# SYLLABUS
# DHAKUAKHANA COLLEGE (AUTONOMOUS)
# FYUGP, 2020

**B.Sc. IN CHEMISTRY (NEP)**
**Approved in the BOS, Chemistry held on 28/11/2024**

**FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP) IN CHEMISTRY,**

# DHAKUAKHANA COLLEGE (AUTONOMOUS)

FYUGP, 2020

DHAKUAKHANA-787055

FYUGP Structure as per UGC Credit Framework of December, 2022

| Year | Semester | Course | Title of the Course | Paper Code | Total Credit |
|---|---|---|---|---|---|
| Year 01 | 1st Semester | Major-01 | Chemistry-1: Organic+ Inorganic + Physical | CHMMJ101 | **4** |
| | | Minor -01 | Fundamentals of Chemistry-1 | CHMMN101 | **4** |
| | | GEC - 01 | Chemistry in Daily Life-1 | CHMGE101 | **3** |
| | | **AEC - 01** | **Modern Indian Language** | * | **4** |
| | | SEC - 01 | Basic Analytical Chemistry-1 | SEC104 | **3** |
| | | **VAC - 01** | **Understanding India** | * | **2** |
| | **Total** | | | | **20** |
| | | | | | |
| | 2nd Semester | Major-02 | Chemistry-2: Organic+ Inorganic + Physical | CHMMJ201 | **4** |
| | | Minor -02 | Fundamentals of Chemistry-2 | CHMMN201 | **4** |
| | | GEC - 02 | Chemistry in Daily Life-2 | CHMGE201 | **3** |
| | | **AEC - 02** | English Language and Communication Skills | * | **4** |
| | | SEC - 02 | Basic Analytical Chemistry-2 | SEC204 | **3** |
| | | **VAC 02** | Environmental Science | * | **2** |
| | | **Total** | | | **20** |
| **Grand Total(Semester I and II)** | | | | | **40** |

The students on exit shall be awarded an ***Undergraduate Certificate*** (in the Field of Study/Discipline) after securing the requisite ***40 Credits in Semesters 1 and 2*** provided they secure ***4 credits in work based vocational courses*** offered ***during the summer term or internship / Apprenticeship in addition to 6 credits from skill based courses earned during 1st and 2nd Semester***

| Year | Semester | Course | Title of the Course | Paper Code | Total Credit |
|---|---|---|---|---|---|
| Year 02 | 3rdSemester | Major- 03 | Chemistry-3: Inorganic + Physical | CHMMJ301 | 4 |
| | | Major- 04 | Chemistry-4: Inorganic + Organic | CHMMJ302 | 4 |
| | | Minor -03 | Fundamentals of Chemistry-3 | CHMMN301 | 4 |
| | | GEC - 03 | Chemistry in Daily Life- 3 | CHMGE301 | 3 |
| | | SEC - 03 | Inorganic Materials of Industrial Importance | SEC304 | 3 |
| | | VAC - 03 | Yoga Education | | 2 |
| | **Total** | | | | **20** |

| | | | | |
|---|---|---|---|---|
| 4thSemester | Major - 05 | Chemistry-5: Inorganic | CHMMJ401 | 4 |
| | Major - 06 | Chemistry-6: Physical | CHMMJ402 | 4 |
| | Major- 07 | Chemistry-7: Organic | CHMMJ403 | 4 |
| | Major - 08 | Chemistry -8: Symmetry & Quantum Chemistry-I | CHMMJ404 | 4 |
| | Minor -04 | Fundamentals of Chemistry-4 | CHMMN-401 | 4 |
| | **Total** | **20** | | **20** |
| **Grand Total(Semester I, II, III and IV)** | | | | **80** |

**FYUGP**
**DETAILED SYLLABUS OF**
**1st SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-1: Organic+ Inorganic + Physical** |
| **Course Code** | **: CHMMJ101** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

To give idea about the basic knowledge of chemistry in different field of specializations (viz. inorganic, organic, and physical chemistry)

## Unit-I: Inorganic Chemistry **14 Lecture, Marks: 15**

**Periodic properties: 6 Lecture, Marks: 06**

Effective nuclear charge (screening constant – Slater's rule only), ionic and covalent radii, ionization potential, electron affinity and electro negativity (Pauling, Mulliken's, and Allred-Rochow Scales).

**Bonding and structure: 8 Lecture, Marks: 09**

Ionic Bonding: Energy consideration in ionic bonding, lattice Energy. Born - Haber cycle and its application, polarizing power, and polarizability. Fajan's rule, Bond moment, dipole moment and percentage ionic character. Hydrogen Bonding. Covalent Bonding: VB Approach-Concept of hybridization (sp, $sp^2$, $sp^3$, $sp^3d$, $sp^3d^2$ and $dsp^2$). VSEPR Theory. Resonance and Resonance energy, study of some inorganic and organic compounds ($O_3$, $NO_3^-$ , $CO_3^{2-}$, $SO_4^{2-}$, $RCOO^-$, $C_6H_6$). Co-ordinate or Dative Bond. Bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals non-bonding combination of orbitals, MO treatment of homonuclear diatomic molecules and heteronuclear diatomic molecules such as CO, NO and $NO^+$

## Unit-II: Physical Chemistry **15 Lecture, Marks: 15**

**Gas: 9 Lecture, Marks: 10**

Derivation of kinetic gas equation, Maxwell distribution of molecular speed, different types of speeds, collision properties, Mean free path, determination of collision diameter, transport phenomenon in gases, coefficient of viscosity, law of equipartition of energy, degrees of freedom and average energy of a molecule, molecular basis of heat capacity, barometric formula, and its uses for determination of Avogadro number. Deviation from ideal behavior, van der Waals and Dieterici's, Virial equation of state, Boyle's temperature, Critical constants,

reduced equation of state, co-efficient of compressibility and thermal expansion.

**Liquid:** **6 Lecture, Marks: 5**

Qualitative treatment of structure of liquids, physical properties of liquids, vapour pressure, surface tension- Explanation of cleansing action of detergents, parachor- determination and application, viscosity, Newtonian and non-Newtonian liquid, liquid crystals.

## Unit-III: Organic Chemistry **16 Lecture, Marks: 15**

**Basics of Organic Chemistry:** **8 Lecture, Marks: 08**

Organic Compounds: classification and Nomenclature. Hybridization: Shape of molecules, Influence of hybridization on bond properties. Electronic displacements: Inductive, Electrometric, Resonance, Mesmeric effects and Hyper conjugation and their applications. Dipole moment. Organic acids and bases: Their relative strength, Homolytic and Heterolytic fission, Electrophiles and Nucleophiles: Nucleophilicity and basicity. Reactive intermediates: Carbocations, carbanions, free radicals, carbenes, nitrenes, Types, Shape and their relative Stability. Energy profile diagrams of one step, two steps and three steps reactions, Rate limiting steps. Activation Energy. Kinetically and thermodynamically controlled reactions.

**Stereochemistry:** **8 Lecture, Marks: 7**

Elements of symmetry and their application in simple organic molecules. Definition and classification of stereoisomerism, Representation of organic molecules in three & two dimension: Fischer Projection, Newman projection, Saw horse and flying wedge projection formula and their interconversions.

Optical isomerism: Concepts of asymmetry, dissymmetry, optical activity, Specific rotation, Chirality, enantiomers, Diastereomers, racemic mixture, racemization, and Resolution, Threo and Erythro forms, Meso structures & Epimers. Relative and absolute configuration: D/L and R/S designations. Walden inversion.

Geometrical Isomerism: Restricted rotation about C=C bonds, physical and chemical properties of diastereomers, determination of configuration of geometrical isomers: cis-trans isomerism, syn-anti and E/Z notation with CIP rules. Geometrical isomerism in oximes and alicyclic compounds.

## Unit -IV **15 Lecture (30 hours), Marks: 15**

**EXPERIMENTAL WORK**

Oxidation-Reduction Titrimetric (any one)

i) Estimation of Cu(II) or oxalic acid using standardized $KMnO_4$ solution.

ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination 10+10=20 Marks
2. Others - 20 Marks
   - Attendance 05 Marks
   - Home Assignment 05 Marks
   - Seminar presentation on any of the relevant topics 10 Marks

**COURSE OUTCOMES:**

After the completion of this course, the learner will be able to:

CO1: Develop a solid understanding of fundamental concepts in periodic properties,bonding, gas and liquid properties, organic chemistry, and stereochemistry.

CO2: Apply theoretical knowledge to solve problems and predict chemical behavior.

CO3: Perform experimental techniques proficiently, analyze data, and draw accurate conclusions.

CO4: Enhance critical thinking, analytical skills, and the ability to communicate scientific information effectively.

**SUGGESTED READINGS:**


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S.Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
3. Inorganic Chemistry – Puri, Sharma and Kalia
4. Inorganic Chemistry – J.D. Lee
5. General and Inorganic Chemistry (Part-I & II) R. Sarkar
6. Inorganic Chemistry – J.E. Huheey
7. Physical Chemistry-- Atkins, P. W. & Paula, J.
8. A Text Book of Physical Chemistry – Negi& S.C. Anand, Wiley Eastern
9. Physical Chemistry, Castellan G. W., Narosa Publishing
10. Principles of Physical Chemistry, Puri, Sharma, Pathania, Shoban Lal, (S. Chand & Co.)
11. Physical Chemistry – P.W. Atkins, Oxford University Press
12. Physical Chemistry – Barrow G.M., Tata-McGraw Hill
13. Physical Chemistry – D.S. Pahari
14. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
15. Organic Chemistry – M.K. Jain, S. Chand & Co.
16. Organic Chemistry – I.L. Finar, Vol. I & II, ELBS
17. Organic Chemistry, R.I. Morrison & R.N. Boyd, S.K. Bhattacharjee
18. Organic Chemistry – Vol. I & II, Mukherjee, and Kapoor
19. Advanced General Organic Chemistry (Part I and Part II) - S. C.Ghosh
20. Organic Chemistry (Oxford) - Clayden, Warren, Greeves and Wothers.
21. Organic Reactions and their Mechanisms (New Age International Privatr Limited) - P.S. Kalsi.

