde, toluene, ethyl bromide, anisole). Simple problems based on NMR spectral data for identification of molecule.

Carbon-13 Nuclear Magnetic Resonance Spectroscopy

Principle of 13C spectroscopy, Number of signals, Proton coupled and decoupled spectra (off-resonance). Position of signals. Factors affecting position of signals (hybridization). Simple Problems based on 13C spectroscopy. Spectral analysis of following compounds: Glucose, Fructose, Glycine, Alanine, Adenine and Oleic Acid.

Practicals 30 Hours (01 Credit)

1. Separation of amino acids by paper chromatography. Ref: 3.
2. To determine the concentration of glycine solution by formylation method. Ref: 3.
3. Study of titration curve of glycine. Ref: 3.

4. To determine the saponification value of an oil/fat. Ref: 3.
5. To determine the acid value of an oil/fat. Ref: 3.
6. Tests to differentiate between a reducing/ nonreducing sugar. Ref: 1, 2, 4.
7. Interpretation of Infra-Red, and proton NMR spectra. Ref: 5, 6,7.
   (A) IR spectra containing Glucose, Glycine, Guanine and Acetone.
   (B) Proton NMR of Alanine, Glycine, Toluene and Benzaldehyde.

Note: Experiment 2, 4 and 5 to be considered for examination and all other experiments are to be considered for viva.

LEARNING OUTCOMES

Theory

Students will

- Understand the Chemistry of the molecules of life i.e. carbohydrates, Amino acids, Peptides and Proteins, enzymes, Nucleic acid and lipids.
- Be able to apply spectroscopic techniques for structure elucidation of these molecules of life.
- They will be able to understand better their future course of studies especially in study of biomolecules.

Practical

Students will

- Be efficient in various laboratory skills of estimations/experiments.
- Be confident in carrying out experiments in estimating oil/fat.
- Be able to interpret IR/NMR spectra and apply the theory learnt in practice.

REFERENCES

Theory

Textbooks

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Paula Yurkanis Bruice, Organic Chemistry, 3rd Edition, Pearson Education, 2007
4. P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.

Reference books

1. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7th Ed.*, W. H. Freeman.
3. Berg, J. M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.
4. A. Carey, Organic Chemistry, 2000, 4th Ed.

5. S. H. Pine, Organic Chemistry, McGraw-Hill International Edn. 2010, 5thEd.
6. Applications of Absorption Spectroscopy of Organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
7. V.M. Parikh, Absorption spectroscopy of organic Molecules, Addison Wesley Longman Publishing Co., 1974.
8. D.H Williams & I. Fleming, Spectroscopic methods in organic chemistry, 6th Ed., Tata Mcgraw Hill Education, 2011.
9. William Kemp, Organic spectroscopy, 3rd Ed., Palgrave Macmillan, 1991.

Practical

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
3. Beedu Sashidhar Rao, Vijay Deshpande. Experimental Biochemistry A Student Companion.
4. Prof. Santosh Nagar, Dr. Madhavi Adhav. Practical Biotechnology and Plant Tissue Culture, S. Chand
5. Practical organic chemistry, F G Mann and B C Saunders, Orient Longman, 4th ed.
6. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.
7. S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.

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Bachelor of Science Programme

CHD-103 **Discipline Specific Elective**

Selected Instrumentation in Chemistry (Semester VI)

Credits: 04

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THOERY: COURSE OBJECTIVES

- To define the terms involved in chromatographic techniques and spectroscopic methods.
- To explain working of chromatographic techniques and detectors, spectrophotometer, Atomic spectroscopy, DTA, DSC.
- To classify different types of chromatographic methods.
- To study the principles of GC, HPLC,
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments.
- To draw the schematic diagrams of different instruments.
- To solve numerical on chromatographic techniques
- To discuss the applications of different chromatographic techniques and spectroscopic methods.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Introduction (4 H)

Overview of instruments in chemical analysis, Basic components of instruments for analysis: Signal generators, detectors (input transducers) Signal processors, read out devices, circuits & electrical devices in the instruments, advantages of instruments interfaced with computers.

2. Chromatographic techniques (12 H)

Classification of chromatography methods. Gas chromatography: Basic principles of GSC and GLC. Terms involved: Distribution equilibria, rate of travel, retention time, retention volume, relative retention, Height Equivalent to a Theoretical Plate(HETP), Van Deemter equation. Instrumentation: carrier gas, column, injections systems,

explanations of factors affecting separation, thermal conductivity and flame ionization detectors. Qualitative and Quantitative analysis: internal standards, determination of peak area. HPLC: Instrumentation, description of pumps, detector choice (UV absorption and refractive index detectors), columns, injection system, packing materials, applications. Introduction to hyphenated techniques: Basic principles of GC-MS and LC-MS. (Numerical problems are to be solved)

3. Mass spectrometry (8 H)

Introduction, theory, making the gaseous molecule into an ion (electron impact, chemical ionization), making liquids and solids into ions (electro spray, electrical discharge), separation of ions on basis of mass to charge ratio. Instrumentation: schematic diagram of single and double focusing. Advantages of Quadrupole Mass Spectrometer, sample introduction, sample purity, spectrum resolution. Applications of mass spectrometry in structure elucidation. Peak matching.

4. X-ray diffraction methods (6 H)

Introduction to X-ray absorption and emission methods, Bragg's law, Diffraction of X-rays, production and detection of X-rays, sample preparation, identification of powder diffraction patterns of ZnO, NiO and $MgAl_2O_4$.

SECTION B

5. UV-Visible Spectroscopy (10 H)

Interaction of electromagnetic radiation with matter, Quantitative calculations- Beer's and Lambert's law, derivation of Beer-Lambert's law, deviations from Beer's law. Principles of instrumentation: Sources, monochromators, cells. Types of instruments: Photoelectric colorimeters and Spectrophotometers: Single & Double beam; comparison between colorimeter and spectrophotometer; applications: qualitative control of purity, quantative analysis; identification of structural groups in a molecule; study of co-ordination compound, cis-trans isomerism; chemical kinetics. Photometric titrations (numerical problems are expected to be solved).

6. Atomic spectrometric methods (14 H)

Atomic absorption Spectroscopy: Introduction, principle, instrumentation, applications, limitations. Flame photometry and introduction, principle, instrumentation, applications, limitations. Differences between flame photometry and atomic absorption spectroscopy. Fluorimetry: principles of fluorescence, chemical structure and fluorescence. Relationship between concentration & fluorescence intensity, instrumentation & applications. (numerical problems are expected to be solved)

7. Analysis of drug in solid state (6 H)

Concepts of particle size, size distribution shown as cumulative undersize curve. Thermal methods of analysis: Basic principles of differential thermal analysis (DTA) and Differential Scanning Calorimetry (DSC), Differential Thermal Analysis - apparatus and methodology, factors affecting DTA results, quantitative DTA, interpretation of results.

Applications to detect polymorphism and pseudo polymorphism in pharmaceuticals by DSC or DTA.

LEARNING OUTCOMES

At the end of the course students will be able to

- Discuss the principles behind the basic components of instruments (signal generators processors and detectors) and their advantages interfaced with computers.
- Define the terms, and principles involved in involved gas chromatography (GC) liquid chromatography (HPLC).GC-MS, LC-MS and solve the numericals with reference to the techniques.
- Explain sampling and working of X ray absorption and emission techniques.
- Describe the working and principles in photoelectric colorimeters and spectrophotometers and its application in isomerism photometric titrations and chemical kinetics.
- Explain principles, instrumentation, applications and limitations of AAS, flourimetry, flame photometry and solve the numerical with reference to the technique.
- Interpret steps involved in thermal methods of analysis- DTA, DSC and its applications in pharmaceuticals.
- To discuss the applications of advantages of different chromatographic techniques and spectroscopic methods.

REFERENCE BOOKS

Textbooks:

1. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut.
2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, Basic principles in Analytical Chemistry, 5th edition, Shet Publications Pvt. Ltd.

Reference books:

1. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, 5th edition (reprint 2003), Himalaya publication.
2. Willard, Meritt and Dean. Instrumental Methods of Analysis.
3. Skoog and Leary, Principles of Instrumental analysis, Saunders College Publication.

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Bachelor of Science Programme

CHP-101 **PROJECT**

(Semester VI)

Credits: 04

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PROJECT COURSE OBJECTIVES

Students will gain knowledge and understanding of

- **Basic research:** The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.
- **Applied research**: Applied research is aimed at gaining knowledge or understanding to determine how a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

This Project course is in lieu of one of the DSE course. The project work is to be started in the beginning of semester V and to be completed at the end of semester VI.

LEARNING OUTCOMES

Students will be able to learn the following:

- Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. Majors to be certified by the American Chemical Society will have extensive laboratory work and knowledge of Biological Chemistry.
- Students will be able to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will be able to clearly communicate the results of scientific work in oral, written, and electronic formats to both scientists and the public at large.
- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

- Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
- Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
- Students will be able to function as a member of an interdisciplinary problem-solving team.

NOTE: Project to be started in semester V and completed at the end of semester VI.

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INDUSTRIAL CHEMISTRY

Bachelor of Science – Industrial Chemistry
Programme Specific Outcome (PSO)

- Students will be able to acquire core knowledge in the key areas of Industrial Chemistry, develop written & oral communication skills in communicating chemistry-related topics.

- Design & conduct experiments, demonstrate their understanding of the scientific methods & processes.

- Develop proficiency in acquiring data using a variety of instruments, analyze & interpret the data, learn applications of numerical techniques.

- Realize & develop an understanding of the impact of Industrial Chemistry on society.

SEMESTER I

(INDUSTRIAL CHEMISTRY)

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ICC-101 **CORE COURSE**

General Industrial Chemistry I
(Semester I)

Credits: 06 (Theory: 04 + Practical: 02)

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COURSE OBJECTIVES

- The students are to be exposed to various organic operations, their use in actual practice in the context of installation of industry.
- It is equally expected that after studying the topics sequentially, the students are well versed with the theoretical principles connected to the practical part of the industrial chemistry.
- This will encourage the students to open any new industry or utilize this knowledge for any ancillary unit to the main industry.

SYLLABUS

THEORY: **Number of hours: 60**

SECTION A (Inorganic and Organic Chemistry) (30 Hours)

1. **Nomenclature (2 H)**
   Generic names, Trade names & Proper names.

2. **Raw material for organic compounds (10 H)**
   Petroleum, natural gas, fractionation of crude oil, reforming, hydroforming, isomerisation.

3. **Renewable Natural Resources (8 H)**
   Cellulose & Starch. Their properties & modifications. Important industrial chemicals derived from cellulose & starch. Alcohols and alcohol-based chemicals, including oxalic acid & furfural.

4. **Inorganic materials of industrial importance (10 H)**
   Alumina, silica, silicates, clay, mica, carbon, zeolites. Their availability, forms, structure and modifications.

SECTION B (Material Balance and utilities) (30 HOURS)

5. **Material Balance without Chemical Reaction (10 H)**
Flow diagram for materials balance processes. Simple material balance with or without recycle or bypass for chemical engineering operations such as distillation, absorption, crystallization, extraction etc.

6. **Material balance with Chemical Reaction (8 H)**
Concept of limiting reactant, Conversion, yield liquid phase reaction & gas phase reaction with/without recycle or by-pass.

7. **Utilities in Chemical Industry (7 H)**
Fuel: Types of fuels – Advantages and Disadvantages. Combination of fuels, Calorific values (Bomb's calorimeter, Boy's gas calorimeter and Dulong's Formula).

8. **Boilers (5 H)**
Types of Boilers and their functions.

PRACTICALS Number of hours:60

SECTION A (30 Hrs, 1 Credit)

1. **Simple laboratory techniques:**
(i) Crystallization from water: i) Sodium Chloride ii) Copper Sulphate (6 Hrs)
(ii) Distillation of: i) Water ii) Ethyl acetate (8 Hrs)
(iii) Fractional distillation: i) Acetone and water ii) Acetone and toluene (8 Hrs)

2. **Determination of depression in melting point of the following compounds: (any two) (8H)**
(i) Calcium chloride in water (ii) sodium chloride in water &
(iii) glucose in water.

SECTION B (30 Hrs, 1 Credit)

1. **Boiling point diagrams for following compounds: (3 × 8 = 24 Hrs)**
(i) Calcium chloride in water
(ii) Sodium chloride in water and
(iii) Glucose in water

2. **Phase diagram with three different concentrations for following mixture**
(Ethanol + Water + toluene) **(3× 2 = 6 Hrs)**

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- To study nomenclature and learn generic names, trade names & proper names of different compounds & describe different raw materials like petroleum, natural gas for synthesizing organic compounds.

- To study techniques like fractionation of crude oil, reforming, hydroforming, isomerization carried out in petroleum refineries and to study properties & industrial chemicals derived from cellulose & starch; alcohols and alcohol-based chemicals.
- To understand the availability, forms, structure and modifications of various inorganic materials of industrial importance.
- To study flow diagram for materials balance processes and learn simple material balance with or without recycle.
- To understand the concept of limiting reactant and study the yield liquid phase reaction & gas phase reaction with/without recycle.
- To study different utilities in chemical industry like fuel and boilers.

Practical

At the end of the course students will be able to

- To learn the simple purification laboratory techniques like crystallization and distillation for organic and inorganic compounds.
- To learn the simple separation techniques for organic and inorganic compounds i.e. fractional distillation.
- To study practically determination of depression in melting point.
- To study boiling point diagrams for different compounds.
- To study and draw Phase diagram with three different concentrations for a mixture.

REFERENCE BOOKS

Theory

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F. A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. UGC course material as prescribed by UGC.
4. Finar, I. L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. & Bahl, B. S. Advanced Organic Chemistry, S. Chand, 2010.

Practical

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000.
4. Sunita Rattan, Experiments in Applied Chemistry, S. K. Kataria & Sons, Second edition, 2008.
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. UGC practical manual for experimental analysis.

