

**HIMACHAL PRADESH UNIVERSITY**

**SHIMLA – 171005**

**SYLLABUS AND SCHEME**

**OF EXAMINATION**

**FOR**

**B. Sc. (HONOURS) CHEMISTRY**

**UNDER**

**CHOICE BASED CREDIT SYSTEM**

**2016 – 2017 ONWARDS**

**OUT LINES OF SYLLABI AND COURSES****IN THE SUBJECT OF CHEMISTRY FOR B. Sc. (Honours) CHEMISTRY 2016-2017 onwards**

Semester	Course Code	Course Name	Credit(s)	Total Credits
I (Odd)	<b>Ability Enhancement Compulsory Course – I</b>	<b>English/Hindi (Communications)/ Environmental Science</b>	<b>4</b>	<b>22</b>
	CHEM HN 101	Inorganic Chemistry	4	
	CHEM HN 101P	Inorganic Chemistry Lab	2	
	CHEM HN 102	Organic Chemistry	4	
	CHEM HN 102 P	Organic Chemistry Lab	2	
	Generic Elective Course – I GE 1	Generic Electric Course of discipline other than Chemistry (Theory)	4	
	Generic Elective Course – I P GE 1 (P)	Generic Electric Course of discipline other than Chemistry (Practical)	2	
II (Even)	<b>Ability Enhancement Compulsory Course - II</b>	<b>English/Hindi (Communications)/ Environmental Science</b>	<b>4</b>	<b>22</b>
	CHEM HN 203	Physical Chemistry	4	
	CHEM HN 203 P	Physical Chemistry Lab	2	
	CHEM HN 204	Inorganic Chemistry	4	
	CHEM HN 204 P	Inorganic Chemistry Lab	2	
	Generic Elective Course – II GE II	Generic Electric Course of discipline other than Chemistry (Theory)	4	
	Generic Elective Course –II P GE II (P)	Generic Electric Course of discipline other than Chemistry (Practical)	2	

Semester	Course Code	Course Name	Credit(s)	Total Credits
III (Odd)	CHEM HN SEC 301 or CHEM HN SEC 302	Basic Analytical Chemistry or Fuel Chemistry and Chemistry of Cosmetics & Perfumes	4	28
	CHEM HN 305	Organic Chemistry	4	
	CHEM HN 305 P	Organic Chemistry Lab	2	
	CHEM HN 306	Physical Chemistry	4	
	CHEM HN 306 P	Physical Chemistry Lab	2	
	CHEM HN 307	Inorganic Chemistry	4	
	CHEM HN 307 P	Inorganic Chemistry Lab	2	
	Generic Elective Course – III GE III	Generic Electric Course of discipline other than Chemistry (Theory)	4	
	Generic Elective Course – III P GE III (P)	Generic Electric Course of discipline other than Chemistry (Practical)	2	
IV (Even)	CHEM HN SEC 403 or CHEM HN SEC 404	Chemical Technology and Society & Business Skills for Chemistry or Pesticide Chemistry and Pharmaceutical Chemistry	4	28
	CHEM HN 408	Organic Chemistry	4	
	CHEM HN 408 P	Organic Chemistry Lab	2	
	CHEM HN 409	Physical Chemistry	4	
	CHEM HN 409 P	Physical Chemistry Lab	2	
	CHEM HN 410	Inorganic Chemistry	4	
	CHEM HN 410 P	Inorganic Chemistry Lab	2	
	Generic Elective Course – IV GE IV	Generic Electric Course of discipline other than Chemistry (Theory)	4	
	Generic Elective Course – IV P GE IV (P)	Generic Electric Course of discipline other than Chemistry (Practical)	2	

Semester	Course Code	Course Name	Credit(s)	Total Credits
<b>V</b> <b>(Odd)</b>	CHEM HN 511	Organic Chemistry	4	<b>24</b>
	CHEM HN 511 P	Organic Chemistry Lab	2	
	CHEM HN 512	Physical Chemistry	4	
	CHEM HN 512 P	Physical Chemistry Lab	2	
	CHEM HN DSE 501*	Polymer Chemistry	4	
	CHEM HN DSE501 P*	Polymer Chemistry Lab	2	
	CHEM HN DSE 502*	Industrial Chemicals and Environment	4	
	CHEM HN DSE502 P*	Industrial Chemicals and Environment Lab	2	
	CHEM HN DSE 503*	Quantum Chemistry, Spectroscopy and Photochemistry	4	
	CHEM HN DSE503 P*	Quantum Chemistry, Spectroscopy and Photochemistry Lab	2	
<b>VI</b> <b>(Even)</b>	CHEM HN 613	Organic Chemistry	4	<b>24</b>
	CHEM HN 613 P	Organic Chemistry Lab	2	
	CHEM HN 614	Physical Chemistry	4	
	CHEM HN 614 P	Physical Chemistry Lab	2	
	CHEM HN DSE 604*	Chemistry of Main group Elements, Theories of acids and Bases	4	
	CHEM HN DSE 604 P*	Chemistry of Main group Elements, Theories of acids and Bases Lab	2	
	CHEM HN DSE 605*	Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy	4	
	CHEM HN DSE 605 P*	Organometallics, Bioinorganic Chemistry, Polynuclear Hydrocarbons and UV, IR Spectroscopy Lab	2	
	CHEM HN DSE 606*	Molecules of Life	4	
CHEM HN DSE606 P*	Molecules of Life Lab	2		
			<b>Total Credits</b>	<b>148</b>