**FYUGP**
**DETAILED SYLLABUS OF 1st SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Fundamentals of Chemistry-1** |
| **Course Code** | **: MINCHM1** |
| **Nature of the Course** | **: MINOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

To build foundational knowledge in chemistry, focusing on atomic structure and bonding. This includes understanding various states of matter and their mechanical properties, as well as gaining introductory knowledge in organic chemistry, including hydrocarbons, stereochemistry, and conformational analysis.

## Unit I: Inorganic Chemistry **15 Lectures, Marks:15**

**Atomic Structure:** **09 Lectures, Marks:09**

(Recapitulation of Bohr's Theory, de Broglie, Theory, Heisenberg Uncertainty Principle) Time independent Schrödinger wave equation (H=E). Significance of ¥ and $¥^2$ Schrodinger equation for Hydrogen atom (qualitative treatment only). Quantum numbers, electronic configuration of elements based upon electronic configuration in the periodic table, periodic properties-effective nuclear charge, ionization energy, electron affinity, electronegativity (Pauling, Mulliken's and Allred-Rochow scales). Redox potential.

**Chemical Bonding and Molecular Structure-1:** **06 Lectures, Marks:06**

Ionic Bonding: Energy consideration 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 rule, dipole moment and percentage ionic character. Hydrogen Bonding.

## Unit II: Physical Chemistry **15 Lectures, Marks:15**

**Kinetic Theory of gases:** **11 Lectures, Marks:10**

Derivation of Kinetic gas equation, Types of molecular velocities, deduction of simple problems on – root mean square speed, most probable speed, collision frequency, collision diameter, mean free path, heat capacity of gases, Deviation from ideal behavior, van der Waals

equation, van der Waalsconstant, critical state of gas, critical constants, continuity of states, law of corresponding states, degree of freedom, law of equipartition of energy (derivation not required), viscosity of gases and effect of temperature and pressure on coefficient of viscosity).

**Liquid state**: **04 Lectures, Marks:05**

Qualitative treatment of the structure of liquids, Physical properties of liquids, vapour pressure. Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald Viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment) Parachor - determination and application.

## Unit III: Organic Chemistry **15 Lectures, Marks:15**

**Introduction to Organic Chemistry:** **08 Lectures, Marks:08**

a) Importance of Organic Chemistry & organic systems to human beings & society. Electronic displacements: Inductive effect, Electrometric effect, Resonance and hyperconjugation.

b) Mechanism of organic reactions: Cleavage of Bonds- Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules- Nucleophiles and electrophiles. Reactive Intermediates- Carbocations, carbanions, free radicals, carbenes & nitrenes. Strength of organic acids and bases: comparative.

**Aliphatic Hydrocarbons-1:** **07 Lectures, Marks:07**

***Alkanes*** (upto 5 carbons) Preparation: - Catalytic hydrogenation, Wurtz reaction, Kolbe's Synthesis, from Grignard reagent. Corey-House Synthesis. Reactions: Free radial Substitution: Halogenations.

## Unit IV: **15 Lecture (30 hours), Marks:15**

**Experimental Work:**

**Inorganic Qualitative Analysis**

Analysis of samples containing 4 radicalsincluding interfering radicals, phosphate, borate and fluoride

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination 10+10=20 Marks
2. Others - 20 Marks
   - Attendance 05 Marks
   - Home Assignment 05 Marks
   - Seminar presentation on any of the relevant topics 10 Marks

**COURSE OUTCOMES:**

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

**CO1:** Analyze and apply fundamental principles of atomic structure and chemical bonding to predict the behavior of elements and compounds.

**CO2:** Apply methods and procedures to solve the Schrödinger wave equation, determine electronic configurations, and analyze periodic properties.

**CO3:** Explain Schrödinger's wave equation, periodic properties, kinetic gas equation, and the significance of electronic displacements and mechanisms in organic reactions.

**CO4:** Use principles of ionic bonding, kinetic theory, and organic reaction mechanisms to solve related problems and predict outcomes in practical scenarios.

**CO5:** Differentiate between various types of molecular interactions, such as ionic bonds, hydrogen bonds, and van der Waals forces, and interpret the behavior of gases and liquids under different conditions.

**CO6:** Assess the stability and solubility of ionic compounds, the effects of temperature and pressure on physical properties of liquids, and the strength of organic acids and bases.

**CO7:** Conduct qualitative inorganic analysis, prepare aliphatic hydrocarbons, and utilize laboratory techniques to measure physical properties of liquids and identify various radicals in samples.

**SUGGESTED READINGS:**


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D.Madan. (S. Chand & Co. Ltd.)
2. Inorganic Chemistry – Puri, Sharma and Kalia
3. General and Inorganic Chemistry (Part-I & II) R. Sarkar
4. A Text Book of Physical Chemistry – Negi & S.C. Anand, Wiley Eastern
5. Principles of Physical Chemistry, Puri, Sharma, Pathania, ShobanLal, (S. Chand &Co.)
6. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
7. Organic Chemistry – M.K. Jain, S.Chand& Co.
8. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. Sharma, (S. Chand & Co.)

**FYUGP**
**DETAILED SYLLABUS OF 1stSEMESTER**

| | |
|---|---|
| **Title of the Cours** | **: Basic Analytical Chemistry-1** |
| **Course Cod** | **: SEC104** |
| **Nature of the Course** | **: SEC-1** |
| **Total Credits** | **: 3** |
| **Distribution of Mark** | **:60 (End Sem) + 40(In-Sem)** |

**COURSE OBJECTIVES:**

To offer a fundamental understanding of the chemical analysis of soil, water, food products, and cosmetics, including separation techniques such as chromatography and ion exchange.

## Unit-I: **8 Lectures, Marks: 12**

**Introduction:** **3 Lectures, Marks: 5**

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

**Analysis of soil:** **5 Lectures, Marks: 7**

Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of pH of soil samples.
b. Estimation of Calcium and Magnesium ions asCalcium carbonate by complexometric titration.

## Unit-II: **10 Lectures, Marks:13**

**Analysis of water:** **5 Lectures, Marks: 6**

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

a. Determination of pH, acidity, and alkalinity of a water sample.
b. Determination of dissolved oxygen (DO) of a water sample.

**Analysis of food products:** **5 Lectures, Marks: 7**

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

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chili powder,turmeric powder, coriander powder and pulses, etc.
b. Analysis of preservatives and colouring matter.

## Unit-III: 12 Lectures, Marks: 15

**Chromatography: 4 Lectures, Marks: 5**

Definition, generalintroduction on principles of chromatography, paper chromatography, TLC etc.

a. Paper chromatographic separation of mixture of metal ion ($Fe^{3+}$and $Al^{3+}$).
b. To compare paint samples by TLC method.

**Ion-exchange: 4 Lectures, Marks: 5**

Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use ofcolumn is not feasible).

**Analysis of cosmetics: 4 Lectures, Marks: 5**

Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn,boric acid, chloride, sulphate.
b. Determination of constituents of talcum powder:Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

## Unit IV: 15 Lectures (30 hours), Marks: 20

Any one experiment:

(i) Determination of dissolved oxygen in water.
(ii) Determination of Chemical Oxygen Demand (COD)
(iii) Determination of Biological Oxygen Demand (BOD)
(iv) Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry
(v) Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
(vi) Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drinks

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

1. Two Internal Examination 10+10=20 Marks
2. Others - 20 Marks
   - Attendance 05 Marks
   - Home Assignment 05 Marks
   - Seminar presentation on any of the relevant topics 10 Marks

**COURSE OUTCOMES:**

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

CO1: Develop a thorough understanding of the principles and practices in analytical chemistry, including sampling, measurement accuracy, and data presentation.

CO2: Gain practical experience in analyzing soil, water, and food products, understanding their composition, and detecting adulterants.

CO3: Learn the techniques in chromatography and ion-exchange, and apply these techniques to real-world samples.

CO4: Acquire skills in analyzing cosmetics and conducting advanced practical experiments to measure various chemical parameters.

CO5: Enhance critical thinking and problem-solving abilities in the context of analytical chemistry applications.

**SUGGESTED READINGS:**


1. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994).
4. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016.
5. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.
7. Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley & Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.
10. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., NewYork (1995).
12. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004
13. Higson, S. P.J. (2003), Analytical Chemistry, Oxford University Press.
14. Fifield, F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
15. Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

**FYUGP**
**DETAILED SYLLABUS OF 1st SEMESTER**

Title of the Course : Chemistry in Daily Life- 1
Course Code : CHMGE101
**Nature of the Course : GEC-1**
**Total Credits : 3**
Distribution of Marks : 60 (End Sem) + 40 (In-Sem)

**COURSE OBJECTIVES:**

The course introduces the students to the fascinating chemistry of some food products. Keeping the importance of food industry in mind this course is aimed to introduce food packaging, processing, and preservation.

## Unit-I **14 Lecture. Marks: 18**

**Dairy Products:**

Composition of milk and milk product. Principles of dairy safety; Milk processing. Qualitative analysis of fat content, minerals in milk and butter. Qualitative analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy.