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CHC-101 **CORE COURSE**

Inorganic Chemistry& Organic Chemistry (Semester I)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To discuss Bohr's theory, Quantum theory for structure of an atom.
- To draw the radial plots, probability distribution curves.
- To generalize the rules for electronic configuration of an atom.
- To explain the general characteristics of ionic compounds and covalent compounds.
- To discuss valence bond theory, VSEPR, and molecular orbital theory for covalent compounds.

Section B

- To understand the curved arrow notations in organic reaction mechanisms.
- To understand the concept of physical effects and electronic displacement with reference to organic molecules.
- To understand the structure, shape and reactivity of organic molecules.
- To study the strength of organic acids and bases.
- To understand the aromaticity of compound.
- To understand the concept of isomerism, stereoisomerism, configuration, chirality and optical rotation.
- To understand the difference between conformational and configurational isomers.
- To draw conformations with respect to ethane, butane and cyclohexane.
- To learn the interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations.
- To understand rules for nomenclature and assigning configuration to configurational isomers.
- To understand various methods of preparation and reactions of alkanes, alkenes and alkynes.

PRACTICALS COURSE OJBECTIVE

- To estimate the metal ions by volumetric methods employing redox and acid-base titration concepts.

- To get hands on experience for the systematic qualitative analysis of the organic compounds.
- To learn the purification and separation techniques for organic compounds.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. Atomic Structure (14 H)

Review of Bohr's theory and its limitations; dual behaviour of matter and radiation; de Broglie's relation; Heisenberg Uncertainty principle; hydrogen atom spectra; need of a new approach to atomic structure; what is quantum mechanics? time independent Schrodinger equation and meaning of various terms in it; significance of ψ and ψ^2; Schrödinger equation for hydrogen atom; radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation); radial and angular nodes and their significance; radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals; quantum numbers and their significance; discovery of spin, spin quantum number(s) and magnetic spin quantum number (m_s); shapes of s, p and d atomic orbitals: nodal planes; rules for filling electrons in various orbitals; electronic configurations of the atoms; stability of half-filled and filled-orbitals; concept of exchange energy; relative energies of atomic orbitals; anomalous electronic configurations.

2. Chemical Bonding and Molecular Structure (16 H)

Ionic bonding: general characteristics of ionic bonding; energy considerations in ionic bonding; lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds; statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; polarizing power, and polarizability; Fajan's rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character. Covalent bonding: VB approach; shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements; concept of resonance and resonating structures in various inorganic and organic compounds: MO approach; rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

Section B

3. Fundamentals of Organic Chemistry (8 H)

Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms; physical effects, electronic displacements: inductive effect, electromeric effect, resonance and hyperconjugation. Cleavage of bonds: homolysis and heterolysis; structure, shape and reactivity of organic

molecules: nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals; strength of organic acids and bases: comparative study with emphasis on factors affecting pk values; aromaticity: benzenoids and Hückel's rule.

4. Stereochemistry (10 H)

Concept of isomerism; types of isomerism; stereoisomerism, conformational isomerism; conformations with respect to ethane, butane and cyclohexane; interconversion of wedge formula, Newmann, Sawhorse and Fischer representations; concept of chirality (up to two carbon atoms); configuration: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds); threo and erythro; D and L; cis – trans nomenclature; CIP Rules: R/ S (for up to 2 chiral carbon atoms) and E/Z Nomenclature (for up to two C=C systems).

5. Aliphatic Hydrocarbons (12 H)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure,

Alkanes (up to 5 carbons): preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent; reactions: free radical substitution: halogenation.

Alkenes (up to 5 Carbons): preparation: elimination reactions: dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration - demercuration, Hydroboration-oxidation.

Alkynes: (up to 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

PRACTICALS Number of hours: 60

Section A-(Inorganic Chemistry) (30 H)

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with standardized $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B:(Organic Chemistry) (30 H)

1. Purification of organic compounds:

i. Solids by recrystallization process using water and ethanol as solvent. Determination of melting point.
ii. Liquids by distillation process, a) acetone b) nitrobenzene. Determination of boiling point.

2. Determination of chemical type, detection of elements, group test for any one compound.

3. Identification of unknown organic compounds.
   i. Water insoluble solids (Acid, Base, Phenol and Neutral)
   ii. Water soluble solid (Acid and Neutral)

4. Thin layer chromatographic techniques: plate preparation, spotting, Separation of mixtures by thin layer Chromatography: Measure the Rf value in each case (combination of two compounds to be given eg. Mixture of o- and p-nitroaniline).

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Interpret the atomic structure based on postulates of Bohr's theory, Quantum mechanics.
- Evaluate the stability and magnetic property based on molecular diagrams of homonuclear and heteronuclear molecules.
- Identify and use the curved arrow notations in organic reaction mechanisms.
- Explain the concept of physical effects and electronic displacement with reference to organic molecules.
- Describe structure, shape and reactivity of organic molecules.
- Interpret strength of organic acids and bases.
- Identify if the given organic compound is aromatic.
- Classify isomers giving examples.
- Discuss the concept of stereoisomerism, configuration, chirality and optical rotation.
- Distinguish between conformational and configurational isomers and also geometrical and optical isomers, giving examples.
- Draw conformations with respect to ethane butane and cyclohexane.
- Draw and interconvert Wedge Formula, Newman, Sawhorse and Fischer representations.
- Give the nomenclature and assign configuration to configurational isomers.
- Give various methods of preparation and reactions of alkanes, alkenes and alkynes.

Practical

- The students will acquire the skill and knowledge to carry out volumetric estimation of inorganic constituents.

- The students will be able to get hands on experience for the systematic qualitative analysis of the organic compounds and the purification and separation techniques for organic compounds.

REFERENCE BOOKS

Inorganic Chemistry

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

Organic Chemistry

1. Graham Solomon, T. W., Fryhle, C. B. & Dnyder, S. A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J. E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
5. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Pearson, 2010.
7. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
8. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.
9. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.
10. Jerry March, Advanced Organic Chemistry; 4th Edition, John Wiley.

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SEMESTER II

(INDUSTRIAL CHEMISTRY)

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ICC-102 **CORE COURSE**

General Industrial Chemistry II
(Semester II)

Credits: 06 (Theory: 04 + Practical: 02)

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COURSE OBJECTIVES

- The basic metallurgical operations in details will give the exposure to the tedious, cumbersome and most complicated operations, so that the importance of metals and their alloys is seriously understood.
- The role of various ferrous and non-ferrous alloys in day today life and their importance are to be given due importance.
- The methods of extraction of metals in pyrometallurgy with due emphasis to Ellingham diagrams will really give the information about the mathematical calculations,
- Surface chemistry and its importance in connection to the adsorption isotherms and applications will widen the horizon of understanding of physical phenomena.
- The mathematical calculations for energy balance will have expertise in complicated calculations.
- The important operations like distillation, adsorption, evaporation, filtration, drying and fluid flow will prove their indispensability in chemical industry.

SYLLABUS

THEORY: **Number of hours: 60**

Section A: Metallurgy and Surface Chemistry (30 Lectures)

1. **Basic metallurgical operations (5 H)**
   Pulverisation, Calcination, Roasting, Refining
   Definition of the terms & illustration of the concept with suitable examples.

2. **Physicochemical principles (10 H)**
   Extraction of Iron, Copper, Lead, Silver, Sodium, Aluminium, Magnesium, Zinc & Chromium (Emphasis should be laid on physicochemical principles).

3. **Surface chemistry and Interfacial phenomena (15 H)**
   Adsorption & Adsorption isotherms (Freundlich & Langmuir), Applications of Adsorption in industrial processes, Colloids & their classification. Preparation, properties & applications of Sols, Gels, Emulsions, Microemulsions, Micelles & Aerosols, Effect of Surfactants and Hydrophilic- Lipophilic ratio.

Section B: Energy balance and Industrial Operations (30 Lectures)

4. Energy Balance (7 H)
Heat capacity of pure gases and gaseous mixtures at constant pressures, Enthalpy changes upon dissolution of solids in liquids.

5. Distillation (3 H)
Introduction- Batch and continuous distillation. Separation of azeotropes.

6. Absorption (3 H)
Introduction- Equipments- packed columns spray columns, bubble columns, packed bubble columns, mechanically agitated contactors.

7. Evaporation (3 H)
Introduction- Equipments- short tube (standard) evaporator, forced circulation evaporators, falling film evaporators, climbing film (outward flow) evaporators & wiped (agitated) evaporators.

8. Filtration (4 H)
Introduction- Filter media and filter aids. Equipments- plate and frame filter, press filter, batch filter, rotary drum filter, sparkler filter, candle filter, bag filter, centrifuge.

9. Drying (3 H)
Introduction- Free moisture, bound moisture, drying curve, Equipments: tray dryer, rotary dryer, flash dryer, fluid bed dryer & spray dryer.

10. Fluid flow (3 H)
Fans, blowers, compressors, vacuum pumps & ejectors.

11. Pumps (4 H)
Reciprocating pumps, Gear pumps & Centrifugal pumps.

PRACTICALS Number of hours:60

SECTION A (30 Hrs, 1 Credit)

1. Ore analysis: (Volumetric analysis only) (5 × 5 = 25 Hrs)

I. Mg from Dolomite
II. Ca from Limestone,
III. Fe from Iron ore,
IV. Mn from Manganese ore.
V. Analysis of alloys such as cupro-nickel.

2. Study experiments / demonstration experiments in laboratory/factory (5H)
Students will have to make a self-study report in the journal equivalent to two experiments (non-evaluative for examination).

3. **Simple laboratory techniques:**
   (i) Crystallization from water: i) Sodium Chloride ii) Copper Sulphate (6 Hrs)
   (ii) Distillation of: i) Water ii) Ethyl acetate (8 Hrs)
   (iii) Fractional distillation: i) Acetone and water ii) Acetone and toluene (8 Hrs)

4. **Determination of depression in melting point of the following compounds: (any two) (8L)**
   (i) Calcium chloride in water (ii) sodium chloride in water &
   (iii) glucose in water.

SECTION B (30 Hrs, 1 Credit)

1. **Boiling point diagrams for following compounds: (3 × 8 = 24 Hrs)**
   (i) Calcium chloride in water
   (ii) Sodium chloride in water and
   (iii) Glucose in water

2. **Phase diagram with three different concentrations for following mixture**
   (Ethanol + Water + toluene) **(3× 2 = 6 Hrs)**

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- To study definition of the various metallurgical processes & understanding the concept with suitable examples.
- To learn the extraction processes of various metals.
- To understand concepts in Adsorption, to learn about colloids, emulsions, micro emulsions, micelles & aerosols.
- To understand the concept of heat capacity and enthalpy changes upon dissolution of solids in liquids.
- To study about distillation process and understand the instrumentation.
- To study about absorption process and understand the instrumentation and equipments.
- To study about evaporation process and understand the instrumentation and equipment.
- To study about filtration process and understand the instrumentation and equipment.
- To learn about drying equipment and understand drying curve.
- To study concept of fluid flow and understand the equipment.

Practical

At the end of the course students will be able to

- To learn various methods to determine physical constants

REFERENCE BOOKS

Theory

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. UGC course material as prescribed by UGC.
4. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
5. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
6. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
7. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
8. P. L. Soni, Textbook of inorganic Chemistry, 20th revised edition.

Practical

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. UGC practical manual for experimental analysis

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CHC-102 **CORE COURSE**

Physical Chemistry and Organic Chemistry (Semester II)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A

- To define the terms and state laws involved in thermodynamics, thermochemistry and chemical equilibrium.
- To explain the concept of enthalpies of solution, buffer solutions.
- To derive the thermodynamic derivation of the law of chemical standard state, enthalpies of solution, chemical equilibrium and relationships between different equilibrium constants based on ideal gases.
- To solve numerical based on chemical energetics, chemical equilibrium and ionic equilibrium.

Section B

- To learn the preparation methods and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- To learn the various named reactions mentioned in the syllabus.
- To understand reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- To understand Benzyne mechanism with respect to aromatic nucleophilic substitution.
- To understand Pinacol-pinacolone rearrangement with mechanism.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory pH metry, thermochemistry
- To understand the mechanism of reactions involved in organic preparation experiments and develop hands on experience with reference to basic laboratory techniques required for organic preparations.

SYLLABUS

Theory: Number of hours: 60

Section A (Physical Chemistry- I)

1. Chemical Energetics (10 H)

Need of thermodynamics and the laws of thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

2. Chemical Equilibrium (8 H)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Definition of ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

3. Ionic Equilibria (12 H)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts.

Section B (Organic Chemistry – II)

4. Aromatic hydrocarbons (8 H)

Preparation (case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (case benzene): electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

5. Alkyl and Aryl Halides (8 H)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN_1, SN_2 and SN_i) reactions. Preparation: from alkenes and alcohols; reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation; Elimination vs substitution.

Aryl Halides Preparation: (chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions; Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$); Reactivity and Relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

6. Alcohols, Phenols, Ethers and Carbonyl Compounds (14 H)

Alcohols: Preparation: Preparation of 1°, 2°and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: oxidation of diols using HIO_4. Pinacol-Pinacolone rearrangement with mechanism.
Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten –Baumann Reaction.
Ethers (aliphatic and aromatic): Williamson's synthesis of ethers. Cleavage of ethers with HI.
Aldehydes and ketones (aliphatic and aromatic): (formaldehyde, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

PRACTICALS Number of hours: 60

Section A

1. Thermochemistry (Any three) (18 H)

i. Determination of heat capacity of the calorimeter.
ii. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
iii. Determination of enthalpy of ionization of acetic acid.
iv. Study of the solubility of benzoic acid in water and determination of ΔH.

