Syllabus for

Bachelor of Science in Chemistry (GE/GENERAL/PASS)

Under Choice Based Credit System

Academic Session:

w.e.f. 2020-2023

for

All Constituent/Affiliated Colleges Under

Binod Bihari Mahto Koyalanchal University, Dhanbad

Members of Board of Studies for Bachelor of Science in Chemistry (Honours) Under Choice Based Credit System as per Guidelines of the Binod Bihari Mahto Koyalanchal University, Dhanbad, Jharkhand.

1.	**Dr. B. Kumar** Associate Professor Dean, Faculty of Science & Head, University Department of Chemistry, BBMKU, Dhanbad	**Chairman**	B. Kumar 21-09-2020
2.	**Dr. Sanjoy Mishra** Professor University Department of Chemistry Ranchi University, Ranchi	**External Expert Member**	
3.	**Dr. L. P. Mishra** Associate Professor University Department of Chemistry VBU, Hazaribag	**External Expert Member**	
4	**Dr. Leelawati** Kumari Assistant Professor University Department of Chemistry, BBMKU, Dhanbad	**Internal Members**	Kumari 21.09.2020
5.	**Sri R. P. Singh** Assistant Professor University Department of Chemistry, BBMKU, Dhanbad	**Internal Members**	21/09/2020
6.	**Dr. Dharmendra Kumar Singh** Assistant Professor University Department of Chemistry, BBMKU, Dhanbad	**Internal Members**	21.09.2020
7.	**Dr. Rajeev Pradhan** Assistant Professor Department of Chemistry P. K. Roy Memorial College, Dhanbad	**Internal Members**	21/9/2020
8.	**Dr. P. K. Jha** Assistant Professor Department of Chemistry B. S. City College, Bokaro	**Internal Members**	21/09/2020

SEMESTER I

COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-101-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-H-GE-101-T
ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Section A: Inorganic Chemistry-1 **(30 Lectures)**

Unit 1

Atomic Structure:

Review of: Bohr's theory and its limitations, Sommerfeld's model, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(14 Lectures)

Unit 2

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

(16 Lectures)

Section B: Organic Chemistry-1 **(30 Lectures)**

Unit 3

Fundamentals of Organic Chemistry: Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures)

Unit 4

Stereochemistry

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

(10 Lectures)

Unit 5

Aliphatic Hydrocarbons

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

Alkanes:

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

Alkenes:

(Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans -addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes:

(Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

(12 Lectures)

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-101-P

Credits: Theory-02 **Lectures: 30**
Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.
There will be two questions, out of which one is to be answered.
2. End Semester Examination (ESE): 3 Hrs.
There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-H-GE-101-P

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.

2. Estimation of oxalic acid by titrating it with $KMnO_4$.

3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Determination of M.P./B.P.

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
2. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
3. Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

SEMESTER II

COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-202-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-H-GE-202-T

CHEMICAL ENERGETICS EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

Section A: Physical Chemistry-1 **(30 Lectures)**

Unit 1

Chemical Energetics

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

(10 Lectures)

Unit 2

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^0, Le Chatelier's principle. Definitions of K_P, K_C and K_X. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

(8 Lectures)

Unit 3

Ionic Equilibria:

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.

(12 Lectures)

Section B: Organic Chemistry-2 **(30 Lectures)**

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

Unit 4

Aromatic hydrocarbons

Structure and aromatic character of benzene.

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene.

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

(10 Lectures)

Unit 5

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. *Preparation:* from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

(10 Lectures)

Unit 6

Alcohols and Phenols (Upto 5 Carbons)

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). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Fries rearrangement.

(10 Lectures)

Reference Books:

1. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
2. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
3. I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
5. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
6. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
7. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

8. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
9. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
10. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-202-P

Credits: 02 **Lectures: 30**
Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.
There will be two questions, out of which one is to be answered.
2. End Semester Examination (ESE): 3 Hrs.
There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-H-GE-202-P
CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.

2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

Ionic equilibria

pH measurements

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

b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

c) Study of the solubility of benzoic acid in water.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER III

COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-303-T

Credits: Theory-04 **Theory: 60 Hrs.**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-H-GE-303-T

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

Section A: Physical Chemistry-2 **(30 Lectures)**

Unit 1

Solutions

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.