## Unit-II **10 Lecture. Marks: 14**

**Food additives:**

Food preservatives like benzoates, propionates, sorbates, disulphates. Artificial sweeteners: Aspartame,saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit Flavors), and monosodium glutamate.

## Unit-III **10 Lecture. Marks: 14**

**Food adulterants, and contaminants:**

Food processing and packaging; Food adulteration: definition and its importance, adulterants present in- coffee, tea, milk, spices, grains, and food colour; Difference between food adulteration and contamination.

## Unit-IV **11 Lecture. Marks: 14**

**Artificial food colorants:**

Natural and synthetic colors, fake colors, inorganic pigments, application of colors in food industry, flavoring agents, Coal tar dyes and non-permitted colors and metallic salts. Utility of coal tar dyes in food and cosmetics and its harmful effect.

**MODES OF IN-SEMESTER ASSESSMENT**: 40 Marks

1. Two Internal Examination - 10+10= 20 Marks
2. Others - 20 Marks
   - Attendance 05 Marks
   - Home Assignment 05 Marks
   - Seminar presentation on any of the relevant topics 10 Marks

**COURSE OUTCOMES:**

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

**CO1:** Identify the composition of dairy products and food additives, and recall key concepts in food safety and processing.

**CO2:** Explain the principles behind dairy safety, milk processing, and the roles of various food preservatives and artificial sweeteners.

**CO3:** Utilize methods for qualitative analysis of fat, minerals, and caffeine in dairy products and beverages, and detect common adulterants and contaminants in foods.

**CO4:** Compare and contrast different food additives, artificial colorants, and their applications in the food industry, including their potential health impacts.

**CO5:** Assess the significance of food adulteration and contamination, and evaluate theharmful effects of synthetic colorants and non-permitted substances.

**CO6:** Develop methods to detect food adulterants and contaminants, and innovate safer and more effective food processing and packaging techniques.

**SUGGESTED READINGS:**


1. 1.Food Science & Quality Control by SMT. B. Poornima - Centrum Press First edition2014.
2. Post-Harvest Management of Horticultural crops - S. Saraswathy, T.L. Preethi AGROBIOS (India) 2013.
3. A Handbook of Agn. Food processing and marketing by S.C. Gaur, Agro Bios (India) 2012.
4. Quality Control for value edition in Food processing – by Dev Raj, Rakesh Sharma & V.K. Joshi New India Publishing Agency, 2011.
5. Food processing and preservation – Subbulakshmi, G. Shobha, A. Udipi, New Age International (P) Ltd., 2006.

**FYUGP**
**DETAILED SYLLABUS OF**
**2nd SEMESTER**

**Title of the Course : Chemistry-2: Organic+ Inorganic + Physical**
**Course Code : CHMMJ201**
**Nature of the Course : MAJOR**
**Total Credits : 4**
**Distribution of Marks : 60 (End Sem) + 40 (In-Sem)**

**COURSE OBJECTIVES:**

To give concept about the chemistry of non-transition elements, metallurgy, 1st law of thermodynamics, solid state chemistry and chemistry of aliphatic hydrocarbons.

## Unit-I: Inorganic chemistry

**15 Lecture, Marks: 15**

**Non-Transition elements:** **09 Lecture, Marks: 9**

**Noble Gas:** Compounds of Xenon only

**Boron:** wade's rule, nomenclature of closo, nido and arachnoboranes, structure of boron hydrides ($B_2H_6$), metalloborane and metallocarboranes. borazine, phosphazine, $S_4N_4$, $(SN)_x$ – preparation, structure and uses.

**Carbon:** Fullerenes ($C_{60}$)

**Silicon:** silicones, classifications, and structure of silicates. Zeolites, use of Zeolites as catalyst and molecular sieve, aluminosilicates.

**Nitrogen:** Hydrazine, hydroxylamine, and hydrazoic acid.

**Phosphorus:** Phosphines, oxy acids of phosphorus, organophosphorus compound

**Metals:** **06 Lecture, Marks: 6**

Theory of reduction (Thermodynamic approach), role of carbon and other reducing agents, electrolytic reduction, roasting and calcinations. Method of purification and refining of metals including modern methods like zone refining, vacuum arc process, ion exchange, solvent extraction and electrolytic method, Van- Arkel process and hydrometallurgy. Study of potassium dichromate, manganese dioxide, potassium permanganate, ammonium molybdate, sodium cobaltinitrite, cobalt nitrate, Ni-DMG, vanadium pentoxide).

## Unit-II Physical chemistry

**15 Lecture, Marks: 15**

**Chemical Thermodynamics -I:** **09 Lecture, Marks: 9**

Extensive and intensive properties of a system, thermodynamic processes: cyclic, reversible, irreversible processes, thermodynamic function, complete differential, Zeroth law of thermodynamics. First law of thermodynamics-internal energy, enthalpy, molar heat capacities,

relation between Cp and Cv, work of expansion in reversible and irreversible process, adiabatic process, relation between P, V, T. Variation in internal energy and enthalpy with temperature, Joule Thomson effect, calculation of Joule Thomson co-efficient for ideal and Vander Waal's gas. Thermo chemistry- Hess's law, Kirchhoff's law relation of reaction enthalpy with internal energy, Bond energy and Bond dissociation energy, calculation from thermo chemical data.

**Solids:** **06 Lecture, Marks: 6**

Basic laws of crystallography, crystal system, crystal lattice, Miller indices, and simple face centered and body centered cubic lattice, number of points in a unit cell. X-Ray diffraction study of crystals, Bragg's law, determination of crystal structure- introduction to powder and single crystal methods of structure analysis, crystal structure of NaCl and KCl, packing of crystals, closed packed structure, radius ratio, crystal defect-point defects, conductors, semiconductors, and insulators from band theory.

## Unit-III Organic chemistry **15 Lecture, Marks: 15**

**Carbon- Carbon sigma bonds:** **04 Lecture, Marks: 4**

Chemistry of Alkanes: Formation of alkanes with special emphasis on Corey House Synthesis, Wurtz reaction, Wurtz-Fittig reaction. Reactions of alkanes: Free Radical substitution: Halogenations-relative reactivities and selectivity.

**Carbon-Carbon pi bonds:** **11 Lecture, Marks: 11**

Formation of alkenes and alkynes by Elimination: Mechanism of E1., E2, E1cB reactions. Saytzeff and Hoffmann elimination, special emphasis on preparation of alkenes by synelimination:- pyrolysis of esters, Chugaev reaction and Wittig reaction.

**Reaction of alkenes:**

**Addition Reaction**- Electrophilic and free radical additions, their mechanisms. (Markonikoff/ Anti Markonikoff addition) regioselectivity (directional selectivity), and steroselective of addition reactions. Mechanism of oxymercuration–demercuration, Hydroboration Oxidation, Ozonolysis, reduction (catalytic and chemical).

**Syn and Anti hydroxylation(oxidation),** simple effect of stereo selectivity and stereo specificity.

**Reactions of Alkynes:** Acidity, Electrophilic and Nucleophilic additions, Hydration to form carbonyl compounds. Alkylation of terminal alkynes.

## Unit IV: **15 Lecture (30 hours), Marks: 15**

**Experimental Work:**

Any one practical

(i) Purification of organic compounds by crystallization using the following solvents:

a. Water, b. Alcohol, c. Alcohol-water, and determination of the melting points of above compounds (Kjeldahl method and electrically heated melting point apparatus)

(ii) Separation of a mixture of o- and p-nitrophenol or o- and p-aminophenol by thin layer chromatography (TLC)

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

3. Two Internal Examination **10+10=20 Marks**
4. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

CO1: Develop a comprehensive understanding of the properties and reactions of non-transition elements and metals.

CO2: Gain in-depth knowledge of chemical thermodynamics and the properties of solids, including crystallography and X-ray diffraction.

CO3: Master the formation and reactions of carbon-carbon sigma and pi bonds, with a focus on alkanes, alkenes, and alkynes.

CO4: Acquire practical laboratory skills in the purification and analysis of organic compounds, enhancing problem-solving abilities and technical expertise in analytical techniques.

**SUGGESTED READINGS**:


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
3. Inorganic Chemistry – Puri, Sharma and Kalia
4. Inorganic Chemistry – J.D. Lee
5. General and Inorganic Chemistry (Part-I & II) R. Sarkar
6. Basic Inorganic chemistry – Cotton and Wilkinson
7. Inorganic Chemistry – J. E. Huheey
8. Physical Chemistry-- Atkins, P. W. & Paula, J.
9. A Text Book of Physical Chemistry – Negi& S.C. Anand, Wiley Eastern
10. Physical Chemistry, Castellan G. W., Narosa Publishing

11. Principles of Physical Chemistry, Puri, Sharma, Pathania, Shoban Lal, (S. Chand &Co.)
12. Physical Chemistry – P.W. Atkins, Oxford University Press
13. Physical Chemistry – Barrow G.M., Tata-McGraw Hill
14. Advanced Physical Chemistry – J.N. Gurta& H. Snehi, Pragati Prakashan
15. Physical Chemistry – D.S. Pahari
16. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
17. Organic Chemistry – M.K. Jain, S. Chand & Co.
18. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. Sharma, (S. Chand & Co.)
19. Organic Chemistry – I.L. Finar, Vol. I & II, ELBS
20. Organic Chemistry, R.I. Morrison & R.N. Boyd, S.K. Bhattacharjee
21. Organic Chemistry – Vol. I & II, Mukherjee and Kapoor
22. Advanced General Organic Chemistry (Part I and Part II) - S. C. Ghosh
23. Organic Chemistry (Oxford) - Clayden, Warren, Greeves and Wothers.
24. Organic Reactions and their Mechanisms (New Age International Private Limited) – P.S.Kalsi.