2. Chemical Kinetics: (10 H)

i. To study the effect of nature of reactants on the rate of reactions
ii. Determination of relative strength between HCl and Urea hydrochloride for hydrolysis of methyl acetate Ionic equilibria.

3. pH measurements (2 H)

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using ph meter.

Section B

4. Preparations (30 H)

Mechanisms involved in the following reactions to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
Each preparation for

a. Bromination of Phenol/Aniline
b. Benzoylation of amines/phenols
c. 2,4-dinitrophenylhydrazone of benzaldehyde/acetophenone
d. Nitration of acetanilide to p-nitroacetanilide.
e. Oxime of Cyclohexanone

f. Chalcone from benzaldehyde and acetophenone
g. Iodoform from acetone

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Define the terms involved in chemical energetics, chemical equilibrium, ionic equilibrium and state the laws used in thermodynamics, thermochemical equilibrium .
- Describe enthalpy, buffer solutions, factors affecting ionization.
- Derive and use the equations thermochemistry, chemical equilibrium and ionic equillibria of to solve the numericals.
- Give methods of preparation and reactions of aromatic hydrocarbons, alkyl and aryl halides, phenols, ethers and carbonyl compounds.
- Identify and give the named reactions mentioned in the syllabus.
- Explain reactivity and relative strength of c-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.
- Explain benzyne mechanism with respect to aromatic nucleophilic substitution.

Practical

At the end of the course students will be able to

- Understand the concepts of thermochemistry, pH metry, chemical kinetics.
- Develop skills of working and set up of calorimeter.
- Solve numericals on and verify the graph of chemical kinetics
- Discuss the mechanisms involved in the organic preparation experiments.
- Develop skills of common laboratory techniques including recrystallisation, recording of melting point required for organic preparations and perform calculations for quantitative analysis.

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Section A

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2. J. N. Gurtu and AayushiGurtu, Undergraduate Physical Chemistry, Vol I, Vol II and Vol III Pragati Prakashan
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Section B

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2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition,2013.
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12. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.
13. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

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SEMESTER III

(INDUSTRIAL CHEMISTRY)

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ICC-103 **CORE COURSE**

General Industrial Chemistry III (Semester III)

Credits: 06 (Theory: 04 & Practical: 02)

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COURSE OBJECTIVES

- The knowledge of mechanical properties will reveal the importance in construction activities.
- Metals and alloys will give detailed information of ferrous and non-ferrous alloys and their applications in day-to-day life.
- Polymeric materials will give their importance and applications.
- Cement, glass and ceramics will inform about know-how of ceramic industry.
- Nitration, halogenation, sulphonation, and hydrolysis will equip the students with fundamental processes in organic chemistry with due emphasis to industrial chemistry.
- The instrumentation information will make the conscious practical hand.
- The practicals are expected to give exposure to the routine synthesis, analysis and further to boost research activities if undertaken.

SYLLABUS

Theory **Number of hours: 60**

Section A: Material Science

1. **Mechanical properties of materials and change with respect to temperature (3 H)**

2. **Polymeric materials (5 H)**
   Industrial Polymers – their constitution, chemical and physical properties. Industrial applications.

3. **Metals and alloys (8 H)**
   Important metals and alloys: iron, copper, nickel, and their alloys - Mechanical and chemical properties and their application.

4. **Cement (4 H)**
   Composition, Manufacturing processes (Dry and Wet), Types of cement, setting and hardening of cement.

5. Ceramics (5 H)
Introduction, Types (Conventional), Manufacturing processes, Applications, Refractories

6. Glass (5 H)
Manufacture (Tank and Pot Furnaces), Distinction between Tank and Pot Furnaces, physical and chemical properties, types of glasses, composition and applications.

Section B: Chemical Unit processes (30 Lectures)

7. Nitration (9 H)
Introduction – Nitrating agents. Kinetics and mechanism of nitration, Processes such as nitration of
(i) Paraffinic Hydrocarbons
(ii) Benzene to nitrobenzene and m- dinitrobenzene
(iii) Chlorobenzene to o – and p – nitrochlorobenzene
(iv) Acetanilide to p- nitroacetanilide.

8. Halogenation (7 H)
Reagents for halogenation. Halogenation of aromatics – side chain and nuclear halogenations. Commercial manufacture – Chlorobenzenes, monochloroacetic acid, Chloromethanes and dichlorofluromethane chloral.

9. Sulphonation (7 H)
Introduction – Sulphonating agents, chemical and physical factors in sulphonation, Kinetics and mechanism of sulphonation reaction. Commercial sulphonation of benzene, naphthalene, alkyl benzene, Batch vs continuous sulphonation.

10. Hydrolysis (2 H)
Introduction, hydrolyzing agents, mechanism of ester hydrolysis (Acid and Alkaline).

11. Temperature measuring instruments (5 H)
Principle, construction and working of following measuring instruments, Temperature glass thermometers, bimetallic thermometer, vapor filled Thermometer resistance thermometer radiation pyrometers.

PRACTICALS ***Number of hours: 60***

SECTION A (30 Hours)

1.	Measurement of dissolved CO_2.	(3 Hours)
2.	Estimation of Aluminum gravimetrically from Bauxite Ore	(3 Hours)
3.	Analysis of Brass (Volumetrically)	(4Hours).
4.	Estimation of chromium colorimetry or spectrophotometry	(4Hours)
5.	Estimation of Iron (Volumetrically) 2 expts	(4Hours)
6.	Rate of Corrosion w.r.t. Al and Fe plates	(6Hours)

7. Dissociation constant of acetic acid – conductometry (4Hours)
8. Percentage of available chlorine in bleaching powder. (2 Hours)

SECTION B (30 Hours)

1. Analysis of oils and fats (iodine value, saponification value, acid value). (4Hours)
2. Nitration
   i) Nitration of acetanilide (4Hours)
   ii) Nitration of nitrobenzene (4Hours)
3. Halogenation
   i) Preparation of p-bromoacetanilide (4Hours)
   ii) Preparationof 2, 4, 6- tribromophenol (3Hours)
4. Hydrolysis
   i) Hydrolysis of benzamide. (4Hours)
   ii) Hydrolysis of ethylbenzoate (4Hours)
5. Preparation of methyl orange. (3Hours)

LEARNING OUTCOMES

Theory

- To understand the changes in mechanical properties of materials with respect to temperature.
- To describe about the Industrial Polymers, their constitution, chemical and physical properties and their applications.
- To describe about various important metals and alloys and also about their properties and applications.
- To describe about the composition, manufacturing process and types of cements.
- To describe about the types, manufacturing process and applications of ceramics.
- To understand the Manufacturing, applications, physical and chemical properties, and types of glasses.
- To describe about the Nitration process, various nitrating agents, kinetics and mechanism and various nitration reactions.
- To understand about the Halogenation process, reagents, and Commercial Manufacture.
- To explain about the Sulphonation process, sulphonating agents, chemical and physical factors, Kinetics and Mechanism of sulphonation and Commercial Sulphonation.
- To describe about the Hydrolysis process, hydrolysing agents, and mechanism.
- To discuss about the Principle, construction and working of various temperature measuring instruments.

Practical

- To Learn about the estimation of metals and alloys gravimetrically, volumetrically, or by colorimetry or spectrophotometry.
- To study the dissociation constant by use of conductometry.
- To study about the Rate of corrosion with respect to Aluminium and Iron plates
- To study the various reactions like Nitration, Halogenation and Hydrolysis.

- To learn about the analysis of Iodine value, saponification value and acid value.

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Theory

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2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
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6. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

Practical

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. S.W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000.
4. Sunita Rattan, Experiments in Applied Chemistry, S.K. Kataria & Sons, Second edition, 2008
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. UGC practical manual for experimental analysis.

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CHC-103 **CORE COURSE**

Physical Chemistry and Organic Chemistry (Semester III)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A (Physical Chemistry)

- To understand the difference between ideal and non-ideal solutions.
- To study phase diagrams of various systems and to apply the phase rule equation.
- To study the conductance of strong and weak electrolytes.
- To study reversible and irreversible cells and measurement of EMF.
- To solve the numerical problems based on standard electrode potentials and conductance measurement of solutions.

Section B (Organic Chemistry)

- To learn the preparation/synthesis and reactions of carboxylic acids and their derivatives, amines, diazonium salts, amino acids and simple peptides.
- To understand the mechanism of reactions.
- To compare Hofmann and Saytzeff elimination.
- To learn and remember the terms involved such as zwitterion, isoelectric point, electrophoresis with examples.
- To learn the laws, the terms involved and the principles in UV –Visible spectroscopy.
- To study various electronic transitions, λmax and effect of conjugation on colour.
- To know Woodward-Fieser rules for calculation of λmax for conjugated dienes and α, β unsaturated carbonyl compounds.
- To acquire knowledge to distinguish between *cis* and *trans* isomers using UV –Visible Spectroscopy
- To know classification of carbohydrates and their general properties.
- To know the open chain and cyclic structure of Glucose and Fructose.
- To gain knowledge of determining the configuration of monosaccharides.
- To study the terms involved with examples.
- To learn the synthesis involved.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory. (phase equilibria, conductometry and potentiometry)
- To get hands on experience for the preparation of derivatives.
- To gain knowledge of analyzing organic compounds.
- To learn to perform estimations.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. **Solutions (7 H)**
   Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Azeotropes. Partial miscibility of liquids: Critical solution temperature, distillation and fractional distillation.

2. **Phase Equilibrium (8 H)**
   Phases, components and degrees of freedom of a system, criteria of phase Equilibrium. Phase diagrams of one-component systems (water, sulphur and CO_2) Component and two systems involving eutectics, congruent and incongruent melting points (Zn-Mg, NaCl-H_2O).

3. **Conductance (5 H)**
   Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Ionic mobility and factors affecting ionic mobility. Transference number and its experimental determination using moving boundary methods. Applications of conductance water, measurements: solubility and solubility products of sparingly soluble salts, ionic product of conductometric titrations (only acid-base).

4. **Electrochemistry (7 H)**
   Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using a hydrogen electrode and quinhydrone electrode.

Section B

5. **Carboxylic acids and their derivatives (10 H)**
   Carboxylic acids (aliphatic and aromatic); Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell - Volhard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversions, Reactions: Comparative study of the

nucleophilicity of acyl derivatives. Reformatsky reaction, Perkin condensation (mechanism).

6. Amines and Diazonium Salts (6 H)

Amines (aliphatic and aromatic): (upto 5 carbons) Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (Hofmann rearrangement).

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann reaction. Electrophilic substitution (case aniline): nitration,bromination, sulphonation.

Diazonium salts: Preparation from aromatic amines, conversion to benzene, phenol, dyes.

7. Amino Acids and Peptides (6 H)

Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis.

Terms: Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: Ester of – COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

8. UV –Visible Spectroscopy in Organic Chemistry (6 H)

Introduction to spectroscopy:

UV Spectroscopy: Beer-Lambert's law, Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption.

Visible Spectroscopy: Effect of conjugation on colour. Application of Woodward - Fieser rules for calculation of λmax for the following systems: α, β unsaturated aldehydes, ketones. Conjugated dienes: alicyclic, homoannular and heteroannular, extended conjugated systems (aldehydes, ketones and dienes). Distinction between cis and trans isomers.

9. Carbohydrates (8 H)

Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, Osazone formation, Killiani Fischer synthesis.

PRACTICALS Number of hours: 60

Section A (PHYSICAL CHEMISTRY)

Phase Equilibria (10 H)

1. To draw the phase diagram of the binary system - diphenyl amine and α – Naphthol and find the eutectic temperature.
2. Study the mutual solubility of phenol and water at various temperatures and hence determine the critical solution temperature.
3. Study the effect of addition of NaCl on critical solution temperature of phenol water system and study of the effect of impurities on it.

Conductance (8 H)

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base

Potentiometry (12 H)

Potentiometric titrations

i. Strong acid vs. strong base (Quinhydrone method)
ii. Potassium dichromate vs. Ferrous Ammonium sulphate

Section B (ORGANIC CHEMISTRY)

1. **Systematic Qualitative Organic Analysis (12 H)**
   Analysis of Organic Compounds possessing monofunctional groups (carboxylic, aldehyde, ketone, amide, nitro, amines) and preparation of one derivative of each group. (Analysis of single compound and its derivative preparation) ethylacetoacetate.

2. **Organic Preparations: (14 H)**
   Synthesis, yield, recrystallisation and Melting Point.
   i. Hippuric acid from glycine (Benzoylation-Schotten Baumann reaction) (4 Hours)
   ii. Osazone from Glucose (Nucleophilic addition) (2 Hours)
   iii. Phthalic acid to Phthalic Anhydride to Phthalimide (4 Hours)
   iv. Preparation of Azo dye (4 Hours)

3. **Organic Estimations: (**Any 2**) (4 H)**
   i. Estimation of glycine by formylation method (2 Hours)
   ii. Estimation of Glucose by oxidation (2 Hours)
   iii. Estimation of Acetamide by hydrolysis

LEARNING OUTCOMES

Theory

At the end of the course students will be able to:

- Define the terms involved in Phase Equilibria, Solutions, Conductance and Electrochemistry.
- State the Raoult's Law and the Kohlrausch's law of independent migration of ions.
- Draw the schematic diagrams of instruments used in Conductance and Electrochemistry.
- Interpret the graphs based on Raoult;s law and in Conductometric titrations.
- Define and explain the terms involved giving examples.
- Describe the preparation of various compounds involved.
- Classify carbohydrates.
- Draw the structures of carbohydrates.

- Predict and compare the mechanism of reactions involved.
- Explain and propose the mechanism of similar reactions.
- Predict the products, intermediates, reactants and reaction conditions for a given chemical reaction.
- State the laws involved in UV –Visible Spectroscopy and will be able to distinguish between cis and trans isomers.
- Calculate λmax for Conjugated dienes and α, β unsaturated carbonyl compounds using Woodward–Fieser rules which will help them to predict the structure of organic compound with the help of other spectroscopic data.