(10 Lectures)

Unit 2

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur). **(7 Lectures)**

Unit 3

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Conductometric titrations (only acid-base). **(6 Lectures)**

Unit 4

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data. **(7 Lectures)**

Section B: Organic Chemistry-3

(30 Lectures)

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

Unit 5

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

(6 Lectures)

Unit 6

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons) *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

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

(6 Lectures)

Unit 7

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of –NH2 group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

(10 Lectures)

Unit 8

Carbohydrates:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose).

(8 Lectures)

Reference Books:

1. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
2. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
3. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
4. R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7 th Ed., W. H. Freeman.

COURSE (CHEMISTRY GE) for other Departments/Disciplines.

PAPER: CHE-H-GE-303-P

Credits: 02 **Lectures: 30**

Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.

There will be two questions, out of which one is to be answered.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-H-GE-303-P

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II

Section A: Physical Chemistry

Conductance

a) Determination of cell constant
b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
c) Perform the following conductometric titrations: i) Strong acid vs. strong base ii) Weak acid vs. strong base iii) Weak acid vs. strong base.

Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base and (ii) Weak acid vs strong base.

Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER IV
COURSE (CHEMISTRY GE) for other Departments/Disciplines.
PAPER: CHE-H-GE-404-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-H-GE-404-T

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

Unit 1

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

(4 Lectures)

Unit 2

***s*- and *p*-Block Elements**

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred- Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of *s*- and *p*-Block Elements Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane). Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH)

(26 Lectures)

Section B: Physical Chemistry-3 **(30 Lectures)**

Unit 3

Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.

(10 Lectures)

Unit 4

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

(10 Lectures)

Unit 5

Chemical Kinetics

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 (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and

Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(10 Lectures)

Reference Books:

1. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
2. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
3. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
4. R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7 th Ed., W. H. Freeman.

COURSE (CHEMISTRY GE) for other Departments/Disciplines.

PAPER: CHE-H-GE-404-P

Credits: 02 **Lectures: 30**

Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

There will be two questions, out of which one is to be answered.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-H-GE-404-P

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

Section A: Inorganic Chemistry

Semi-micro qualitative analysis of mixtures using H2S or any other scheme- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

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

Anions: CO_3^{2-}, S^{2-} , SO_3^- , NO_2^- , CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO^{42-} , PO_4^{3-} , BO_3^{3-} , $C_2O_4^{2-}$, F^-.

(Spot tests should be carried out wherever feasible).

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

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

(b) Study of the variation of surface tension of a detergent solution with concentration.

(2) Viscosity measurement (use of organic solvents excluded):

(a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.

(b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

Total Numbers of Papers and Marks semester wise for General Course with Practical/ Without Practical

TABLE - 05

SEM.	COURSE CODE	FULL MARKS	END SEMESTER MARKS	MID SEMESTER MARKS
I	CHE-G-DSC-101A-T	75	60	15
	CHE-G- DSC-101A-P	25	20	05
	TOTAL	**100**	**80**	**20**
II	CHE-G- DSC-201B-T	75	60	15
	CHE-G- DSC-201B-P	25	20	05
	TOTAL	**100**	**80**	**20**
III	CHE-G- DSC-301C-T	75	60	15
	CHE-G- DSC-301C-P	25	20	05
	TOTAL	**100**	**80**	**20**
IV	CHE-G- DSC-401D-T	75	60	15
	CHE-G- DSC-401D-P	25	20	05
	TOTAL	**100**	**80**	**20**
V	CHE-G-DSE-501A-T	75	60	15
	CHE-G-DSE-501A-P	25	20	05
	TOTAL	**100**	**80**	**20**
VI	CHE-G-DSE-601A-T	75	60	15
	CHE-G-DSE-601A-P	25	20	05
	TOTAL	**100**	**80**	**20**
	TOTAL (SEM I+II+III+IV+V+VI)	**600**	**480**	**120**

SEMESTER I

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G-DSC-101A-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G- DSC-101A-T
ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Section A: Inorganic Chemistry-1 **(30 Lectures)**

Unit 1

Atomic Structure:

Review of: Bohr's theory and its limitations, Sommerfeld's model, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(14 Lectures)

Unit 2

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

(16 Lectures)

Section B: Organic Chemistry-1 **(30 Lectures)**

Unit 3

Fundamentals of Organic Chemistry: Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

(8 Lectures)

Unit 4

Stereochemistry

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

(10 Lectures)

Unit 5

Aliphatic Hydrocarbons

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

Alkanes:

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

Alkenes:

(Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans -addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes:

(Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

(12 Lectures)

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G- DSC-101A-P

Credits: Theory-02 **Lectures: 30**
Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.
There will be two questions, out of which one is to be answered.
2. End Semester Examination (ESE): 3 Hrs.
There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G- DSC-101A-P

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.