**FYUGP**
**DETAILED SYLLABUS OF**
**2nd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Fundamentals of Chemistry-2** |
| **Course Code** | **: CHMMN201** |
| **Nature of the Course** | **: MINOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To develop the basic knowledge of chemistry in relation to atomic structure, bonding. To emphasize on different states of matter & their mechanical treatment.
- To develop preliminary knowledge in basic organic chemistry, hydrocarbons, stereochemistry & conformational analysis etc.

## Unit-I: Inorganic Chemistry **15 Lecture, Marks: 15**

**Coordination Chemistry:** **07 Lecture, Marks: 7**

Review of Werner's theory. Types of ligands, monodentate, bidentate ambidentate and polydentate ligands (including _ Acceptor and macrocyclic ligands. IUPAC nomenclature of Co-ordination compounds. Isomerism of 4-and 6- coordinate compounds. Introduction to Valence Bond and Crystal Field theory. Application of dimethyl glyoxime, EDTA, 8-hydroxy quinoline, 2,2bipyridyl, and ethylenediamine in analysis.

**Chemical Bonding and Molecular Structure-2** **08 Lecture, Marks: 8**

**Covalent Bonding:** VB Approach-Concept of hybridization, sp, sp2 , sp3 , sp3d, sp3d2 and dsp2 VSEPR Theory. Resonance and Resonance energy: Study of some inorganic and organic compounds ($O_3$, $NO_3^-$, $CO_3^{2-}$, $SO_4^{2-}$, $RCOO^-$, $C_6H_6$). Molecular Orbital Approach: LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals, non-bonding combination of orbitals, MO treatment of homonuclear diatomic molecules and heteronuclear diatomic molecules such as CO, NO and $NO^+$

## Unit-II: Physical Chemistry **15 Lecture, Marks: 15**

**Solids:** **09 Lecture, Marks: 9**

Forms of solids, unit cells, crystal systems, Bravais lattice, types and identification of lattice

planes.

Miller and Weiss indices. Laws of crystallography- Law of constancy of interfacial angles. Law of rational indices. X-Ray diffraction by crystals. Bragg's law. Structure of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Liquid crystals.

**Ionic Equilibria:** **06 Lecture, Marks: 6**

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 – applications of solubility product principle.

## Unit-III: Organic Chemistry **15 Lecture, Marks: 15**

**Stereochemistry:** **07 Lecture, Marks: 7**

Conformation 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.

**Aliphatic Hydrocarbons-2 Alkenes:** (up to 5 carbons): **08 Lecture, Marks: 8**

Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: (up to 5 carbons):

Preparation: Acetylene from $CaC_2$ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinaldihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. $KMnO_4$.

## Unit-IV: Experimental Work: **15 Lecture (30 hours), Marks: 15**

Surface tension/Viscosity/pH -metry (Any one experiment)

i) Determine the surface tension of various liquids by drop number method.
ii) Determination of viscosity of aqueous solutions at room temperature.
iii) Study the variation of surface tension of detergent solutions with concentration.
iv) Determination of viscosity of aqueous solutions of (a) polymer (b) ethanol and (c) sugar at room

v) pH- metric titration;
   a) strong acid vs. strong base
   b) weak acid vs. strong base

vi) Preparation of buffer solutions of different pH
   (a) sodium acetate-acetic acid
   (b) ammonium chloride-ammonium hydroxide
   (c) Determination of dissociation constant of weak acid ($CH_3COOH$)

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

CO1: Apply the concepts of Werner's theory, isomerism in coordination compounds and Valence Bond and Crystal Field theories, to understand and solve problems related to the structure and function of coordination compounds.

CO2: Evaluate the bonding and structural properties of various inorganic and organic compounds by applying concepts of covalent bonding theories, including hybridization, VSEPR, resonance and MO.

CO3: Gain a clear understanding of coordination chemistry, including its theories, naming rules, and types of ligands.

CO4: Learn about chemical bonding, molecular structures, and the basics of solid-state chemistry.

CO5: Understand stereochemistry and the chemistry of aliphatic hydrocarbons, including how to make and react them.

CO6: Develop practical lab skills in measuring surface tension, viscosity, and pH, and in making buffer solutions, which will improve your problem-solving and technical abilities in analytical techniques.

**SUGGESTED READINGS**:

1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)

2. Inorganic Chemistry – Puri, Sharma and Kalia
3. General and Inorganic Chemistry (Part-I & II) R. Sarkar
4. A Text Book of Physical Chemistry – Negi& S.C. Anand, Wiley Eastern
5. Principles of Physical Chemistry, Puri, Sharma, Pathania, Shoban Lal, (S. Chand & Co.)
6. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
7. Organic Chemistry – M.K. Jain, S. Chand& Co.
8. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. Sharma, (S. Chand & Co.)

**FYUGP**
**DETAILED SYLLABUS OF**
**2nd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry in Daily Life-2** |
| **Course Code** | **: CHMGE201** |
| **Nature of the Course** | **: GEC-2** |
| **Total Credits** | **: 3** |
| **Distribution of Marks** | **:60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To introduce the students to the chemistry of some biomolecules.
- To familiarized the students with vitamins and their importance in human body.

## Unit-I: 12 Lecture, Marks: 16

**Vitamins:**

Classification and Nomenclature. Sources, deficiency diseases, and structures of Vitamin A, Vitamin B, Vitamin C, Vitamin D, Vitamin E & Vitamin K.

## Unit-II: 10 Lecture, Marks: 13

**Oils and fats:**

Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils.

Soaps & Detergents: Definition, classification, manufacturing of soaps and detergents, composition and uses.

## Unit-III: 12 Lecture, Marks: 16

**Proteins:**

Sources, Composition and Biological values of protein, Elementary ideas of proteins and amino acids, Essential and Non-essential amino acids. Peptide bonds, Polypeptides, Qualitative ideas of structure of proteins (Primary, secondary, Tertiary and Quaternary structure), Denaturation and coagulation of proteins; Factors contributing to denaturation and coagulation of proteins.

## Unit-IV: 11 Lecture, Marks: 15

**Nucleic Acids:**

Nucleic acids and their Chemical composition. Classification, functions, and structure of nucleic acids. Concept of DNA fingerprinting and its applications.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

**CO1:** Develop a comprehensive understanding of vitamins, including their sources, deficiency diseases, and chemical structures.

**CO2:** Gain in-depth knowledge of oils and fats, including detection of purity, rancidity, and the manufacturing and uses of soaps and detergents.

**CO3:** Understand the composition, structure, and biological significance of proteins and amino acids.

**CO4:** Learn about nucleic acids, their chemical composition, classification, functions, and applications such as DNA fingerprinting.

**SUGGESTED READINGS:**


1. Berg, J.M.; Tymoczko, J.L.; Stryer, L. (2006), Biochemistry. W.H. Freeman and Co.
2. Nelson, D.L.; Cox, M.M.; Lehninger, A.L. (2009), Principles of Biochemistry. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A.; Rodwell, V.W. (2009), Harper's Illustrated Biochemistry. Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018) Biochemistry, (First Indian addition 2018) Viva Books.
5. Kumar, A.; Garg, S.; Garg, N. (2012), Biochemical Tests: Principles and Protocols.

**Viva Books.**

1. Finar, I. L. (2008), Organic Chemistry, Volume 2, 5th Edition, Pearson Education.

**FYUGP**
**DETAILED SYLLABUS OF**
**2nd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Basic Analytical Chemistry-2** |
| **Course Code** | **: SEC204** |
| **Nature of the Course** | **: SEC-2** |
| **Total Credits** | **: 3** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

The course aims to provide students with a basic scientific and technical understanding of the production, behaviour and handling of hydrocarbon fuels, petrochemicals, and lubricants. This will enable them to be industry ready to contribute effectively in the field of petroleum chemistry and technology.

## Unit-I: 09 Lecture, Marks: 12

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value. **03 Lecture, Marks: 4**

**Coal: 06 Lecture, Marks: 8**

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 bases chemicals

## Unit-II: 15 Lecture, Marks: 20

**Petroleum and Petrochemical Industry: 09 Lecture, Marks: 12**

Composition of crude petroleum; Different types of petroleum products and their applications. Principle and process of fractional distillation, Cracking - Thermal and catalytic cracking; Qualitative treatment of nonpetroleum fuels -LPG, CNG, LNG, bio-gas, fuels derived from biomass, fuel from waste; synthetic fuels -gaseous and liquids.

**Petrochemicals: 06 Lecture, Marks: 08**

Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene, and its derivatives Xylene.

## Unit-III: 06 Lecture, Marks: 08

**Lubricants:**

Classification of lubricants, lubricating oils (conducting and non-conducting), Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants–viscosity index, cloud point, pore point.

## Unit-IV: 15 Lecture (30 hours), Marks: 20

**Experimental works**

**Any one experiment:**

(i) To determine the Aniline point of a given lubricating oil.
(ii) To determine the acid value of a given oil
(iii) To determine the enthalpy of combustion of liquid fuels using spirit / alcohol burner.
(iv) To perform the proximate analysis of coal
(v) To perform the ultimate analysis of the coal sample.

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

1. Two Internal Examination **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

**CO1:** Develop a comprehensive understanding of vitamins, including their sources, deficiency diseases, and chemical structures.

**CO2:** Gain in-depth knowledge of oils and fats, including detection of purity, rancidity, and the manufacturing and uses of soaps and detergents.

**CO3:** Understand the composition, structure, and biological significance of proteins and amino acids.

**CO4**: Learn about nucleic acids, their chemical composition, classification, functions, and applications such as DNA fingerprinting.