Practical

At the end of the course students will be able to

- Understand the concepts of phase equilibria, conductometric titration and potentiometric
- Develop skills of working and carrying out conductometric and potentiometric titrations.
- Draw Phase equilibria curve, Conductometric and Potentiometric titration curves.
- Perform reactions and prepare derivatives.
- Develop skills of identification and analysis of organic compounds at microscale level.
- Carry out organic estimations by formylation, oxidation and hydrolysis.

REFERENCE BOOKS

Theory

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2. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009)
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12. Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India
13. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds.

Practical

Physical Chemistry

1. Systematic experimental physical Chemistry by S.W. Rajbhoj, Dr. T. K. Chondhekar, Anjali Publication, Aurangabad.
2. Practical Chemistry by O.P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication
3. Khosla, B. D., Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Organic Chemistry

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

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ICS-101 **Skill Enhancement Course**

Entrepreneurship Development Course - I (Semester III)

Credits: 04 (Theory: 04)

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THEORY COURSE OBJECTIVES

- To expose students to entrepreneurship and to develop skills to be effective businessmen and to identify areas of utmost importance in the starting and managing of the business.
- The topics such as Entrepreneur, Types of Businesses and Industries, and Identification and Evaluation of Business Opportunities will give the exposure to the theoretical principles practical approaches.
- Market Surveys and Feasibility Studies will give them opening to the technologies used in economics.
- Venturing Methods, Financial Incentives and Promotional Schemes of the Government of India and Government of Goa and Financial Procedures, project report will teach them different schemes, fund raising methods and make them capable to start new industry.

SYLLABUS

Theory: **Number of hours: 60**

1. **Entrepreneur (7 H)**
   Entrepreneurship and Enterprise; achievement motive; need for and characteristics of Entrepreneurship; role and functions of entrepreneurs.

2. **Types of Businesses and Industries (5 H)**
   Extraction, Manufacturing and Services; Demand-based and Resources-based; Import substitution and Export-promotion Businesses.

3. **Identification and Evaluation of Business Opportunities (10 H)**
   Porter's Five Forces Analysis (Market Structure Analysis); The SWOT technique: analysis of strengths, weaknesses, opportunities and threats.

4. **Market Surveys and Feasibility Studies (8 H)**
   Choice of Technology, Plant and Equipment.

5. **Venturing Methods (10 H)**
   Ownership patterns; legal requirements pertaining to the setting up of business.

6. **Financial Incentives and Promotional Schemes of the Government of India and Government of Goa (5H)**

7. **Financial Procedures (8L)**
   Funds and Funding; Institutions and Entrepreneurship Support Systems.

8. **Purpose and Components of a Business Plan / Project Report (7 L)**

LEARNING OUTCOMES

The students are expected to develop their own skills with regards to the preparation of budget, Fund raising methods, the concerned laws which are helpful for the smooth functioning of the system.

REFERENCE BOOKS

1. Adam, Everette (1997), Production and Operations Management, Prentice Hall India, New Delhi; Baker, Michael J. (1996), Marketing: An Introductory Text, Macmillan, London.
2. Colombo Plan Staff College for Technical Education, Manila (1999): Entrepreneurship Development, Tata McGraw Hill, New Delhi.
3. Chandra, Prasana (1995), Projects: Planning, Analysis, Selection, Implementation.
4. Davies, M. M.; Aquilano N. J.; Chase R. B. (1999), Fundamentals of Operations Management, Irwin-McGraw Hill, Boston.
5. Dessai, Vasant (1996), Dynamics of Entrepreneurial Development and Management, Himalaya, Mumbai.
6. Government of Goa, Daman and Diu (Law and Judiciary Department): The Goa, Daman and Diu Shops and Establishments Act,1973.
7. Horngren, Charles (1997), Cost Accounting- A Managerial Emphasis, Prentice Hall India, New Delhi.
8. Kuriloff, A. H.; Hemphill J. M. (1988), Starting and Managing the Small Business, McGraw Hill, New York.
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11. Kossek, Ellen Ernst; Block Richard N. (2000), Managing Human Resources in the 21st Century: From Core Concepts to Strategic Choice, South-Western College Publishing, USA.
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14. Patel, J. B.; Modi S. S. (1995), A Manual on Business Opportunity Identification and Selection, Entrepreneurship Development Institute of India, Ahmedabad.
15. Pandey, I. M. (1998), Management Accounting, Vikas, New Delhi.
16. Pandey, G. N. (1995), A Complete Guide to Successful Entrepreneurship, Vikas, New Delhi.

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SEMESTER IV

(INDUSTRIAL CHEMISTRY)

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ICC-104 **CORE COURSE**

General Industrial Chemistry IV
(Semester IV)

Credits: 06 (Theory: 04 & Practical: 02)

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COURSE OBJECTIVES

- The general awareness of the environment in which we live is given importance in terms segments of environment, air pollution, water pollution, pesticide pollution, radiation pollution and noise pollution. It is expected to create the responsible citizens for future.
- The effluent treatment analysis will highlight the scarcity of water and importance to recycle it.
- Solid waste disposal, safety limits for industry and the methods for evaluation of pollutants will make the more literate citizens to overcome the menace of pollution.
- The organic processes like alkylation, esterification, amination, hydrogenation, oxidation is expected to be used in all advanced chemical industries.
- The various instruments used for the measurement of different physical properties will give their applications in chemical industries.
- The practicals will give the exposure to the all-theoretical principles in industrial chemistry.

SYLLABUS

Theory: **Number of hours: 60**

Section A: Material Science (30 Lectures)

1. Segments of environment (5 H)

Air, Oxygen, nitrogen cycle, water, Biosphere, Flora and Fauna, Energy, Soil.

2. Types of Pollution (5 H)

(i) Various pollutants
(ii) Air Pollution – Green House Effect.
(iii) Water pollution – Organic /Inorganic pollutants Sewage analysis
(iv) Pesticide pollution
(v) Radiation pollution,
(vi) Noise pollution

3. Effluent treatment (5 H)

Wastewater treatment methods,

Physical: i) sedimentation, (Clarification),
ii) Filtration etc.

Chemical: i) Disinfection: Chlorination, UV-radiation, Ozonation
ii) Coagulation
iii) adsorption
iv) Oxidation

Biological: i) Aerobic treatment and its mechanism
ii) Anaerobic treatment and its mechanism

4. Bag filters, electrostatic precipitators, mist eliminators, wet scrubbers, Absorbers (6 H)

5. Solid Waste Management (4 H)

6. Industrial safety w. r. t. Chemical hazards (3 H)

7. Pollutants and their statutory limits. Pollution evaluation methods (2 H)

Section B: Chemical Unit processes and instrumentation (30 Lectures)

8. Alkylation (3 H)

Introduction; types of alkylation, Alkylating agents, Thermodynamics and mechanism of alkylation reactions. Manufacture of alkyl benzenes (for detergents), ethyl benzene.

9. Esterification (3 H)

Introduction, Hydrodynamics and Kinetics of esterification reactions, Esterification by organic acids, by addition of unsaturated compounds, esterification of carboxyl acid derivatives, commercial manufacture of ethyl acetate, cellulose acetate.

10. Amination (6 H)

(a) By reduction: Introduction, Methods of reduction – metal and acid catalytic, electrolytic, metal and alkali sulfites, metal hydrides, sodium metal, concentrated caustic oxidation, reduction, Commercial manufacture of aniline, m – nitroaniline.

(b) By aminolysis: Introduction, ammoniating agents, factors affecting aminolysis, manufacture of monomethylaniline

11. Hydrogenation (6 H)

Introduction – Kinetics and thermodynamics of hydrogenation reactions, catalysts for hydrogenation reactions, Hydrogenation of vegetable oil, Manufacture of methanol from carbon monoxide and hydrogen, hydrogenation of acids and esters to alcohol, catalytic reforming.

12. Oxidation (6 H)

Introduction – Types of oxidation reactions, oxidizing agents,

Liquid phase oxidation, vapor phase oxidation; Commercial manufacture of benzoic acid, maleic anhydride, phthalic anhydride, acrolein, acetaldehyde and acetic acid.

13. Pressure measuring instruments (6 H)

Manometers, barometers, bourdon pressure gauge: bellow type, diaphragm type pressure gauges, Macleod gauges, Pirani gauges, etc. Liquids level measuring instrument: direct – indirect liquid level measurement, Float type liquid level gauge, ultrasonic level gauges; viscosity measurement.

PRACTICALS — Number of hours: 30

SECTION A (30 Hours)

One experiment each on following in a given water sample. (3×10 =30 Hours)

1. Determination of solids content.
2. Determination of Hardness.
3. Determination of acidity.
4. Determination of Alkalinity.
5. Determination of dissolved oxygen
6. Determination of BOD.
7. Determination of COD.
8. Determination of mixture of halide potentiometrically.
9. Estimation of Available Oxygen in Hydrogen Peroxide.
10. Determination of alkali in water samples and soaps.

SECTION B (30 Hours)

1. Esterification: benzocaine (4 Hours)
2. Oxidation: p-nitrobenzoic acid, benzyl anthraquinone. 2 expts. (2×4 = 8Hours)
3. Reduction: p- aminobenzoic acid, m-nitroaniline. (3 Hours)
4. Preparation of o –chlorobenzoic acid (3 Hours)
5. Preparation of o–benzoyl benzoic acid. (4 Hours)
6. Estimation of glucose in food samples. (4 Hours)
7. Preparation of soap. (4 Hours)

LEARNING OUTCOMES

Theory

- To learn about various segments of environment.
- To describe about various types of pollutions.
- To learn about various wastewater treatment methods i.e., Physical, Chemical and Biological methods.
- To explain about the various types of pollution control devices and statutory limits of pollutants.
- To understand about the solid waste management and Industrial safety with respect to chemical hazards.
- To understand the Alkylation process, Types, Alkylating agents, Thermodynamics, Mechanism and Commercial Manufacture.

- To understand the Esterification process, Kinetics, Types of reactions and Commercial Manufacture
- To learn about amination process by reduction and by aminolysis, methods, factors affecting and commercial manufacture.
- To discuss about the hydrogenation process, kinetics, thermodynamics, catalysts used and Commercial manufacture
- To discuss about the oxidation process, types and commercial manufacture.
- To explain about the various pressure measuring instruments along with the types of measurements.

Practical

- To learn about determination of various factors like BOD, COD, Dissolved Oxygen, Hardness, Acidity, Solid content, Alkalinity, etc.
- To learn about various reactions like Esterification, Oxidation, Reduction, etc.
- To explain how to estimate the amount of glucose in food samples.

REFERENCE BOOKS

Theory

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F. A., Wilkinson, G. & Gaus, P. L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. UGC course material as prescribed by UGC.
4. Finar, I.BL. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

Practical

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000.
4. Sunita Rattan, Experiments in Applied Chemistry, S. K. Kataria & Sons, Second edition, 2008.
5. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. UGC practical manual for experimental analysis

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CHC-104 **CORE CORSE**

Physical Chemistry and Organic Chemistry (Semester IV)

Credits: 06 (Theory: 04 & Practical: 02)

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THOERY COURSE OBJECTIVES

Section A –Physical Chemistry

- To study the postulates of kinetic theory of gases and understand the deviations of real gases from ideal behaviour.
- To understand properties of liquids such as surface tension and viscosity and the methods to measure them.
- To study the structures of cubic crystals and the laws explaining their structure.
- To understand rates of chemical reactions of zero, first and second orders.
- To apply reaction rate theories for chemical reactions.

Section B-Inorganic Chemistry

- To understand electronic configuration, variable valency, color, magnetic and catalytic properties of 3d series.
- To understand the complexing ability and stability of various oxidation states (Latimer diagrams) for Mn, Fe, and Cu.
- To understand electronic configurations, oxidation states, color, magnetic properties of lanthanides.
- To explain lanthanide contraction, separation of lanthanides (ion exchange method only).
- To understand the IUPAC system of nomenclature for coordination compounds.
- To understand the bonding in complexes using valence bond theory.
- To study the different types of isomerism's associated with coordination compounds.
- To understand the factors affecting the magnitude of 10Dq.
- To study the effect of strong field and weak field ligands on CFSE.
- To study crystal field splitting in tetrahedral and octahedral complexes and to calculate CFSE.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory.
- To systematically analyse the cations and anions in a given mixture.

- To quantitatively estimate several metal ions using the gravimetric and volumetric techniques.
- To determine the concentration of coloured compounds using the colorimetric technique.

SYLLABUS

Theory: **Number of hours: 60**

Section A

1. Kinetic Theory of Gases (8H)

Postulates of Kinetic Theory of Gases, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrew's isotherms for CO2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation), collision number, collision frequency, collision diameter and mean free path of molecules.

2. Liquids (6 H)

Surface tension and its determination using stalagmometer. Effect of temperature on surface tension. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer and factors affecting viscosity.

3. Solids (8 H)

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice. Laws of crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices, X–Ray diffraction by crystals, Bragg's law. Particle size determination using powder method. Structures of NaCl, KCl and CsCl (qualitative treatment only)

4. Chemical Kinetics (8 H)

The concept of reaction rates. Effect of temperature, pressure and catalyst on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions.

Section B

5. Transition Elements (10 H)

General characteristic properties of 3d series with special reference to electronic configuration, variable valency, color, magnetic and catalytic properties. Ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe, and Cu. Lanthanides: Electronic configurations, oxidation states, color, magnetic properties,

lanthanide contraction, separation of lanthanides (ion exchange method only). Actinides: Electronic configuration and general characteristics.

6. Coordination Chemistry (10 H)

IUPAC system of nomenclature. Bonding in complexes based on Valence Bond Theory (VBT), Inner and outer orbital complexes of Cr, Fe, Co, Ni, and Cu (coordination numbers 4 and 6). Different types of structural and stereo-isomerism including optical isomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT.