2. Estimation of oxalic acid by titrating it with $KMnO_4$.

3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

Section B: Organic Chemistry

3. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
4. Determination of M.P./B.P.

Reference Books:

1. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
2. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
3. Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

SEMESTER II

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G-DSC-201B-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G-DSC-201B-T

CHEMICAL ENERGETICS EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

Section A: Physical Chemistry-1 **(30 Lectures)**

Unit 1

Chemical Energetics

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

(10 Lectures)

Unit 2

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^0, Le Chatelier's principle. Definitions of K_P, K_C and K_X. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

(8 Lectures)

Unit 3

Ionic Equilibria:

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.

(12 Lectures)

Section B: Organic Chemistry-2 **(30 Lectures)**

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

Unit 4

Aromatic hydrocarbons

Structure and aromatic character of benzene.

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene.

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

(10 Lectures)

Unit 5

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions. *Preparation:* from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

(10 Lectures)

Unit 6

Alcohols and Phenols (Upto 5 Carbons)

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). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Fries rearrangement.

(10 Lectures)

Reference Books:

1. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
2. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
3. I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
5. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
6. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
7. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

8. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
9. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
10. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G- DSC-201B-P

Credits: 02 **Lectures: 30**
Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.
There will be two questions, out of which one is to be answered.
2. End Semester Examination (ESE): 3 Hrs.
There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G-DSC-201B-P
CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.

2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

Ionic equilibria

pH measurements

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

b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

c) Study of the solubility of benzoic acid in water.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER III

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G-DSC-301C-T

Credits: Theory-04 **Theory: 60 Hrs.**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G-DSC-301C-T

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

Section A: Physical Chemistry-2 **(30 Lectures)**

Unit 1

Solutions

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.

(10 Lectures)

Unit 2

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur). **(7 Lectures)**

Unit 3

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Conductometric titrations (only acid-base). **(6 Lectures)**

Unit 4

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data. **(7 Lectures)**

Section B: Organic Chemistry-3

(30 Lectures)

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

Unit 5

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

(6 Lectures)

Unit 6

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons) *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

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

(6 Lectures)

Unit 7

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of –NH2 group, complexation with Cu^{2+} ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

(10 Lectures)

Unit 8

Carbohydrates:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose).

(8 Lectures)

Reference Books:

1. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
2. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
3. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
4. R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7 th Ed., W. H. Freeman.

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G-DSC-301C-P

Credits: 02 **Lectures: 30**
Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.
There will be two questions, out of which one is to be answered.
2. End Semester Examination (ESE): 3 Hrs.
There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G-DSC-301C-P

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II

Section A: Physical Chemistry

Conductance

d) Determination of cell constant
e) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
f) Perform the following conductometric titrations: i) Strong acid vs. strong base ii) Weak acid vs. strong base iii) Weak acid vs. strong base.

Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base and (ii) Weak acid vs strong base.

Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER IV
COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.
PAPER: CHE-G-DSC-401D-T

Credits: 04 **Lectures: 60**
Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G-DSC-401D-T

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

Unit 1

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

(4 Lectures)

Unit 2

***s*- and *p*-Block Elements**

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred- Rochow scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of *s*- and *p*-Block Elements Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements. Concept of multicentre bonding (diborane). Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH)

(26 Lectures)

Section B: Physical Chemistry-3 **(30 Lectures)**

Unit 3

Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.

(10 Lectures)

Unit 4

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

(10 Lectures)

Unit 5

Chemical Kinetics

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 (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and

Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(10 Lectures)

Reference Books:

1. G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
2. J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
3. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
4. R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) □ Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7 th Ed., W. H. Freeman.

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.

PAPER: CHE-G-DSC-401D-P

Credits: 02 **Lectures: 30**

Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.

There will be two questions, out of which one is to be answered.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 14 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G-DSC-401D-P

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

Section A: Inorganic Chemistry

Semi-micro qualitative analysis of mixtures using H2S or any other scheme- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

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

Anions: CO_3^{2-}, S^{2-} , SO_3^- , NO_2^- , CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO^{42-} , PO_4^{3-} , BO_3^{3-} , $C_2O_4^{2-}$, F^-.

(Spot tests should be carried out wherever feasible).

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

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

(b) Study of the variation of surface tension of a detergent solution with concentration.