**SUGGESTED READINGS:**


1. Berg, J.M.; Tymoczko, J.L.; Stryer, L. (2006), Biochemistry. W.H. Freeman and Co.
2. Nelson, D.L.; Cox, M.M.; Lehninger, A.L. (2009), Principles of Biochemistry. W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A.; Rodwell, V.W. (2009), Harper's Illustrated Biochemistry. Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018) Biochemistry, (First Indian addition 2018) Viva Books.
5. Kumar, A.; Garg, S.; Garg, N. (2012), Biochemical Tests: Principles and Protocols.

**Viva Books.**

6. Finar, I. L. (2008), Organic Chemistry, Volume 2, 5th Edition, Pearson Educa

**FYUGP**

**DETAILED SYLLABUS OF 3rdSEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-3: Inorganic + Physical** |
| **Course Code** | **: CHMMJ301** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To develop the basic knowledge of chemistry in relation to *d* and *f* block elements and coordination compounds
- To develop the basic knowledge of chemistry in relation to chemical thermodynamics and ionic equilibrium
- To conduct experimental work in conductometry, thermochemistry,

## Unit I: Inorganic Chemistry **15 Lecture, Marks: 15**

***d* and *f* block elements**: **06 Lecture, Marks :06**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes.

Electronic configuration, oxidation states, colour, spectral and magnetic properties of lanthanides and actinides. Lanthanide contraction, separation of lanthanides (ion-exchange method only).

**Coordination compounds**: **09 Lecture, Marks :09**

Types of ligands: monodentate, bidentate, ambidentate, polydentate and macro cyclic ligand. Effective atomic number (EAN) rule, valence bond theory (VBT), crystal field theory (CFT), MOT and introduction to ligand field theories and their applications.

*Magnetic properties:* paramagnetism, diamagnetism, magnetic properties of octahedral complexes, ferromagnetism, antiferromagnetism and ferrimagnetism.

## Unit II: Physical Chemistry **30 Lecture, Marks :30**

**Chemical Thermodynamics II:** **9 Lecture, Marks :9**

Second law of thermodynamics, Carnot's theorem, Carnot cycle, efficiency of heat engines,

thermodynamic scale of temperature, concept of entropy, entropy change in a cyclic, reversible, irreversible processes, calculation of entropy changes of an ideal gas with change in P,V,T, entropy change in physical transformation, entropy of mixing. Helmholtz free energy (A) and Gibb's free energy (G), variation of A and G with P,V,T, criteria for spontaneity and equilibrium, Maxwell's relationship, Gibb's–Helmholtz equation. Nernst heat theorem- consequence of the theorem, third law of thermodynamics, and its verification. Determination of absolute entropies of pure substance.

**Ionic equilibrium:** **06 Lecture, Marks :06**

Strong and weak electrolyte with modern classification of electrolytes (true and potential electrolyte), degree of ionization, factors affecting degree of ionization, ionization constant, 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 solution, derivation of Henderson equation and its applications, buffer capacity, buffer range, buffer action. Solubility and solubility product of sparingly soluble salts-application of solubility product principle in salt analysis. Qualitative treatment of acid-base titration curves. Theory of acids- base indicators, selection of indicators and their limitations.

**Conductance:** **07 Lecture, Marks :07**

Arrhenius theory of electrolytic dissociation, conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, molar conductivity at infinite dilution, Kohlrausch law of independent migration of ions, Debye-Huckel - Onsagar equation, Wien effect, Debye-Falkenhagen effect, Walden's rule. Ionic mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and moving boundary methods (principle only , calculations not required), anomalous transference number, application of conductance measurement: i) degree of dissociation of weak electrolytes ii) ionic product of water iii) solubility and solubility product of sparingly soluble salts iv) Hydrolysis constant of aniline hydrochloride, v) Conductometric titration (Acid-Base and precipitation).

**Electrochemistry:** **08 Lecture, Marks :08**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Electrochemical cells, reversible and irreversible cells with examples. Electromotive force of a

cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction,
(ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and $SbO/Sb_2O_3$ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)

**Unit III: EXPERIMENTAL WORK (Any one) 15 Lecture (30 hours), Marks :15**

(i) Determine the surface tension of various liquids by drop number method.
(ii) Determination of viscosity of aqueous solutions at room temperature.
(iii) Study the variation of surface tension of detergent solutions with concentration.
(iv) Determination of viscosity of aqueous solutions of
(a) polymer (b) ethanol and (c) sugar at room temperature.

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

At the end of this programme, students will be able to-

CO1: Develop a solid understanding of the properties and behaviours of d and f block elements and coordination compounds.
CO2: Gain comprehensive knowledge of chemical thermodynamics and ionic equilibrium.
CO3: Gain comprehensive knowledge of conductance, electrochemistry.
CO4: Acquire practical laboratory skills in measuring surface tension and viscosity, enhancing analytical and problem-solving abilities.

**SUGGESTED READINGS:**


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
3. Inorganic Chemistry – Puri, Sharma and Kalia
4. Inorganic Chemistry – J.D. Lee
5. General and Inorganic Chemistry (Part-I & II) R. Sarkar Basic Inorganic chemistry – Cotton and Wilkinson.
6. Inorganic Chemistry – J.E.Huheey
7. Physical Chemistry-- Atkins, P. W. & Paula, J.
8. A Text Book of Physical Chemistry – Negi& S.C. Anand, Wiley Eastern
9. Physical Chemistry, Castellan G. W., Narosa Publishing
10. Principles of Physical Chemistry, Puri, Sharma, Pathania, ShobanLal, (S. Chand & Co.)
11. Physical Chemistry – P.W. Atkins, Oxford University Press
12. Physical Chemistry – Barrow G.M., Tata-McGraw Hill
13. Advanced Physical Chemistry – J.N. Gurta& H. Snehi, PragatiPrakashan
14. Physical Chemistry – D.S. Pahari

**FYUGP**

**DETAILED SYLLABUS OF 3rd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-4: Inorganic + Organic** |
| **Course Code** | **: CHMMJ302** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To understand the concepts of acids and bases, including Brönsted-Lowry and Lewis theories, and the application of HSAB principles.
- To learn about inorganic reaction mechanisms, conductance, and electrochemistry, including substitution reactions in complexes, conductometric titrations, and the principles of electrochemical cells.
- To develop the basic knowledge of chemistry in relation to cycloalkanes and conformational analysis and chemistry of halogenated hydrocarbons.
- To explore aromatic hydrocarbons, electrophilic aromatic substitution, and the chemistry of C-O bonds in alcohols, phenols, ethers, and epoxides,

## Unit I: Inorganic Chemistry **15 Lecture, Marks :15**

**Acids and Bases:** **06 Lecture, Marks :06**

Brönsted-Lowry concept of acid- base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, classification of Lewis acids, hard and soft acids and bases (HSAB). Application of HSAB principle.

**Inorganic reaction mechanism:** **09 Lecture, Marks :09**

Introduction to inorganic reaction mechanism, inert and labile complexes, association, dissociation and concerted paths. Acid and base hydrolysis (with reference to cobalt complexes only). Substitution reaction in octahedral and square planar complexes. Trans effect, Irving-William series.

## Unit II: Organic Chemistry **30 Lecture, Marks :30**

**Cycloalkanes and conformational analysis:** **07 Lecture, Marks :07**

Synthesis and reactions of three, four, five and six membered cycloalkanes, their relative

stability, Baeyer strain theory. Conformational analysis of Alkanes: (ethane & butane) Relative stability, Energy diagram. Cyclohexane: Chair, Boat and Twist boat forms, Relative stability with energy diagram, axial and equatorial bonds including perspective representation and Newman projections. Conformation & conformational analysis of monosubstituted cyclohexane derivative.

**Chemistry of Halogenated Hydrocarbons Alkyl halides: 07 Lecture, Marks :07**

Methods of preparation including Hunsdiecker reaction from silver or lead (IV) salts of carboxylic Acid). Nucleophilic substitution reactions: $SN_1$, $SN_2$, and $SN_i$ Mechanisms with stereochemical aspects and effect of solvent. Nucleophilic substitution vs elimination. Haloform reaction. Aryl halides: Preparation from diazonium salts. Nucleophilic Aromatic Substitution SNAr, Benzyne intermediates. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

**Aromatic Hydrocarbons Aromaticity: 08 Lecture, Marks :08**

Huckel's rule, aromatic characters of arenes, benzenoid, non-benzenoid- aromatic compounds and heterocyclic and polynuclear hydrocarbons with suitable examples Synthesis and properties of naphthalene and anthracene. Antiaromaticity and nonaromaticity Electrophilic Aromatic Substitution: Halogenation, nitration, sulphonation and Friedel- craft's alkylation / acylation with their mechanism. Activation/deactivation of aromatic ring and directing effects of groups. Partial rate factor (O/P ratio)

**Chemistry of C-O Bond Alcohols: 08 Lecture, Marks :08**

Preparation and properties of Glycol: Oxidation by $OsO_4$, alkaline, KMnO4, periodic acid and lead tetracetate. Pinacol-Pinacolone rearrangement with mechanism.

**Trihydric alcohol:** Glycerol: preparation & properties. ***Phenols:*** Preparation and properties: - acidity- comparison with alcohol. Substitution reaction,

Reimer- Tiemann and Kolbe-Schmidt reaction, Fries rearrangement with mechanism.

**Other aromatic Hydroxy compounds:** Cresol, nitrophenols, picric acid, benzyl alcohol, dihydric phenols. Ethers and Epoxides: Preparation and reactions with acids.