7. Crystal Field Theory (10 H)

Crystal field splitting in octahedral complexes. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Spectrochemical series. Crystal Field Splitting in Tetrahedral complexes. Calculation of CFSE. Comparison of CFSE for Oh and Td complexes. Factors affecting the magnitude of 10Dq. Merits and Demerits of Crystal Field Theory.

PRACTICALS Number of hours: 60

Section A (Physical Chemistry)

1. Surface Tension measurement (4 H)

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

II. Solutions of Solids in Liquids (4 H)

Determine solubility curve for KCl from 25^0C to 50^0C.

III. Viscosity measurement (10 H)

a. Determination of the viscosity of a liquid or dilute solution using an Ostwald's viscometer.
b. Study of the variation of viscosity of an aqueous solution with concentration of solute.

IV. Chemical Kinetics (12 H)

a. To determine the rate constant and order of reaction between KI and $K_2S_2O_8$.
b. Study of saponification of ethyl acetate with sodium hydroxide at equal concentration of ester and alkali.
c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Section B (Inorganic Chemistry)

I. Semi-micro qualitative analysis: not more than four ionic species (two anions and two cations): (4 Mixtures) (12 H)

Cations: NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+.

Anions:

CO_3^{2-}, S^{2-}, SO^{2-}, SO_4^{2-}, NO_3^-, Cl^-, Br^-, I^-, NO_2^-, PO_4^{3-}, F^-

II. Gravimetric/Volumetric (12 H)

1. Estimate the amount of Nickel present in a given solution as bis (dimethylglyoximato) Nickel(II) gravimetrically by counterpoise filter paper.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. To estimate the amount of Bismuth present in the given solution of $Bi(NO_3)_2.3H_2O$ by complexometric titration.
4. To estimate the amount of Nitrite present in the given $NaNO_2$ solution by titrating v/s Ceric ammonium sulphate /Ceric sulphate.

III. Colorimetric Experiments (6 H)

1. Draw calibration curve (absorbance at λ_{max} v/s concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
2. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.

LEARNING OUTCOMES:

Theory

Section A: Physical Chemistry

At the end of the course students will be able to:

- Define the terms involved in Kinetic Theory of Gases, Liquids, Solids, and Chemical Kinetics.
- Draw the schematic diagrams of stalagmometer, Ostwald viscometer and cubic crystal structures.
- Draw the graphs for first order and second order reactions.
- Explain the terms involved like unit cell, space lattice, activation enery, surface tension, viscosity, average velocity, root mean square velocity.

Section B: Inorganic Chemistry

- Explain general characteristics and electronic configuration of 3d Lanthanide and Actinide elements.
- Explain oxidation states, colour, and magnetic properties of 3d and lanthanide elements.
- Understand the Latimer diagram for Mn, Fe, and Cu.
- Name coordination compounds using IUPAC nomenclature.
- Explain inner and outer orbital complexes.
- Identify the different types of isomerism's associated with coordination complexes.
- Calculate crystal field stabilization energy of coordination complexes. Understand the effect of strong field and weak field ligands on the crystal field splitting of coordination complexes.

Practicals

At the end of the course, students will be able to:

- Understand the concepts of surface tension, viscosity, and solubility.
- Develop skills for doing chemical kinetics titrations.
- Draw graphs and determine order of reactions.

- Understand on how to use a stalagmometer and Ostwald's viscometer.
- Develop skills in the identification and analysis of cations and anions.
- Perform gravimetric, volumetric and colorimetric experiments for quantitative interpretation of substances/metal ions.
- Carry out quantitative estimations of various metal ions.

REFERENCE BOOKS

Section A: Physical Chemistry

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R.
3. Chand & Co.: New Delhi (2011).
4. Systematic experimental physical Chemistry by S.W. Rajbhoj, Dr. T. K. Chondhekar, Anjali Publication.
5. Practical Chemistry by O.P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication.
6. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg, A. Gulati, R. Chand & Comp , New-Delhi

Section B: Inorganic Chemistry

1. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
2. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
3. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
4. Rodgers, G.E. Inorganic & Solid-State Chemistry, Cengage Learning India Ltd.,2008.
5. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
6. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
7. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
8. Principles of Inorganic chemistry by B.R. Puri, S. Sharma, and Kalia, Vallabh Publication.
9. Inorganic Chemistry Principles of Structure and Reactivity James E Huheey, Ellen A. Keiter, Richard L.Keiter, Okhil K Medhi

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ICS-102 **Skill Enhancement Course**

Entrepreneurship Development Course - II (Semester IV)

Credits: 04 (Theory: 04)

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THEORY COURSE OBJECTIVES

- To expose the students to accounting, marketing and financial system for starting, managing and running of the business.
- The topics 1 -6 emphasise the importance of costs, price, management, taxation and uncertainties which may occur in the business. Thus, the students should be ready to accept the probable challenges in the business.

SYLLABUS

Theory: **Number of hours: 60**

1. **Costs, Price, Profits and Book of Accounts (12 H)**
   Analysis of Costs and Costing Strategies; Market structures and Pricing Strategies; Cost-Volume-Profit Analysis. Financial Statements and Funds Flow Analysis.

2. **Elements of Marketing and Sales Management (10 H)**
   Marketing Channels; Marketing Mix and Role of Advertising; Nature of the Product/Service and Market Strategies.

3. **Management of Plant and Equipment; Management of Materials; Inventory Control Strategies. Management of Human Resources (15 H)**
   Importance and Scope of Human Resources Management.

4. **Important provisions of Shops and Establishments Act; Factories Act; Sale of Goods Act (5 H)**

5. **Taxation and Entrepreneurship (8 H)**
   Income Tax: Value Added Tax (Sales Tax, Central Excise); Customs Duties.

6. **Coping with Uncertainty; Stress Management and Positive Reinforcement. Social Responsibility of Business and Business Ethics (10 H)**

LEARNING OUTCOMES

- The students are expected to meet the requirement of the installation of industry, its management, with sufficient exposure to the rules and regulations of concerned industries.
- Since they are trained to face the probable difficulties and challenges, they should not lose the sincerity and steadfastness in the accepted venture.

REFERENCE BOOKS

1. Adam, Everette (1997), Production and Operations Management, Prentice Hall India, New Delhi.
2. Baker, Michael J. (1996), Marketing: An Introductory Text, Macmillan, London.
3. Colombo Plan Staff College for Technical Education, Manila (1999): Entrepreneurship Development, Tata McGraw Hill, New Delhi.
4. Chandra, Prasana (1995), Projects: Planning, Analysis, Selection, Implementation & Review, Tata McGraw Hill, New Delhi.
5. Davies M. M.; Aquilano N. J.; Chase R. B. (1999), Fundamentals of Operations Management, Irwin-McGraw Hill, Boston.
6. Dessai, Vasant (1996), Dynamics of Entrepreneurial Development and Management, Himalaya, Mumbai.
4. Government of Goa, Daman and Diu (Law and Judiciary Department) (1973): The Goa, Daman and Diu Shops and Establishments Act.
5. Horngren, Charles (1997), Cost Accounting: A Managerial Emphasis, Prentice Hall India, New Delhi.
6. Kuriloff, A. H.; Hemphill J. M. (1988), Starting and Managing the Small Business, McGraw Hill, New York.
7. Kazmi, Azhar (1997), Business Policy, Tata McGraw Hill, New Delhi.
8. Kotler, Philip (1997), Marketing Management, Prentice Hall India, New Delhi.
9. Kossek, Ellen Ernst; Block Richard N. (2000), Managing Human Resources in the 21st Century: From Core Concepts to strategic Choice, South-Western College Publishing, USA.
10. Kanka, S. S. (2005), Entrepreneurship Development, S. Chand, New Delhi.
11. Mishra, S. K. (2002), Labour and Industrial Law, Allahabad Law agency, Faridabad (Haryana).
12. Patel, J. B.; Modi S. S. (1995), A Manual on Business Opportunity Identification and Selection, Entrepreneurship Development Institute of India, Ahmedabad.
13. Pandey, I. M. (1998), Management Accounting, Vikas, New Delhi.
14. Pandey, G. N. (1995), A Complete Guide to Successful Entrepreneurship, Vikas, N.

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SEMESTER

V

(INDUSTRIAL CHEMISTRY)

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ICD-101 **Discipline Specific Elective**

Industrial Chemical Analysis (Semester V)

Credits: 04 (Theory: 03 & Practical: 01)

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COURSE OBJECTIVES

- Infra-red spectroscopy, and NMR spectroscopy are the essential methods for qualitative analysis and can be used very widely in all analytical procedures,
- Thermal methods such as thermogravimetric (TG), Derivative thermogravimetric analysis (DTG), Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC) are the modern techniques to study thermal effects.
- Nephelometry, turbidimetry and polarimetry are the analytical tools, which are required depending upon the nature of the substances.
- Food chemistry elaborately involves, different colours, preservatives, fruit beverages and appetizers give exposure to the food chemistry as an industry.
- Soap and detergents briefly inform about eco-friendly detergents and bio-degradable surfactants.
- Different kinds of organic estimations and two steps organic preparations will take care of minimum required skill in organic chemistry.

SYLLABUS

THEORY **No. of hours: 45**

1. Infra-Red Spectroscopy (7 H)

Principle of I.R. Spectroscopy (Hooke's law), types of molecular vibrations (Stretching and bending,). Functional group region and Fingerprint region. Applications of I. R. Spectroscopy: Functional group analysis, detection of purity of sample, establishing the identity of an unknown molecule, Effect of H-bonding.

2. Nuclear Magnetic Resonance Spectroscopy (8 H)

Basic Principles of 1H NMR spectroscopy, Number of signals, Position of signals, Chemical shift: Reference standard, Shielding and deshielding effect, anisotropic effects in aldehydes, Intensity of signals: Peak area and proton counting. Spin-Spin coupling: Coupling constant (J). Interpretation of NMR spectra of simple compounds. (acetone, acetaldehyde, toluene, ethyl bromide, anisole). Simple problems based on NMR spectral data for identification of molecule.

3. Thermoanalytical methods (8 H)

Basic principle, theory and applications of

i) Thermo gravimetric analysis (TG) with examples such as Ag_2CrO_4, Hg_2CrO_4, CaC_2O_4 and MgC_2O_4,

ii) Derivative thermogravimetric analysis (DTG),
iii) Differential thermal analysis (DTA),
iv) Differential scanning calorimetry (DSC).

4. Nephelometry and Turbidimetry (4H)

Light scattering, nephelometry and turbidimetry, choice between nephelometry and turbidimetry, theory, instrumentation, turbidimetric titrations, applications.

5. Polarimetry (3H)

Introduction, polarization of light, optical activity, specific rotation, factors affecting angle of rotation, polarimeter, types of molecules analysed by polarimetry, applications of optical activity.

6. Food Chemistry (10 H)

Colour chemicals used in food - soft drinks - and its health hazards Chemicals in food production - fertilizers used in natural sources - Fertilizers urea, NPK and Super phosphates need - user and hazards. Food Preservatives - definition - classification - Food Spoilage - definition - Prevention. Beverages - definition and examples - Classification of beverages Fruit beverages - Milk based beverages - malted beverages - examples. Alcoholic and non-alcoholic beverages - examples. Appetizers - definition - classification - examples - Water - functions and deficiency.

7. Soap and detergents (5 H)

Cleaning action of soap - Metal soaps - Oils used for Soaps. Classification of surface-active agents - Anionic detergents - Bio-degradability of surfactants - Eco-friendly detergents.

PRACTICALS

1. Organic Estimations:
    1. Saponification value of the oil
    2. Estimation of formaldehyde/acetone
    3. Estimation of phenol/Aniline
    4. Estimation of H2O2 and to find out percentage purity of H2O2

2, Two step organic preparations
    1. Anilne to acetanilide o p-bromoacetanilide
    2. Acetanilide to p-bromoacetanilide to p-bromoaniline
    3. Phthalic acid to phthalic anhydride to phthalimide
    4. p- Bromoacetanilide to p-bromoaniline to 1-bromo-4-iodobenzene
    5. Acetanilide to p-niroacetanilide to p-nitroaniline

LEARNING OUTCOMES

Theory

- IR spectroscopy and NMR spectroscopy are frequently used for determination of functional groups.

- Thermoanalytical methods are having applications in construction, polymers, pharmaceuticals etc.
- Nephelometry, turbidimetry and polarimetry are especially used in titrations and analysis of molecules for optically active substances.
- Food chemistry is expected to give exposure for applications in day-to-day life.

Practical

- Organic estimations and two step preparations are routinely used in all major and minor industries.

REFERENCE BOOKS

Theory

Textbooks

1. Instrumental methods of chemical analysis, B. K. Sharma, 30th edition (2015).
2. Instrumental methods of chemical analysis, Chatwal and Anand, 5th edition and onwards.

Reference Books:

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. P.S. Kalsi, Spectroscopy of Organic compounds, New Age International Pub. Ltd. & Wiley Eastern Ltd., Second edition, 1995.
3. Applications of Absorption Spectroscopy of Organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
4. Principles of instrumental analysis, F.J. Holler, D.A. Skoog, S. R. Crouch, 6th edition.
5. Food Science - III Edition - B. Sri Lakshmi - New age international publishers 2005.
6. Food chemistry Lillian Hoagland Meyer - CBS publishes & distributors - 2004.
7. Fundamentals of foods and nutrition - Mudambi. R.Sumathi, and Raja gopal, M.V. - Willey Eastern Ltd., Madras.
8. Applied chemistry - K. Bagavathi Sundari - MJP Publishers.

Practical

Textbook

1. UGC study material for practicals in Industrial Chemistry

Reference Books

1. A.I. Vogel, A.R. Tatchell, B. S. Furniss, A.J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Prentice Hall; 2011.
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
3. R.K. Bansal, Laboratory Manual in Organic Chemistry, New Age International, 5th Edition, 2016.