(2) Viscosity measurement (use of organic solvents excluded):

(a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.

(b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

Reference Books:

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SEMESTER V

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.

PAPER: CHE-G-DSE-501A-T

Credits: 04 **Lectures: 60**

Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G-DSE-501A-T

GENERAL-V INDUSTRIAL CHEMICALS AND ENVIRONMENT

Unit 1

Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene. *Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(14 Lectures)

Unit 2

Environment and its segments

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO2 , CO2, CO, NOx, H2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates. *Water Pollution*: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

(30 Lectures)

Unit 3

Energy & Environment

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

(10 Lectures)

Unit 4

Biocatalysis

Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

(6 Lectures)

Reference Books:

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. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005). G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
8. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.

PAPER: CHE-G-DSE-501A-P

Credits: 02 **Lectures: 30**

Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.

There will be two questions, out of which one is to be answered.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G-DSE-501A-P

INDUSTRIAL CHEMICALS & ENVIRONMENT

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Percentage of available chlorine in bleaching powder.
4. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
5. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.

Reference Books:

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. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.

SEMESTER VI

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.

PAPER: CHE-G-DSE-601A-T

Credits: Theory-04 **Theory: 60 Hrs.**

Full Marks: 15 (MSE) + 60 (ESE) =75 **Pass Marks: (MSE: 06 +ESE: 24) = 30**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 1.5 Hrs.

The Mid Semester Examination shall have two components. (a) One Semester Internal Assessment Test (SIA) of 10 Marks. There will be three short type questions of 5 marks each, out of which two are to be answered. Each question may be subdivided into two or more parts (b) Class Attendance Score (CAS) & Day to day activities (DDA) of 5 marks.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A is compulsory and will contain two questions. Q. No. 1(A) will be multiple type six questions of 1 mark each. Q. No. 1(B) will contain two short answer type questions (max. 50 words) each of 3 marks. Group B will contain descriptive type eight questions of twelve marks each, out of which any four are to be answered. Each question may be subdivided into two or more parts.

PAPER: CHE-G-DSE-601A-T

GREEN CHEMISTRY

Unit 1:

Introduction to Green Chemistry:

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

(4 Lectures)

Unit 2:

Principles of Green Chemistry and Designing a Chemical synthesis:

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products (Atom Economy); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

(24 Lectures)

Unit 3:

Examples of Green Synthesis/ Reactions

1. Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural. 2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzole acid), Oxidation (of toluene, alcohols). Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation. Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2- dihydrotriazine derivatives; benzimidazoles. 3. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizaro reaction, Strecker synthesis, Reformatsky reaction. 4. Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate; Use of "Clayan", a nonmetallic oxidative reagent for various reactions; Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.

(24 Lectures)

Unit 4

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

(8 Lectures)

Reference Books:

1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry,
2. Anamalaya Publishers (2005).
3. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
4. A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
5. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
6. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

COURSE (CHEMISTRY GENERAL) for other Departments/Disciplines.

PAPER: CHE-G-DSE-601A-P

Credits: Theory-02 **Theory: 30 Hrs.**

Full Marks: 05 (MSE) + 20 (ESE) =25 **Pass Marks: (MSE: 02 +ESE: 08) = 10**

Instruction to Question Setter for

1. Mid Semester Examination (MSE): 3 Hrs.

There will be two questions, out of which one is to be answered.

2. End Semester Examination (ESE): 3 Hrs.

There will be two groups of questions. Group A will contain two questions out of which one is to be answered for 12 marks. Group B will contain marks for NOTE BOOK and VIVA-VOCE each of 04 marks.

PAPER: CHE-G-DSE-601A-P

1. **Safer starting materials**

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.

(a). Effect of concentration on clock reaction. (b) Effect of temperature on clock reaction. (if possible).

2. **Using renewable resources**

Preparation of biodiesel from vegetable oil.

3. **Avoiding waste**

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of propene by following method can be studied

(I) Triethylamine ion + OH^- → propene + trimethylpropene + water.

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

4. **Use of enzymes as catalysts**

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Alternative Green solvents

5. **Diels Alder reaction in water**

Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.

6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
7. Mechanochemical solvent free synthesis of azomethines
8. Co-crystal controlled solid state synthesis (C^2S^3) of N-organophthalimide using phthalic anhydride and 3-aminobenzoic acid.

Alternative sources of energy

9. Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
10. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

1. Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998). 2.
2. Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002). 3.
3. Ryan, M.A. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002). 4.
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).