## Unit III: EXPERIMENTAL WORK: 15 Lecture (30 hours), Marks :15

Inorganic Preparation (Any one)

1. Potash alum
2. Chrome alum

3. Potassium trioxalatochromate
4. Potassium trioxalatoferrate

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**

2. Others - **20 Marks**

- Attendance **05 Marks**
- Home Assignment **05 Marks**
- Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

At the end of this programme, students will be able to-

CO1: Develop a solid understanding of the properties and behaviours of acids, bases, and inorganic reaction mechanisms.

CO2: Learn the concepts and applications of cycloalkanes, conformational analysis, and halogenated hydrocarbons, aromatic hydrocarbons, and the chemistry of the C-O bond.

CO3: Learn the concepts and applications of theoretical principles in practical contexts.

CO4: Acquire practical laboratory skills in inorganic synthesis, enhancing analytical and problem-solving abilities.

**SUGGESTED READINGS:**


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
3. Inorganic Chemistry – Puri, Sharma and Kalia
4. Inorganic Chemistry – J.D. Lee
5. General and Inorganic Chemistry (Part-I & II) R. Sarkar
6. Basic Inorganic chemistry – Cotton and Wilkinson
7. Inorganic Chemistry – J.E.Huheey
8. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
9. Organic Chemistry – M.K. Jain, S.Chand& Co.
10. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K.
11. Sharma, (S. Chand & Co.)
12. Organic Chemistry – I.L. Finar, Vol. I & II, ELBS
13. Organic Chemistry, R.I. Morrison & R.N. Boyd, S.K. Bhattacharjee
14. Organic Chemistry – Vol. I & II, Mukherjee and Kapoor
15. Advanced General Organic Chemistry (Part I and Part II) - S.C.Ghosh
16. Organic Chemistry (Oxford) - Clayden,Warren,Greeves and Wothers.
17. Organic Reactions and their Mechanisms (New Age International Privatr Limited) - P.S. Kalsi.

**FYUGP**

**DETAILED SYLLABUS OF 3rd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Fundamentals of Chemistry - 3** |
| **Course Code** | **: CHMMN301** |
| **Nature of the Course** | **: MINOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

To give the concept of physico-chemical methods involved in metallurgy; first and second law thermodynamics; aromatic hydrocarbons and reactions involved etc.

## Unit I: Inorganic Chemistry — 15 Lecture, Marks :15

**Chemistry of non-metals: — 08 Lecture, Marks :08**

Boron: Preparation, structure, and bonding of diborane Silicon: Structure, properties and use of silicon carbide and silicon polymers (linear).

Nitrogen: Hydroxylamine, Hydrazine, Hydrazoic acid; preparation, properties, uses and electronic structure.

Rare gases: Xenon compounds.

Phosphorous: Structures of oxides and oxyacids.

**General principles of metallurgy: — 07 Lecture, Marks :07**

Physico-Chemical methods involved in metallurgy (concentration, calcinations, reduction, roasting, zone refining, solvent extraction, hydrometallurgy, and electrochemical methods) with reference to gold, nickel, thorium uranium and manganese (whichever is applicable).

## Unit II: Physical Chemistry: — 15 Lecture, Marks :15

**Chemical Thermodynamics & First law**

Thermal equilibrium and zeroth law of thermodynamics- concept of temperature, Mechanical work, SI sign convention.1st law of thermodynamics, internal energy, enthalpy, reversible and irreversible processes, calculation of W,Q, $\Delta U$, $\Delta H$ for expansion of ideal gas , isothermal work and enthalpy, relation between enthalpy change, and entropy change, molar heat

capacities, relation between Cp and Cv, adiabatic processes- relation between P, V and T, Joule- Thomson effect, liquefication of gases, conversion of heat into work, efficiency of heat engine. Enthalpy of reaction, thermodynamical equation, variation of enthalpy of reaction with temperature-Kirchhoff's equation, enthalpy of different processes. Hess law, calculations based on Hess law.

**Second law of thermodynamics**

Second law of thermodynamics, Spontaneous and Non-Spontaneous processes cyclic process- Carnot cycle, Entropy, Entropy change in reversible and irreversible processes and for ideal gas, concept of work function and free energy.

## Unit III: Organic Chemistry **15 Lecture, Marks :15**

**Aromatic Hydrocarbons:** **08 Lecture, Marks :08**

Preparation (only benzene) from phenol by decarboxylation, from acetylene, from benzenesulphonic acid. Reactions- Electrophitic substitution in benzene- nitration, halogenations, sulphonation, Fridel-Craft alkylation and acylation with mechanism.

**Alkyl halides** **07 Lecture, Marks :07**

Nucleophilic Substitution Reactions ($SN_2$, $SN_1$, &$SN_i$) Preparation: from alkenes and alcohols Reactions; Hydrolysis, nitrite and nitro formation, nitrile and isonitrile formation. Williamson's Synthesis: elimination vs Substitution.

## Unit IV: Experimental Work: **15 Lecture (30 hours), Marks :15**

**Organic Qualitative Analysis**

Detection of elements (nitrogen, sulphur and halogens) and functional groups of organic compounds containing one functional group.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

CO1: Develop a clear and comprehensive understanding of non-metal chemistry, metallurgical principles, thermodynamics, and organic chemistry.

CO2: Gain detailed knowledge of the properties, preparation methods, and reactions of important chemical compounds.

CO3: Apply theoretical principles in practical scenarios, including laboratory experiments.

CO4: Acquire practical skills in qualitative analysis, enhancing analytical and problem-solving abilities in chemical investigations.

**SUGGESTED READINGS:**


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry – Satyaprakash, Basu, Tuli
3. Inorganic Chemistry – Puri, Sharma and Kalia
4. General and Inorganic Chemistry (Part-I & II) R. Sarkar
5. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
6. Organic Chemistry – M.K. Jain, S.Chand& Co.
7. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. Sharma, (S. Chand & Co.)

**FYUGP**

**DETAILED SYLLABUS OF 3rd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry in Daily Life- 3** |
| **Course Code** | **: CHMGE301** |
| **Nature of the Course** | **: GEC-3** |
| **Total Credits** | **: 3** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To understand the learners about the applications of polymers, fertilizers, cosmetics and perfumes in everyday life.

## Unit I: Chemical and Renewable Energy Sources: 11 Lecture, Marks :15

Principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy, future energy storer.

## Unit II: Polymers: 11 Lecture, Marks :15

Basic concept of polymers, classification and characteristics of polymers. Applications of polymers as plastics in electronic, automobile components, medical fields, and aerospace materials. Problems of plastic waste management. Strategies for the development of environment friendly polymers.

## Unit III: Chemistry of Cosmetics & Perfumes 12 Lecture, Marks :15

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), 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.

## Unit IV: Fertilizers: 11 Lecture, Marks :15

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium

nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

CO1: Develop a thorough understanding of chemical and renewable energy sources, polymers, cosmetics, perfumes, and fertilizers.

CO2: Gain detailed knowledge of the principles, applications, and manufacturing processes related to each unit's content.

CO3: Apply theoretical knowledge to practical scenarios, such as the development of environmentally friendly polymers and the use of essential oils in cosmetics.

CO4: Acquire practical skills in analyzing and evaluating the environmental and industrial implications of chemical substances and processes.

**SUGGESTED READINGS:**


1. Barel, A.O.; Paye, M.; Maibach, H.I. (2014), Handbook of Cosmetic Science and Technology, CRC Press.
2. Garud, A.; Sharma, P.K.; Garud, N. (2012), Text Book of Cosmetics, Pragati Prakashan.
3. Gupta, P.K.; Gupta, S.K. (2011), Pharmaceutics and Cosmetics, Pragati Prakashan
4. Butler, H. (2000), Poucher's Perfumes, Cosmetic and Soap, Springer.
5. Kumari, R. (2018), Chemistry of Cosmetics, Prestige Publisher.
6. Gopalan, R. Venkappayya, D.; Nagarajan, S. (2004), Engineering Chemistry, Vikas Publications.
7. Sharma, B. K. Engineering Chemistry, Goel Publishing House, Meerut, 2006
8. Carraher, C. E. Jr. (2013), Seymour’s Polymer Chemistry, Marcel Dekker, Inc. Ghosh, P. (2001), Polymer Science & Technology, Tata Mcgraw-Hill

**FYUGP**

**DETAILED SYLLABUS OF 3rd SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Inorganic Materials of Industrial Importance** |
| **Course Code** | **: SEC304** |
| **Nature of the Course** | **: SEC-3** |
| **Total Credits** | **: 3** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

The course introduces the students to the diverse roles of inorganic materials in the industry. It gives an insight into how these raw materials are converted into products used in day-to-day life. Students learn about silicates, fertilizers, surface coatings and batteries. The course helps develop the interest of students in the frontier areas of inorganic and material chemistry.

## Unit I: Silicate Industries: **09 Lecture, Marks :12**

*Glass*: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

*Ceramics*: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber.