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CHD-101 **Discipline Specific Elective**

Basic Topics in Analytical Chemistry (Semester V)

Credits: 04 (Theory: 03 & Practical: 01)

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THOERY COURSE OBJECTIVES

- To define the terms involved in analytical chemistry, sampling techniques, data handling, chromatographic Techniques and electroanalytical methods.
- To explain scope and importance of analytical chemistry, different types of sampling and the types of solvent extractions.
- To classify different types of chromatographic techniques and errors with examples.
- To study the principles of volumetric analysis and gravimetric analysis and the basic principles of instrumentation of electrogravimetry, coulometry and polarographic analysis.
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments of electroanalytical methods.
- To draw the schematic diagrams of different electroanalytical methods.
- To solve numericals of evaluation of data and solvent extractions.
- To discuss the applications of different chromatographic techniques and electroanalytical methods.

PRACTICALS COURSE OBJECTIVES

- To understand and develop the problem-solving skills and hands on experience with reference to concepts studied in theory (ion exchange chromatography, colorimetry, statistical data).

SYLLABUS

Theory: **Number of hours: 60**

1. Introduction (3 H)

Scope and importance of analytical chemistry, chemical analysis and analytical chemistry. Classification of instrumental methods, analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results.

2. Quantitative analysis (8 H)

A. Principles of volumetric analysis: Theories of acid-base, redox, complexometric, iodometric and precipitation titrations - choice of indicators for these titrations.

B. Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition.

3. Sampling Techniques (4 H)

Terms encountered in sampling: the population or the universe, Sample, Sampling unit, increment, the gross sample, the sub sample, Analysis sample, Bulk ratio, Size to weight ratio, Random sampling, Systematic sampling, Multistage sampling, Sequential sampling. Sampling of Gases, Liquids and Solids. Preservation, storage and preparation of sample solution.

4. Evaluation of analytical data (10 H)

Significant figures and rounding off, accuracy and precision Errors: determinate and indeterminate error, constant and proportionate errors, minimization of errors. Measures of central tendency and dispersion. Standard deviation, Gaussian distribution curve and its characteristics, Histogram and Frequency polygon. Confidence limit. Test of significance: Students t, F test, Rejection of the results: 2.5d & 4d rule and Q test. Linear least squares and Method of averages (Numerical problems are expected to be solved)

5. Solvent Extraction (4 H)

Basic Principle, percentage extraction, role of complexing agents in solvent extraction, separation factor, types of extraction (continuous, batch) (Numerical problems are to be solved)

6. Chromatography (7 H)

Principles Classification of chromatographic techniques

1. Column chromatography: Principle, experimental details, theory of development, factors affecting column efficiency and applications.
2. Paper and thin layer chromatography: Principles, techniques and applications of paper and thin layer chromatography.
3. Ion exchange chromatography: Principles, classification of ion exchange materials, Nature of exchanging ions, Ion exchange capacity, applications in analytical chemistry.

7. Electroanalytical methods (9 H)

Electro gravimetric analysis: Introduction, principles, instrumentation, Electrolysis at constant current, apparatus, determination of copper by constant current electrolysis. Coulometry: Introduction, constant Current measuring device, Hydrogen-Oxygen coulometer, Silver coulometer. General characteristics of coulometric method, applications of coulometry in Neutralization, complexation, precipitation and redox titrations. Polarography: Introduction, Basic principles of instrumentation, Deposition potential, Dissolution potential, Polarization of electrode, Polarographic wave, Ilkovic equation, Supporting electrolytes, Interference of oxygen, Applications of polarography – inorganic and organic.

PRACTICALS Number of hours: 60

1. Determination of iron by salicylic acid by colorimetry.
2. Determination of nitrite in water by colorimetry.
3. Separation of organic compounds by TLC. (Demonstration)
4. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Magnesium with standard EDTA.
5. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Zinc with standard EDTA.
6. Estimation of Na^{+} in NaCl by cation exchange resin using standard NaOH.
7. Estimation of Ca in calcium tablet by oxalate method and titration with $KMnO_4$.
8. Determination of hardness of water by EDTA i.e. estimate Ca as $CaCO_3$ and report analysis in ppm. (The candidate should record more than 5 observations and carry out statistical analysis to find out mean, median, range, standard deviation, absolute error, relative error and possibly Q test.

LEARNING OUTCOMES

Theory

At the end of the course students will be able to

- Define the terms, state the laws and principles involved in involved in sampling techniques, data handling, chromatographic techniques, solvent extractions, volumetric analysis and gravimetric analysis.
- Explain sampling of liquid, solid and gases, different types of tests related to data handling, scope and importance of analytical chemistry.
- Draw and describe the basic components of instruments of electroanalytical methods.
- Classify and explain different types of errors, sampling and chromatographic techniques.
- Derive and use the equations of linear least squares and method of averages and solvent extraction to solve numerical.
- Interpret steps involved in chemical analysis.
- To discuss the applications of different chromatographic techniques and electroanalytical methods

Practical

At the end of the course students will be able to

- Understand the concepts based on ion exchange chromatography, colorimetry and to estimate acidic and basic radicals quantitatively.
- Develop skills to prepare different plates of thin layer chromatography.
- Solve numericals based on statistical data obtained from experimental results.

REFERENCE BOOKS

Textbooks

1. Baliga and Shetty, College Analytical Chemistry, 15th edition, Himalaya Publishing House, 2004.

2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, 5th Edn., Sheth Publishers Pvt. Ltd.

Reference Books

1. G. D. Christan Analytical Chemistry by, 5th edition Wiley publications.
2. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis 5th edition (reprint 2003), Himalaya publication.
3. Vogels Textbook of Quantitative Inorganic Analysis 4th edition ELBS.
4. Willard, Meritt and Dean. Instrumental Methods of Analysis.
5. Skoog and Leary, Principles of Analytical Chemistry 4th International edition.
6. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut.
7. Mendham, J. Vogel's Quantitative Chemical Analysis (6th Edition) Pearson.

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DSE-3A **DISCIPLINE SPECIFIC ELECTIVE**

Statistical Methods
(Semester V)

Credits: 04 (4 + 0)

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COURSE OBJECTIVES

- The students are to be introduced to some testing methods of hypothesis and theory involved in probability.
- This will help students to understand basic concepts from statistics and their applications.

SYLLABUS

Theory: **Number of hours: 60**

1. **Introduction and basic concepts of statistics (6 H)**
   Meaning and Scope, Definition of Statistics, Importance and scope of Statistics, Limitations of Statistics, Distrust of Statistics, Measures of central tendency and dispersions: mean, median, mode, variance, mean-deviation, quartile deviation, standard deviation. Introduction and basic concepts of statistics.

2. **Correlation and Regression Analysis (8 H)**
   Introduction. Karl Pearson's coefficient of Correlation, Rank correlation method. Regression Analysis.

3. **Theory of Probability (12 H)**
   Introduction, Mathematical probability, Statistical probability, Axiomatic probability, Addition theorem of probability. (Proof omitted), Multiplication theorem of probability. Pair wise and mutual independence, Inverse probability – Baye's theorem.
   Random Variables: Probability Distributions and Mathematical Expectation, Random variable, Probability distribution of a Discrete Random Variable, Probability distribution of a Continuous random variable, Mathematical Expectations.

4. **Theoretical Distributions (6 H)**
   Binomial distribution, Poisson Distribution, Normal Distribution and their properties

5. **Sampling theory-I (14 H)**
   Testing of Hypothesis: Interval Estimation, Testing of Hypothesis for single mean and difference of means using "t-test" and paired "t-test"; Large sample tests: Introduction, Sampling of Attributes, Sampling of Variables, Z test, F test.

6. Sampling theory-II (14 H)

Parametric tests, ANOVA, Post-hoc analysis, Non-Parametric tests: Chi Square test, Mann-Whitney test, Kruskal wallis test.

LEARNING OUTCOMES

At the end of the course students will be able to

- Find measures of central tendency and measures of dispersion.
- Test a given hypothesis.

REFERENCE BOOKS

1. Fundamentals of Statistics, S.C Gupta, Himalaya Publishing House, Seventh Edition.
2. Fundamentals of Mathematical Statistics, S. C. Gupta, V. K. Kapoor, S. Chand Publications.
3. Mathematical Statistics, J. N. Kapur, H. C. Saxena, S. Chand Publications.
4. Probability Theory, B. R. Bhat, New Age International, 2007.

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ICS-103 **Skill Enhancement Course**

ECONOMICS AND INDUSTRIAL ORGANIZATION (Semester V)

(04 Credits: Theory – 03, On-job-training – 01)

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THEORY COURSE OBJECTIVE

- Since for semester III and IV the basics of economics with regards to the Entrepreneurship Development Course are covered, therefore for Semester V, emphasis is given on the further discussion on the same points with respect to detailed study.

SYLLABUS

Theory **No. of hours: 45**

1. **A) Factors involved in project cost estimation (5 H)**
   Meaning, process, features and importance of project cost estimation/capital budgeting – 5 factors involved in project cost estimation/capital budgeting.
   B) Methods employed for the estimation of capital investment
   Discounted cash flow methods (Three)
   Non-discounted cash flow methods (Two)
   N.B: Problems may be solved on payback method.

2. **Elements of cost accounting (2 H)**
   3 elements of cost accounting.

3. **Interest and investment costs (2 H)**
   Simple and compound interest
   Time value of money equivalence - discounting principle.

4. **A) Some aspects of marketing (3 H)**
   Meaning of marketing.
   B) Industrial v/s consumer marketing
   Distinction between the two.
   C) Pricing policy and types of price policies
   Meaning and types of price policies.

5. **A) Depreciation and methods of determining depreciation (4 H)**
   Meaning of depreciation - explanation and problems on uniform charge methods and declining charge methods.

B) Taxes and types of taxes
Meaning of a tax, characteristics, concept of direct and indirect taxes

6. **A) Profitability criteria (3 H)**
Explanation of cost-volume profit analysis
B) Economics of selecting alternatives
Economic analysis of selecting alternatives via the cost benefit analysis.

7. **A) Variation of cost with capacity (6 H)**
Variation of cost with capacity - meaning of flexible budgeting, construction of a flexible budget
B) Break-even point
Meaning, calculation and charts depicting break-even point, explanation of the safety margin (calculation of BEP in units and value)
C) Optimum batch size
Batch costing, Economic Batch Quantity (EBQ) and problems based on EBQ
D) Production scheduling
Steps in Production Planning and Control (PPC); meaning of master scheduling.

8. **Introduction to management (3 H)**
Meaning and characteristics of management; scientific management: concept and features.

9. **Functions of Management (5 H)**
A) Planning
Meaning of planning, process of planning; limitations of planning.
B) Organizing
Concept of organizing, organization charts (meaning and types); concepts of authority, responsibility and accountability; concepts of centralization and decentralization.
C) Directing
Meaning of directing; leadership: meaning, characteristics and functions, communication – concept and elements; process of communication; forms of communication; motivation - meaning and importance.
D) Controlling: concept of control; process of control

10. **Location of Industry (2 H)**
Meaning of industrial location and factors determining the location of an industrial unit.

11. **Materials Management and Inventory Control (5 H)**
Concept and objectives of materials management; purchasing function; storage of materials; concept of inventory control; techniques of inventory control – economic order quantity, fixation of different stock levels, always better control (ABC), VED analysis.

12. **Human Resources Management (5 H)**
Concept of Human Resources Management (HRM)
A) Recruitment: Meaning and sources (methods) of recruitment.
B) Selection: Meaning and process of selection.
C) Incentives: Meaning and types of incentives.
D) Employee Welfare

Meaning of employee (labour) welfare; types of welfare activities.

E) Safety

Meaning of Industrial safety; industrial hazards and accidents; safety programme.

ON JOB TRAINING – (01 Credit) (25 Marks)

Internal examiner (Course coordinator) 12 Marks

Break up	Marks
Project report	04
Industrial visit/field work/library work/practical work	03
Attendance/lectures/presentation/meetings	03
Record of lib. work/field work	02
	12
External examiner	13 Marks
Total:	**25 Marks**

Note: Factory personnel /person in charge of the training will assess the student depending on the performance or efficiency of a student to accomplish the given.

LEARNING OUTCOMES

Theory

- The students are expected to become expert as an entrepreneur, taxation rules, laws existing in a state of Goa, the calculated difficulties and actual difficulties and making the bridge between them and solving the incidental problems.

Practicals: On-Job-Training

- When the students are going for 60 days mandatory training in different factories/industries, they are given a job of preparation of budget, its practical calculations, and at last execution.

REFERENCE BOOKS

Theory

Textbooks:

1. I. M. Pandey, Financial Management, 8th Edition (2002), Vikas Publishing House Pvt.Ltd., New Delhi.

2. Kale N.G., Ahmed Mehtab (2011) Industrial Management, Vipul Publications, Mumbai.

Reference books:

1. Aswathappa K. (2006) Human Resource & Personnel Management, Tata McGraw Hill publishing Co. Ltd., New Delhi.
2. Kale N. G. (2002) Business Organisation, Vipul Publications, Mumbai.
3. Soundaian S. (2012) Principles of Management, MJP Publishers Chennai (Tamil Nadu).
4. Tripathy P. C., P. N. Reddy (2017) Principles of Management, McGraw Higher Education, 6th Edition, New Delhi.
5. Tulsian P. C., Pandey Vishal (2002) Business Organisation & Management, Pearson Education, New Delhi 110092.

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ICS-105 **SKILL ENHANCEMENT COURSE**

Applications of Materials in Industrial Chemistry (Semester V)

Credits: 04 (Theory: 03 & Practical: 01)

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COURSE OBJECTIVES

- Detergents, insecticides, adhesives, perfumes and flavours are the topics of day-to-day needs faced by the present civilization. Their applications are so extensive that their knowledge becomes part of the advanced society.
- Explosives and toxic chemical weapons bring the level of students up to the mark in these industries and make them competent to understand about recent developments.
- Paints and pigments, fertilizer etc. male the students aware about recent advancements and inspire about new ideas if any.
- The practicals will really give exposure and strengthen the knowledge given by theory topics.

SYLLABUS

THEORY **No. of hours: 45**

1. Detergents (7 H)

Introduction, Principal groups of synthetic detergents. Classification of surface-active agents. anionic detergents, cationic detergents, non-ionic detergents, and amphoteric detergents (brief discussion; methods of preparation are not expected), suds regulators, builders, additives, biodegradability of surfactants, ecofriendly detergents containing enzymes, eco-friendly detergents-zeolites, detrimental effects of detergents, Manufacture of shampoos.

2. Insecticides (7 H)

Introduction. Classification of insecticides according to their mode of actions. Inorganic insecticides, Natural or Plant insecticides, Organic insecticides e.g., DDT, Methoxychlor, BHC (benzene hexa chloride), Gammaxane, Aldrin, Dieldrin, Endrin, Malathion, Parathion (only applications are to be expected). Attractants and Repellants, Fumigants, Miticides, Rodenticides, Fungicides, Herbicides, and Acaricides.

3. Adhesives (4 H)

Introduction, Classification of adhesives such as

a) Solvent responsive adhesives
b) Heat sealing adhesives
c) Pressure sensitive adhesives
d) Chemically reactive adhesives.

Preparation of adhesives, other protein adhesives, starch adhesives, synthetic resin adhesives, rubber-based adhesives, cellulose and silicate adhesives, Uses of adhesives.

4. Perfumes and flavours: (3 H)

Introduction. Nitro musks such as Musk xylene, Musk ketone, Musk ambrette. Production of natural perfumes, Floral perfumes. Fruit flavours, artificial flavours.

5. Explosives and Toxic chemical weapons (7 H)

Introduction, history of explosives, definition, classification of explosives

A) Detonating or high explosives, primary or initiating explosives, secondary high explosives.

B) Deflagrating or low explosives, military, and industrial explosives (examples are expected)

C) Characteristics of explosives, power of explosion, sensitivity of explosives, heat of explosion, and rate of detonation

D) Preparation and explosive properties of

i) PETN

ii) Nitroglycerine and dynamite

iii) RDX or cyclonite (by Wolfram method)

E) Toxic chemical weapons with reference to Formula, products per formula weight, heat of explosion, explosion temperature, potential etc.

6. Paints, pigments and varnishes (10 H)

Introduction, distinction between paints and pigments.

A) Paints: Classification of paints, distempers, constituent of paints, extenders or fillers, film foaming materials, driers, thinners, or diluents, anti-skinning agents, plasticizers, resins, binders, setting of the paint, requirement of the good paint, pigment volume concentration (PVC) formula, importance of PVC. Types of paints (only applications are expected), emulsion paints, luminescent paints, heat resistant paints, paint removers.

B) Pigments: Introduction, types of pigments, manufacture and uses of the following

i) White pigment e.g. White lead (by Dutch process)

ii) Blue pigment e.g. Iron blue (by precipitation method)

iii) Green pigment e.g. Chrome green

iv) Yellow pigment e.g. Chrome yellow.

7. Fertilizers as plant nutrients (7 H)

Major and minor plant nutrients (mention only their role). Need for fertilizers, fertility of the soil, and pH value of the soil. Classification of the fertilizers – direct and indirect fertilizers, natural organic fertilizers (mention just types), natural inorganic fertilizers. Manufacture of the following fertilizers and their action with soil – NH_4NO_3, $(NH_4)_2SO_4$, Urea, calcium ammonium nitrate, NH_4Cl, ammonium phosphate, triple super phosphate. NPK fertilizers. Pollution caused by fertilizers.

PRACTICALS (30 HRS -1 credit)

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of calcium in calcium ammonium nitrate fertilizer.
3. To determine the percentage of ammonia in an ammonium salt
4. Estimation of phosphoric acid in superphosphate fertilizer.
5. Determination of % sulphur in ammonium sulphate by gravimetric analysis.

6. Preparation of Malachite [$CuCO_3.Cu(OH)_2$].
7. Estimation of copper (II)ions from malachite iodometrically using $Na_2S_2O_3$.
8. Preparation of Chrome Yellow ($PbCrO_4$).
9. Preparation of Prussian blue. (for demonstration).

LEARNING OUTCOMES

Theory

- Detergents, insecticides, adhesives, perfumes and flavours etc. are applied oriented topics, where their innumerable applications are versatile in the advanced human society.
- Explosive's topic has to bring the level of students, to update their advanced knowledge.
- Paints, pigments and fertilizers are very useful topics in the applied part of the industrial chemistry.

Practical

- The practicals are designed in such a way that, they involve preparation of pigments, analysis of fertilizers and free acidity of some fertilizers. This is need oriented programme.

REFERENCE BOOKS

Theory

Textbooks

1. Sharma, B.K.: Industrial Chemistry (including Chemical Engineering), Goel Publishing House, Meerut, 21st Edition, 2018.

Reference Books

1. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
2. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai& Sons, Delhi.
3. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic chemistry, Milestone Publishers.
4. Shriver and Atkins Inorganic chemistry, 4th edition.

Practical

Textbook

1. G H Jefeery, J Bassett, J Mendham, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 5th edition.

Reference Book

1. 1.Sharma, B.K., Industrial Chemistry (including chemical Engineering), Goel Publishing House, Meerut, 21st Edition, 2018.

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SEMESTER VI

(INDUSTRIAL CHEMISTRY)

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ICD-102 **Discipline Specific Elective**

Pharmaceutics and Pharmacognosy (Semester VI)

Credits: 04 (Theory: 03 & Practical: 01)

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COURSE OBJECTIVES

- The introduction of drugs, their classification, pharmaceutical excipients, sterilization and pharmaceutical packaging opens up the new horizon for the students. Something new but essential for the various pharmaceutical industries, they master the ideas.
- Introduction to crude drugs, evaluation and isolation will make them up to date about crude drugs.
- Chemical constituents of Plants will awaken the curiosity about the plants and later their extension to the essential applications.
- Most of the practicals emphasize the analysis of drugs and allied chemical tests, which partly covers the drug analysis.
- On-Job-training is directly giving opportunity to the students in various industries. So that they have real experience about what they learn and incidentally they also know the minimum demand/requirement from the industries.

SYLLABUS

Theory **No. of Hours: 45**

1. Introduction (8 H)

Drugs, sources of drugs. Introduction and classification of dosage forms, routes of administration. Historical background and development of pharmaceutical industry in India in brief. Introduction to Pharmacopoeias – Monographs, Development of Indian pharmacopoeias. Introduction to British Pharmacopoeia, United States Pharmacopoeia, European Pharmacopoeia, National Formulary and other important pharmacopoeias. Drugs & Cosmetics Act 1940 and Drugs & Cosmetics Rules 1945 - Introduction, Definitions of various important terms, Study of Schedule G, M (GMP & cGMP). Licensing authorities, controlling authorities.

2. Pharmaceutical Excipients (7 H)

Introduction, classification of various pharmaceutical excipients, their chemistry, uses and quality specifications of glidants, lubricants, binders, diluents, disintegrating agents, coating agents, organoleptic additives, preservatives, antioxidants, buffers, emulsifying agents, suspending agents, viscosity modifiers, gelatin, sorbitol, mannitol, microcrystalline cellulose, pharmaceutical waters.

3. Sterilization & Pharmaceutical Packaging (8 H)

Aseptic conditions, need for sterilization, various methods of sterilization. Introduction to packaging, package selection, packaging material, ancillary materials, packaging machinery, quality control of packaging materials

4. Introduction to Crude Drugs (8 H)

Introduction, classification of crude drugs, cultivation, collection and processing of crude drugs (preparation for the market and storage of medical plants). Drug adulteration, deterioration substitution, types of adulterants. Introduction, occurrence and distribution of different phytochemical constituents like alkaloids, glycosides, volatile oils, resins, tannins, carbohydrates, Lipids (fixed oils, fats, waxes) and proteins. Introduction to different methods of extraction – maceration, percolation, infusion, decoction, soxehlet extraction. Introduction to newer techniques of extraction.

5. Evaluation & Isolation of Crude Drugs (8 H)

Definition and different methods of evaluation of crude drugs like: Organoleptic, Physical, Chemical, Biological and Microscopical. Various isolation procedures for active constituents, in alkaloids e.g. vinca alkaloids, reserpine and steroids e.g. sapogenin. Introduction to spectroscopic & chromatographic methods of identification of crude drugs.

6. Chemical Constituents of Plants (6 H)

Classification, properties, chemical tests for identification, adulteration, analytical parameters, uses and storages of any two in the following categories:

a) Carbohydrates and derived products e.g., honey, Indian gum, Agar

b) Glycosides- e.g Anthraquinone glycosides (Senna), cardiac glycosides (digitalis), steroidal Saponins (Liquorice, Dioscorea), flavonoids (Orange peel).

c) Tannins – e.g. Hydrosable (Myrobalan, Arjuna) Condensed (Ashoka, Black Catechu).

d) Alkaloids, Alkaloidal drugs – e.g., ergot, ephedra, Nux Vomica, opium

e) Enzymes and Protein drugs-e.g., trypsin, urokinase, streptokinase, gelatin

f) Lipids- e.g., Fixed oils (Linseed oil, Castor oil), Fats (Cocoa Butter), Waxes (bees wax).

g) Volatile oils and terpenoids- e.g., peppermint oil, clove oil, sandalwood oil, turpentine.

h) Resins and resin combinations- e.g., Ginger, turmeric, capsicum, cannabis

Practical

1. Extraction of active constituent from crude drugs
   - i) Caffeine from tea powder.
   - ii) Pectin from lemon peel
   - iii) Ammonium Glycyrrhizinate from Liquorice.
2. Chemical tests for identification of any two crude drugs.
3. Evaluation tests for packaging material –Glass
   - i) Powdered glass test.
   - ii) Whole container test.
   - iii) Chemical resistance test.
   - iv) Water attack test.

4. Preparation of standard calibration curve of drug by UV spectrophotometry.
5. Estimation of drug content from drug dosage form using UV spectrophotometry.
6. Simultaneous spectrophotometric estimation method – estimation of two drugs from dosage form (optional)

LEARNING OUTCOMES

Theory

- Introduction, Pharmaceutical excipients and sterilization with pharmaceutical packings will give the students, exposure to sources of drugs, classification of excipients and need for sterilization.
- Introduction to crude drugs, Evaluation & Isolation of Crude Drugs will inform the students about drug adulteration and definition and different methods of evaluation of crude drugs.
- Chemical Constituents of Plants introduces the classification, properties, chemical tests for identification, adulteration, analytical parameters, uses and storages. In essence, it elaborately informs comprehensive information about the plant constituents.

Practical

- The practicals are designed in such a way that, they involve extraction of active constituents from the crude drug, caffeine from tea powder, Pectin from lemon peel, Ammonium Glycyrrhizinate from Liquorice.
- In addition, other incidental essential physical properties are also expected to be indispensable to the students. Thus, a need-oriented syllabus for practicals is prepared.

REFERENCE BOOKS

Theory

Textbooks:

1. Harkishan Singh, Pharmacopoeias and formularies, History of Pharmacy in India and Related Aspects, vol.1, Delhi, Vallabh Prakashan, 1994.
2. Kokate C. K., Purohit A. P. and Gokhale S. B., Pharmacognosy 41st Ed., Nirali Prakashan, 2008.
3. Wallis, T. E., Textbook of Pharmacognosy, 5th Ed., J. A., Churchill Limited, London, 1985.

Reference Books:

1. Ansel’s pharmaceutical dosage form and drug delivery system, lyod allen and howard ansel, 10th edition. Lippincott, Williams and wilkinsons.
2. Remington: The science and practice of Pharmacy- Alfonso R. Gennaro
3. Bentleys Text book of Pharmaceutics- Rawlins (ELBS)
4. Industrial Pharmacy: Lachman (Lea & Febiger)

5. Banker and Rhodes- Modern Pharmaceutics- (Dekker)
6. IP, BP, USP, NF, BNF, NFI, Martindale, Ph. Eur, and international Pharmacopoeia
7. Hanlon- Handbook of Packaging and Engineering (McGraw Hill)
8. Trease G. E. and Evans, W. C., Pharmacognosy, 16th Ed, Bailliere Tindall, Eastbourne, U.K., 2010.
9. Tyler V. E., Brady R., Textbook of Pharmacognosy, 8th Ed, Lea and Febiger, Philadelphia, 1981.

Practicals

Textbooks:

1. Kokate, C. K., Practical Pharmacognosy, 3rd Ed., Vallabh Prakashan, New Delhi. 1991.
2. Hanlon- Handbook of Packaging and Engineering (McGraw Hill).

Reference books:

1. Medicinal plants of India, Indian Council of Medical Research, New Delhi.
2. Anatomy of Crude Drugs, Iyengar, M. A., and Nayak, S. G. K., 8th Ed., Manipal Power Press, Manipal., 2001.

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CHD-103 **Discipline Specific Elective**

Selected Instrumentation in Chemistry (Semester VI)

Credits: 04

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THOERY: COURSE OBJECTIVES

- To define the terms involved in chromatographic techniques and spectroscopic methods.
- To explain working of chromatographic techniques and detectors, spectrophotometer, Atomic spectroscopy, DTA, DSC.
- To classify different types of chromatographic methods.
- To study the principles of GC, HPLC,
- To interpret steps involved in chemical analysis.
- To describe the basic components of instruments.
- To draw the schematic diagrams of different instruments.
- To solve numerical on chromatographic techniques
- To discuss the applications of different chromatographic techniques and spectroscopic methods.