*Cements*: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

## Unit II: Fertilizers: **05 Lecture, Marks :07**

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

## Unit III: **08 Lecture, Marks :10**

## Surface Coatings:

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface

coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

## Batteries: **08 Lecture, Marks :11**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

## Unit IV: **15 Lecture (30 hours), Marks :20**

**Any one experiment:**

1. Estimation of free phosphoric acid in superphosphate fertilizers.
2. Estimation of CaO in cement.
3. Laboratory synthesis of the pigments; Prussian blue, Malachite green, chrome yellow, etc.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**

2. Others - **20 Marks**

- Attendance **05 Marks**
- Home Assignment **05 Marks**
- Seminar presentation on any of the relevant topics **10 Marks**

**SUGGESTED READINGS:**


1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi
7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut

**FYUGP**

**DETAILED SYLLABUS OF 4th SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-5: Inorganic** |
| **Course Code** | **: CHMMJ401** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**OBJECTIVES:**

- To develop the knowledge of chemistry in relation to nuclear chemistry
- To develop the knowledge of chemistry in relation to various statistical methods of analysis
- To develop the preliminary idea on organometallic chemistry
- To introduce various organic reagents and their applications in inorganic analysis

## Unit I: Nuclear Chemistry: **16 Lecture, Marks :16**

Nuclear structure, mass defect, binding energy and stability of nuclei, nuclear transmutations and artificial radioactivity, fundamentals of radioactive decay, nuclear reactions including fission and fusion reactions, nuclear reactor and its components, measurement of radioactivity, analytical applications of nuclear reactions and radioactive tracers - in **s**tudying reaction mechanism, in diagnosis and treatment of diseases, in industry, in agriculture, in analytical chemistry, in determination of the age of the earth by rock dating method and determination of the age of recent objects by radio carbon dating method.

## Unit II: Statistical Methods of Analysis: **10 Lecture, Marks :10**

Accuracy, precession, deviation, standard deviation, classification of errors, minimization of errors, significant figures.

Indicators: choice of indicators in neutralization, redox, adsorption and complexometric reactions.

## Unit III: Organometallic Chemistry-I: **11 Lecture, Marks :11**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of

mononuclear, polynuclear and substituted metal carbonyls of 3*d* series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.

Oxidative addition and reductive elimination reaction, π- acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

## Unit IV: Organic Reagents in Inorganic Analysis: **08 Lecture, Marks :08**

Cupferron, dithizone, benzoin-α-oxime, 1-nitroso-2- naphthol, diphenyl carbazide, diphenyl carbazone, salicylaldoxime, 1,10- phenanthroline, magneson, thiourea, zinc uranyl acetate, oxine.

## Unit V: Experimental Work: (Any One) **15 Lecture (30 hours), Marks :15**

a) Estimation of $Ca^{2+}$ and $Mg^{2+}$ by EDTA

b) Estimation of $Cu^{2+}$ by iodometric method

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20** Marks

2. Others - **20 Marks**

- Attendance **05 Marks**
- Home Assignment **05 Marks**
- Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES**:

At the end of this programme, students will be able to-

CO1: To define mass defect, binding energy, accuracy, precession, etc.

CO2: To identify different organic reagents in inorganic analysis

CO3: To distinguish nuclear fission and fusion reactions

CO4: To explain18 electron rule

CO5: To elucidate the structures of mononuclear and binuclear carbonyls using VBT

CO6: To apply organic reagents in inorganic analysis

CO7: To estimate of $Ca^{2+}$ and $Mg^{2+}$ by EDTA and $Cu^{2+}$ by iodometric method Cognitive map of course outcomes with Bloom's Taxonomy:

**Recommended Books**:


1. Selected Topics in Inorganic Chemistry--Wahid U. Malik, G. D. Tuli and R. D. Madan. (S. Chand & Co. Ltd.)
2. Advanced Inorganic Chemistry-- Satyaprakash, Basu, Tuli
3. Inorganic Chemistry -- Puri, Sharma and Kalia
4. General and Inorganic Chemistry (Part-I & II) -- R. Sarkar
5. Concise Inorganic Chemistry Wiley India, 2008 -- Lee J. D.
6. Inorganic Chemistry – Principles of structure and reactivity, Pearson Education-- Huheey J. E., Keiter E. A. and Keiter R. L.
7. Qualitative Analysis—Vogel

**FYUGP**

**DETAILED SYLLABUS OF 4th SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-6: Physical** |
| **Course Code** | **: CHMMJ402** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To acquaint students in details on chemical kinetics, catalysis and surface chemistry.

## Unit I: Chemical Kinetics: **20 Lecture, Marks :20**

Order and Molecularity of a reaction, elementary and complex reactions rate laws, differential and integral forms of rate equations of zero,1st, 2nd order reactions, half life periods of 1st and 2nd order reactions, determination of order of reaction by method of integration, half life period, differential method, isolation method, evaluation of rate constant, integrated equation method, graphical method, Guggenheim method (1st order reaction), rate laws and mechanism, steady state approximation.

Rate equation of first order, opposite, parallel, consecutive reaction, chain reactions, chain branching, explosion limit, Hydrogen – Bromine thermal reaction.

Temperature dependence of reaction rates, Arrhenius equation, energy of activation, collision theory of bimolecular reactions, its limitation.

Introduction to activated complex theory, Lindeman's theory of unimolecular gas phase reaction.

## Unit II: Surface Chemistry **15 Lecture, Marks :15**

Physical and chemical adsorption of gases on solid surface, adsorption isotherms, types of adsorption isotherm, Freundlich equation, Langmuir adsorption equation. Determination of surface area.

Gibbs adsorption equation, application of adsorption in chemical analysis and in industry.

## Unit III: Catalysis **10 Lecture, Marks :10**

Criteria of catalysis, homogeneous and heterogeneous catalysis, introduction to acid base catalysis. Mechanisms of catalyzed reactions at solid surfaces, effect of temperature on surface

reactions, nano particles as catalysts, autocatalysis, catalytic poison, Michaelis-Menten equation.

## Unit IV:EXPERIMENTAL WORK (Any one) **15 Lecture (30 hours), Marks :15**

a) To determine the rate constant of hydrolysis of methyl acetate catalyzed by hydrogen ion concentration at room temperature.
b) To determine the rate constant of Saponification of ethyl acetate.
c) Compare the strengths of HCl and $H_2SO_4$ by studying kinetics of hydrolysis of methyl acetate.
d) To study the kinetics of iodination of propanone in acidic medium.
e) To study the rate constant of hydrolysis of sucrose by polarimeter.

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES**:

After the completion of this course, the learner will be able to:

CO1: Develop a comprehensive understanding of chemical kinetics, surface chemistry, and catalysis principles and their applications.

CO2: Apply theoretical knowledge and experimental techniques to analyze reaction mechanisms, rate laws, and surface phenomena.

CO3: Evaluate the factors influencing reaction rates, adsorption processes, and catalytic mechanisms using kinetic data and experimental results.

CO4: Apply critical thinking skills to design experiments, interpret experimental data, and solve problems related to reaction kinetics and surface chemistry.

**SUGGESTED READINGS:**

**Text Books:**


1. Physical Chemistry- G.W. Castellan, Narosa Publishing House, New Delhi.
2. Physical Chemistry - P.C. Rakshit, Science Book Agency, Kolkata.
3. Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd.,

New Delhi.

4. Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.

**Ref. Books:**

1. P.W. Atkins, Physical Chemistry, Oxford University Press.
2. Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, S. Chand & Co.
3. Physical Chemistry – D.S. Pahari (Vol. I &II ).
4. Physical Chemistry - Levine

**FYUGP**

**DETAILED SYLLABUS OF 4th SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry-7: Organic** |
| **Course Code** | **: CHMMJ403** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**OBJECTIVES:**

- To make the students familiar about chemistry of carbonyl compounds, carboxylic acids, thiols and amines.
- To provide knowledge about natural as well as synthetic polymers.

## Unit I: Carbonyl Compounds: (Aliphatic and Aromatic)

**Part A:** **10 Lecture, Marks :10**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Clemmensen, Wolff- Kishner, MPV reduction

Addition reactions of unsaturated carbonyl compounds: Michael addition. Unsaturated Aldehydes (Acrolein, Crotonaldehyde, Cinnamaldehyde) Unsaturated Ketone(MVK).

**Part B:** **04 Lecture, Marks: 04**

Active methylene compounds: Keto-enol tautomerism.

Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate, malanonitrile.

## Unit II: Carbonyl Compounds: (Aliphatic and Aromatic) 10 Lecture, Marks :10

**Carboxylic Acids and their Derivatives: (Aliphatic and Aromatic):**

Preparation, physical properties, and reactions of monocarboxylic acids (Acidity and factors affecting it): Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann- bromamide degradation

Dicarboxylic acids: Oxalic acid, malonic acid, and succinic acid

Hydroxy acids: lactic acid, tartaric acid, citric acid and salicylic acid.

## Unit III: Sulphur containing compounds: 03 Lecture, Marks :03

Preparation and reactions of thiols, thioethers and sulphonic acids.

## Unit IV: Nitrogen Containing Functional Groups (Aromatic and Aliphatic)

**10 Lecture, Marks :10**

Preparation and important reactions of nitro compounds, nitriles and isonitriles

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications. Diazomethane & Diazoacetic-Ester with synthetic application.

## Unit V: Polymers 08 Lecture, Marks :08

Introduction and classification of polymers; Polymerisation reactions -Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable polymers with examples.

## Unit VI: EXPERIMENTAL WORK (Any one) 15 Lecture (30 hours), Marks :15

Systematic qualitative analysis of organic compounds having -OH, $-NH_2$ ,$-NO_2$ , $-CONH_2$ , -CHO, -COOH, $-CONH_2$ groups.

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

After the end of the course students will be able to

CO1: Learn preparation and properties aldehyde, ketone, carboxylic acid, thiols, amines, etc.

CO2: Understand and analyze the mechanisms of key name reactions involving organic compounds, such as Aldol condensation, Cannizzaro reaction, and Hofmann rearrangement.

CO3: Perform systematic qualitative analysis of organic compounds containing functional groups such as -OH, $-NH_2$, $-NO_2$, $-CONH_2$, -CHO, and -COOH.