SYLLABUS

Theory: **Number of hours: 60**

SECTION A

1. Introduction (4 H)

Overview of instruments in chemical analysis, Basic components of instruments for analysis: Signal generators, detectors (input transducers) Signal processors, read out devices, circuits & electrical devices in the instruments, advantages of instruments interfaced with computers.

2. Chromatographic techniques (12 H)

Classification of chromatography methods. Gas chromatography: Basic principles of GSC and GLC. Terms involved: Distribution equilibria, rate of travel, retention time, retention volume, relative retention, Height Equivalent to a Theoretical Plate(HETP), Van Deemter equation. Instrumentation: carrier gas, column, injections systems, explanations of factors affecting separation, thermal conductivity and flame ionization detectors. Qualitative and Quantitative analysis: internal standards, determination of

peak area. HPLC: Instrumentation, description of pumps, detector choice (UV absorption and refractive index detectors), columns, injection system, packing materials, applications. Introduction to hyphenated techniques: Basic principles of GC-MS and LC-MS. (Numerical problems are to be solved)

3. Mass spectrometry (8 H)

Introduction, theory, making the gaseous molecule into an ion (electron impact, chemical ionization), making liquids and solids into ions (electro spray, electrical discharge), separation of ions on basis of mass to charge ratio. Instrumentation: schematic diagram of single and double focusing. Advantages of Quadrupole Mass Spectrometer, sample introduction, sample purity, spectrum resolution. Applications of mass spectrometry in structure elucidation. Peak matching.

4. X-ray diffraction methods (6 H)

Introduction to X-ray absorption and emission methods, Bragg's law, Diffraction of X-rays, production and detection of X-rays, sample preparation, identification of powder diffraction patterns of ZnO, NiO and $MgAl_2O_4$.

SECTION B

5. UV-Visible Spectroscopy (10 H)

Interaction of electromagnetic radiation with matter, Quantitative calculations- Beer's and Lambert's law, derivation of Beer-Lambert's law, deviations from Beer's law. Principles of instrumentation: Sources, monochromators, cells. Types of instruments: Photoelectric colorimeters and Spectrophotometers: Single & Double beam; comparison between colorimeter and spectrophotometer; applications: qualitative control of purity, quantative analysis; identification of structural groups in a molecule; study of co-ordination compound, cis-trans isomerism; chemical kinetics. Photometric titrations (numerical problems are expected to be solved).

6. Atomic spectrometric methods (14 H)

Atomic absorption Spectroscopy: Introduction, principle, instrumentation, applications, limitations. Flame photometry and introduction, principle, instrumentation, applications, limitations. Differences between flame photometry and atomic absorption spectroscopy. Fluorimetry: principles of fluorescence, chemical structure and fluorescence. Relationship between concentration & fluorescence intensity, instrumentation & applications. (numerical problems are expected to be solved)

7. Analysis of drug in solid state (6 H)

Concepts of particle size, size distribution shown as cumulative undersize curve. Thermal methods of analysis: Basic principles of differential thermal analysis (DTA) and Differential Scanning Calorimetry (DSC), Differential Thermal Analysis - apparatus and methodology, factors affecting DTA results, quantitative DTA, interpretation of results. Applications to detect polymorphism and pseudo polymorphism in pharmaceuticals by DSC or DTA.

LEARNING OUTCOMES

At the end of the course students will be able to

- Discuss the principles behind the basic components of instruments (signal generators processors and detectors) and their advantages interfaced with computers.
- Define the terms, and principles involved in involved gas chromatography (GC) liquid chromatography (HPLC).GC-MS, LC-MS and solve the numericals with reference to the techniques.
- Explain sampling and working of X ray absorption and emission techniques.
- Describe the working and principles in photoelectric colorimeters and spectrophotometers and its application in isomerism photometric titrations and chemical kinetics.
- Explain principles, instrumentation, applications and limitations of AAS, flourimetry, flame photometry and solve the numerical with reference to the technique.
- Interpret steps involved in thermal methods of analysis- DTA, DSC and its applications in pharmaceuticals.
- To discuss the applications of advantages of different chromatographic techniques and spectroscopic methods.

REFERENCE BOOKS

Textbooks:

1. B. K. Sharma. Instrumental Methods of Chemical Analysis: Goel Publishing House, Meerut.
2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, Basic principles in Analytical Chemistry, 5th edition, Shet Publications Pvt. Ltd.

Reference books:

1. G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, 5th edition (reprint 2003), Himalaya publication.
2. Willard, Meritt and Dean. Instrumental Methods of Analysis.
3. Skoog and Leary, Principles of Instrumental analysis, Saunders College Publication.

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DSE-3B **Discipline Specific Elective**

OPERATIONS RESEARCH
(Semester VI)

Credits: 04 (Theory)

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COURSE OBJECTIVES

This course helps in understanding basic concepts of operations research in decision making.

SYLLABUS

Theory **No. of Hours: 60**

1. **Project Management (6 H)**
   Planning, Scheduling and controlling of a project. Techniques of analysing. Methods of planning and programming. Development of bar charts. Shortcomings and remedial measures. Milestone Charts.

2. **Elements of Network (6 H)**
   Event, activity, dummy. Rules of Network, Numbering of events, Cycles. Planning for network construction. Work breakdown structures.

3. **Project Evaluation & Review Technique (PERT) (6 H)**
   PERT time estimates T_E, T_L. Network analysis. Probability of meeting schedule time.

4. **Critical Path Method (CPM) (6 H)**
   CPM process and network. Time estimates, Float. Critical activities and path. Project crashing.

5. **Inventory Control (12 H)**
   Basics of Inventory control, Inventory model with no shortages and instantaneous production, Inventory model with shortages allowed and instantaneous production.

6. **Queuing Theory (12 H)**
   Basics of Queuing theory, Models of Queuing theory, Model (M/M/1): (∞/FIFO), Model (M/M/1):(N/FIFO).

7. **Game theory (12 H)**
   Some basic terminologies, Optimal solution of two-person zero sum game, Solution of mixed strategy games, graphical solution of games, linear programming solution of games. Two-person Zero sum games. Solving simple games.

LEARNING OUTCOMES

- Students will learn basic concepts in decision making.

REFERENCE BOOKS

1. Operations Research, Kanti Swarup and Gupta, S. Chand and Company, New Delhi.
2. Operations Research, An Introduction by H. A. Taha, Pearson India.
3. Operations Research, Principles and applications, G. Srinivasan, PHI.

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ICS-104 **Skill Enhancement Course**

PHARMACEUTICAL MICROBIOLOGY (Semester VI)

(04 Credits: Theory – 03, On-job-training – 01)

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THOERY COURSE OBJECTIVES

- A Brief idea about contributions of different scientist in the field of microbiology, history of discoveries of antibiotics, different microbial products used in therapy such as antibiotics, vitamins, steroids, hormones, vaccines.
- A brief introduction to Medical Biotechnology and its applications in making diagnostic kits.
- Biomedical engineering and its applications.
- Basic knowledge about Recombinant DNA technology and Drug designing.
- Challenges and responsibilities faced by a pharmacist.
- Role of regulatory bodies such as FDA, CBER, CDER and GMP Considerations.
- Production of Streptomycin, l-lysine and ascorbic acid on an industrial scale in the form of a flow chart.
- Introduction to Plant tissue culture and synthesis of Secondary metabolites.
- A Knowledge about different factors affecting the biosynthesis of secondary metabolites and production of alkaloids.
- A brief introduction to animal tissue culture giving a knowledge about media used , cultivation methods ,large scale production , cell lines , animal cell bioreactors used for production and also its pharmaceutical applications.
- A brief introduction to the concept of gene therapy and problems associated with it different methods of drug delivery systems in gene therapy have also been discussed in detail.
- A brief knowledge about applications of gene therapy in treatment of Cancer and AIDS.
- A brief introduction to Monoclonal Antibodies – Production on a commercial scale,
- applications and side effects.
- An Introduction to types of Vaccines-Multivalent subunit vaccines, purified macromolecules, synthetic peptide vaccines, Immunoadhesion, Recombinant antigen vaccines, Vector vaccines, Anti idiotype vaccines, targeted immune stimulants, miscellaneous approaches, new generation vaccines, novel vaccine delivery systems.

SYLLABUS

Theory **No. of Hours: 45**

1. **Pharmaceutical Microbiology – Introduction and history (15 H)**
   Industrial microbiology, Louis Pasteur as a founding father, Edward Jenner, Robert Koch, Paul Ehrlich – Salvarsan, founder of chemotherapy, Joseph Lister – use of

disinfectant in surgery; history of discoveries of antibiotics, development of microbiology in India; microbial products used in therapy- antibiotics, vitamins, steroids, hormones, vaccines. Medical biotechnology- diagnostic kits; Biomedical engineering- artificial organs, polymer engineering, enzyme immobilization, prosthetic limbs. Recombinant technology and drug designing. Pharmacist and biotechnology- challenges and responsibilities. Role of FDA, CDER (Centre for drug evaluation and research), CBER (Centre for biologics evaluation and research), GMP considerations.

2. Production of Pharmaceutical agents (15 H)

(A) Production process of

Streptomycin, L- lysine, Ascorbic acid

(B) Plant tissue culture and biosynthesis of secondary products

Comparison of natural product yields from cell cultures and whole plants e.g. alkaloids, anthraquinones, plant phenolics, volatile oils etc; Factors affecting biosynthesis. Production of alkaloids.

(C) Animal tissue culture

Introduction, media, cultivation, Cell lines. Large scale culture and production. Animal cell reactor, biological film reactor. Pharmaceutical applications.

3. Drug delivery systems in gene therapy, monoclonal antibodies and vaccines (15 H)

(A) Gene therapy.

Introduction and problems associated; types of delivery systems i) viral mediated ii) non-viral mediated; gene therapy for cancer and AIDS.

(B) Monoclonal antibodies

Introduction and production; Commercial production process, Applications and side effects.

(C) Vaccines

Introduction and types of vaccines: Multivalent subunit vaccines, purified macromolecules, synthetic peptide vaccines, immunoadhesion, recombinant antigen vaccines, vector vaccines, anti-idiotype vaccines, targeted immune stimulants, miscellaneous approaches, new generation vaccines, novel vaccine delivery systems.

LEARNING OUTCOMES

Theory

- Students will gain knowledge about contributions of different scientist in the field of Microbiology.
- Knowledge of History of discoveries of antibiotics, a brief understanding about different microbial products used in therapy such as antibiotics, vitamins, steroids, hormones, vaccines.
- Understand the term Medical Biotechnology and its applications in making diagnostic kits.
- Understand the term biomedical engineering. Understand the applications of various fields like Polymer engineering, enzyme immobilization. artificial organs and prosthetic limbs
- Understand the term Recombinant DNA technology. Explain the steps involved in Recombinant DNA technology and applications of rDNA Technology.
- Explain the challenges and responsibilities faced by a pharmacist with the growing field of biotechnology.

- Explain the role of different regulatory bodies in the operation and working of different pharmaceutical industries such as CBER, CDER, GMP considerations, FDA.
- Explain the steps involved in the production of Streptomycin, l-lysine and ascorbic acid on an industrial scale in the form of a flow chart with regard to main steps , process parameters , production media etc.
- Define and explain Plant tissue culture and explain the production of Secondary metabolites.
- Understand and explain about different factors affecting the biosynthesis of secondary metabolites and Explain the production of alkaloids.
- Define and explain animal tissue culture giving a knowledge about media used explain the cultivation methods used in large scale production of animal tissue culture.
- Define and explain Cell lines.
- Explain the various parameters of animal cell bioreactors used for Production.
- Explain the pharmaceutical applications of Animal tissue Culture.
- Explain the concept of gene therapy and problems associated with it.
- Explain the different methods of drug delivery systems in gene therapy.
- Explain the applications of gene therapy in treatment of Cancer and AIDS.
- Define and explain Monoclonal Antibodies. Explain the steps involved in the production of monoclonal antibodies on a commercial scale . Explain the applications and side effects of monoclonal antibodies.
- Define and explain Multivalent subunit vaccines, purified macromolecules, synthetic peptide vaccines, Immunoadhesion, Recombinant antigen vaccines, Vector vaccines, Anti idiotype vaccines, targeted immune stimulants, miscellaneous approaches, new generation vaccines, novel vaccine delivery systems.

REFERENCE BOOKS

1. Pharmaceutical microbiology- Purohit, Saliya and Kalrani.
2. Pharmaceutical Biotechnology- Vyas and Dixit.
3. Biotechnology and fermentation process – JohnI. D’Souza, Suresh G. Killedar Nirali Prakashan.
4. Industrial Microbiology- Cassida.
5. Medical Microbiology- Ananthnarayan
6. Microbiology - Prescott, Harley, Klein.
7. Essentials of Microbiology - Frobisher.
8. Microbiology - Pelczar.
9. Microbiology - A. H. Modi.
10. Laboratory Manual in Biochemistry - Jayaraman.
11. An Introduction to Practical Biochemistry - David T. Plummer.
12. Fundamental Principles of Bacteriology - A.J. Salle

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ICP- **PROJECT**

(Semester VI)

Credits: 04

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PROJECT COURSE OBJECTIVES

Students will gain knowledge and understanding of

- **Basic research:** The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.
- **Applied research**: Applied research is aimed at gaining knowledge or understanding to determine how a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

This Project course is in lieu of one of the DSE course. The project work is to be started in the beginning of semester V and to be completed at the end of semester VI.

LEARNING OUTCOMES

Students will be able to learn the following:

- Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. Majors to be certified by the American Chemical Society will have extensive laboratory work and knowledge of Biological Chemistry.
- Students will be able to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will be able to clearly communicate the results of scientific work in oral, written, and electronic formats to both scientists and the public at large.
- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.

- Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
- Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.
- Students will be able to function as a member of an interdisciplinary problem-solving team.

NOTE: Project to be started in semester V and completed at the end of semester VI.

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