**SUGGESTED READINGS:**

**Text Books:**


1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Advanced Organic Chemistry by Bahl and Bahl (S Chand Publication)
4. A Textbook of Organic Chemistry by KS Tiwari (Vikash Publishing)
5. Modern Organic Chemistry by Jain and Sharma (Vishal Publishing)
6. Advanced and General Organic Chemistry by SK Ghosh (NCBA)
7. Practical Organic Chemistry by OP Agarwal (Krishna)


**Reference Book**


1. Organic Chemistry by Paula Y Bruice (Pearson).
2. Advanced Organic Chemistry by Clayden Greeves and Wothers (Oxford).
3. Advanced Organic Chemistry by J March and Michael B Smith (Wiley).
4. Organic Chemistry by Solomons (Wiley).

**FYUGP**

**DETAILED SYLLABUS OF 4th SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Chemistry 8: Symmetry & Quantum Chemistry-I** |
| **Course Code** | **: CHMMJ404** |
| **Nature of the Course** | **: MAJOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

To make the students familiar with symmetry elements & point groups and the various aspects of basic quantum mechanics with special reference to classical mechanics.

## Unit I: Symmetry & Group Theory-I **15 Lecture, Marks :15**

Symmetry elements and symmetry operations. Definition of group, symmetry group, point group. Perspective sketch and point group of some common molecules ($H_2$, HF, $CO_2$, $C_2H_2$, $C_2H_4$, $CHCl_3$, $PCl_5$, $NH_3$, $BF_3$, $[PtCl_4]^{2-}$, $BrF_5$).

Symmetry and mathematical tools, matrix algebra, reducible and irreducible representation, great orthogonality theorem (deduction not necessary), Character table for $C_{2v}$ and $C_{3v}$ point groups.

## Unit II: Quantum Chemistry-I **30 Lecture, Marks :30**

Background of quantum mechanics; Black body radiation – Planck's hypothesis, photoelectric effect, de Broglie hypothesis and Heisenberg's uncertainty principle. Postulates of quantum mechanics, quantum mechanical operators (Linear and Hermitian operators), Wave functions, Normalized and Orthogonal Wave Functions. Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy; wave functions, probability distribution functions, nodal properties, separation of variables, two- and three- dimensional boxes, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component.

Rigid rotator model of rotation of diatomic molecule: Schrödinger equation and its solution. Qualitative treatment of hydrogen atom and hydrogen- like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, energy (only final energy expression). Average and most probable distances.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

## Unit III: EXPERIMENTAL WORK: 15 Lecture (30 hours), Marks :15

**pH-metry and Polarimetry (Any one experiment)**

(i) pH metric titration

(a) strong acid vs. strong base

(b) weak acid vs. strong base

(c) strong acid vs. weak base

(ii) Preparation of buffer solutions of different pH

(a) sodium acetate-acetic acid

(b) ammonium chloride-ammonium hydroxide

(c) Determination of dissociation constant of weak acid ($CH_3COOH$) / base ($NH_4OH$)

(d) To determine the concentration of an optically active substance by polarimetric method.

**MODES OF IN-SEMESTER ASSESSMENT: 40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

After the completion of this course, the learner will be able to:

CO1: Develop a comprehensive understanding of symmetry and group theory principles, quantum mechanics foundations, and experimental techniques in analytical chemistry.

CO2: Apply theoretical knowledge and experimental skills to identify molecular symmetries, analyze quantum mechanical systems, and conduct analytical experiments.

CO3: Evaluate molecular structures, wave functions, and experimental data to assess symmetry elements, energy levels, and chemical concentrations.

CO4: Apply critical thinking skills to solve problems related to molecular symmetry, quantum mechanics, and experimental analysis in chemistry.

CO5: Perform pH metric titrations, prepare buffer solutions to analyze the interaction between different types of acids and bases, including strong acid vs. strong base, weak acid vs. strong base, and strong acid vs. weak base.

CO6: Determine the concentration of optically active substances through polarimetric methods, enhancing the understanding of optical activity and its applications in chemical analysis.

**SUGGESTED READINGS:**

**Text Books**:


1. Quantum Chemistry – Ira N. Levine, PHI, New Delhi.
2. Introductory Quantum Chemistry – A.K. Chandra, Tata- McGraw.
3. Chemical Applications of Group Theory- F.A. Cotton, Wiley Eastern Ltd., New Delhi.


**Ref. Books**:


1. Quantum Chemistry, R.K. Prasad.
2. Quantum Chemistry, B. K. Sen.

**FYUGP**

**DETAILED SYLLABUS OF 4th SEMESTER**

| | |
|---|---|
| **Title of the Course** | **: Fundamentals of Chemistry-4** |
| **Course Code** | **: CHMMN-401** |
| **Nature of the Course** | **: MINOR** |
| **Total Credits** | **: 4** |
| **Distribution of Marks** | **: 60 (End Sem) + 40 (In-Sem)** |

**COURSE OBJECTIVES:**

- To develop the knowledge about industrial chemistry like-glass, ceramics and cements.
- To develop the knowledge about nuclear chemistry.
- To study the principles of chemical kinetics and the properties of different types of solutions.
- To study the preparations and the properties of aryl halides, alcohols, phenols and ethers.

## Unit I: 13 Lecture, Marks :13

**Introduction to Industrial Chemistry: 07 Lecture, Marks :07**

**Glass**: Glassy state and its properties, classification (silicate and nonsilicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, safety glass, borosilicate glass, coloured glass,

**Ceramics**: Important clays and feldspar, ceramic, their types and manufacture fullerenes carbon nanotubes and carbon fiber.

**Cements**: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements

**Nuclear Chemistry: 06 Lecture, Marks :06**

Nuclear structure, Mass defect, Binding energy and stability of nuclei, Nuclear transmutations and Artificial radioactivity, Fundamentals of radioactive decay, Nuclear reactions including fission and fusion reactions, Analytical applications of Nuclear Reactions and Radioactive tracers.

## Unit II: 15 Lecture, Marks :15

**Chemical Kinetics 08 Lecture, Marks :08**

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on

reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. 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. Comparison of the two theories (qualitative treatment only).

**Solutions** **07 Lecture, Marks :07**

Types of solutions, concentration units, Solution of gases in liquids-Henry's law. Solution of liquids in liquids: 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. Distillation of solutions. Lever rule, Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction. Solutions of solids in liquids: the solubility curves.

## Unit III: **17 Lecture, Marks :17**

**Aryl Halides**: **08 Lecture, Marks :08**

Preparation (Chloro, Bromo & Iodo benzene only): From phenol, Sandmeyer and Gattermann reaction .

Reactions: (Chlorobenzene) Aromatic Nucleophilic substitution (replacement by – OH) and effect of Nitro Substituent, Reactivity and relative strength of Carbon- halogen bond in alkyl, allyl, vinyl and Aryl Halide.

**Alcohols, Phenols and Ethers:** **09 Lecture, Marks :09**

**Alcohols**: Preparation: Preparation of $1^o$, $2^o$ and $3^o$ 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. $HNO_3$).

**Diols**: oxidation of diols. Pinacol-Pinacolone rearrangement.

**Phenols**: Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer Tiemann Reaction

**Ethers** (aliphatic and aromatic): Cleavage of ethers with HI.

## Unit IV: 15 Lecture (30 hours), Marks :15

**Experimental Work:**

**Inorganic Volumetric Analysis: (any one)**

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

**MODES OF IN-SEMESTER ASSESSMENT:** **40 Marks**

1. Two Internal Examination - **10+10=20 Marks**
2. Others - **20 Marks**
   - Attendance **05 Marks**
   - Home Assignment **05 Marks**
   - Seminar presentation on any of the relevant topics **10 Marks**

**COURSE OUTCOMES:**

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

CO1: Recall key concepts in industrial chemistry, nuclear chemistry, chemical kinetics, and solution chemistry.

CO2: Develop a comprehensive understanding of the principles underlying industrial chemistry, nuclear chemistry, chemical kinetics, and solution chemistry.

CO3: Apply theoretical knowledge and experimental skills to analyze and solve problems related to industrial processes, reaction kinetics, and solution behavior.

CO4: Analyze reaction mechanisms, solution properties, and experimental data to draw conclusions and make predictions.

CO5: Evaluate the effectiveness of reaction mechanisms, solution properties, and experimental procedures to assess their reliability and accuracy.

CO6: Design experiments, propose solutions, and develop new methodologies to address challenges in chemistry and enhance understanding of chemical phenomena.

**SUGGESTED READINGS:**

1. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017

2. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed. 2010.
3. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017
4. Physical Chemistry- G.W. Castellan, Narosa Publishing House, New Delhi.
5. Physical Chemistry - P.C. Rakshit, Science Book Agency, Kolkata
6. Physical Chemistry Vols. I, II, III and IV – K.L. Kapoor, MacMillan (India) Ltd., New Delhi
7. Advanced Physical Chemistry – J.N. Gurta & H. Snehi, Pragati Prakashan.
8. Organic Chemistry – B.S. Bahl and A. Bahl (Vol. I & II)
9. A Text Book of Organic Chemistry (Vol. I & II) – B.K. Sharma, G.P. Pokhriji and S.K. Sharma, (S. Chand & Co.)

**Ref. Books:**

1. P.W. Atkins, Physical Chemistry, Oxford University Press
2. Physical Chemistry – B.R. Puri, L.R. Sharma, Madan S. Pathania, Shobanlal Nagin, S. Chand & Co.
3. Physical Chemistry – D.S. Pahari (Vol. I &II )
4. Physical Chemistry – Levine Organic Chemistry – M.K. Jain, S. Chand& Co.