**\* Choose any two Discipline specific elective courses from three DSE courses in Semester V and Semester VI each.**

## Course Structure B. Sc. Honours (Chemistry)

### Details of courses under B.Sc. (Honours)

	<b>Credit</b>
<b>I. Core Course (14 papers)</b>	14X4 = 56
Core course practical (14 papers)	14X2 = 28
<b>II. Elective Courses (8 papers)</b>	
A.1. Discipline Specific Elective (4 papers)	4X4 = 16
A.2. Discipline Specific Elective Practical (4 papers)	4X2 = 8
B.1. Generic Specific Elective/Interdisciplinary (4 papers)	4X4 = 16
B.2. Generic Specific Elective Practical (4 papers)	4X2 = 8
Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester	
<b>III. Ability Enhancement Courses</b>	
<b>1. Ability Enhancement Compulsory</b> (2 Papers of 2 credit each)	2X4 = 8
Environmental Science, English/MIL Communication	
<b>2. Ability Enhancement Elective</b> (Skill Based) (Minimum 2) (2 Papers of 2 credit each)	2X4 = 8
<b>Total Credit</b>	<b>148</b>

# Comprehensive Continuance Assessment (CCA) and End-semester Examination (ESE) Scheme in Chemistry of Three years

## B.Sc. (Honours) Chemistry

### Scheme of Examination for every course except Skill enhancement course\*

English shall be the medium of instructions and Examinations.

Examinations shall be conducted at the end of each semester as per the academic calendar notified by H.P. University Shimla-5

Each course of 6 credits will carry 100 marks (theory + practical) and will have following components:

<b>1. Theory</b>	<b>70 marks</b>
<b>i) Comprehensive Continuous Assessment</b>	<b>20 marks</b>
a) Assignment/Quiz/Seminar/model/ Mid-Term Examination	15 marks
b) Attendance	05 marks
<b>ii) End- Semester Examination</b>	<b>50 marks</b>

<b>II. Practical</b>	<b>30 marks</b>
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Practical examination will have following components:

i) Performing the two practical exercises assigned by the examiner in terms of requirement of chemicals/apparatus/ theory/ reaction (if any) involved, procedure/ scheme/ observations/calculations and results.	20 marks
ii) viva-voce examination	5 marks
ii) Practical note book and regularity during practical classes	5 Marks

**{Theory Paper (CCA + End semester Examination) +Practical [(20 +50) +30] =100 marks}**

\* Each Skill Enhancement course will be of 4 credits and scheme of examination for these courses is as under:

**{CCA + End semester Examination [20 + 80] =100 marks}**

**Criterion for marks on the basis of Class-room attendance (0 - 5 marks)**

under component CCA/ IA be defined as follows:

- Attendance 75 -- 80% = 3 marks
- Attendance 81 – 90 % = 4 marks
- Attendance 91% and above = 5 marks
- Candidates securing 75% Attendance after condonation will not be entitled to get any marks.

**CORE COURSES**

**CHEMISTRY HONOURS**

**FIRST SEMESTER**  
**CHEM HN 101**  
**INORGANIC CHEMISTRY-I**

**Max. Marks: 50**

**Time Allowed: 3 Hours**

**Credits: 4**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION - A**

**Atomic Structure:**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of  $\psi$  and  $\psi^2$ . Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. **(14 Hours)**

**SECTION - B**

**Periodicity of Elements:**

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block.

- Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
- Atomic radii (van der Waals)
- Ionic and crystal radii.
- Covalent radii (octahedral and tetrahedral)
- Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
- Electron gain enthalpy, trends of electron gain enthalpy.
- Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio. **(16 Hours)**



## SECTION - C

### Chemical Bonding:

(i) **Ionic bond:** General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) **Covalent bond:** Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules  $N_2$ ,  $O_2$ ,  $C_2$ ,  $B_2$ ,  $F_2$ ,  $CO$ ,  $NO$ , and their ions;  $HCl$ ,  $BeF_2$ ,  $CO_2$ , (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding ( $\sigma$  and  $\pi$  bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. **(16 Hours)**

## SECTION - D

(iii) **Metallic Bond:** Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(iv) **Weak Chemical Forces:** van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

### Oxidation-Reduction:

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis to be carried out in class.

**(14 Hours)**

### Reference Books:

- Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
- Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970
- Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
- Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.

## CHEM HN 101 P

### INORGANIC CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

#### (A) Titrimetric Analysis

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarities/Normality of titrants

### **(B) Acid-Base Titrations**

- (i) Estimation of carbonate and hydroxide present together in mixture.
- (ii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iii) Estimation of free alkali present in different soaps/detergents

### **(C) Oxidation-Reduction Titrimetry**

- (i) Estimation of Fe(II) and oxalic acid using standardized  $\text{KMnO}_4$  solution.
- (ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iii) Estimation of Fe(II) with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal (diphenylamine, anthranilic acid) and external indicator.

### **Reference Book**

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

## **FIRST SEMESTER**

### **CHEM HN 102**

### **ORGANIC CHEMISTRY**

**Max. Marks: 50**

**Time Allowed: 3 Hours**

**Credits: 4**

**Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

### **SECTION - A**

#### **Basics of Organic Chemistry:**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions. **(10 Hours)**

### **SECTION - B**

### **Stereochemistry:**

Fischer Projection, Newman and Sawhorse Projection formulae and their inter conversions; Geometrical isomerism: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Diastereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

**(15 Hours)**

## **SECTION - C**

### **Chemistry of Aliphatic Hydrocarbons**

#### **Carbon-Carbon sigma bonds**

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

#### **Carbon-Carbon pi bonds:**

Formation of alkenes and alkynes by elimination reactions, Mechanism of E<sub>1</sub> and E<sub>2</sub>, reactions. Saytzeff and Hofmann eliminations.

**Reactions of alkenes:** Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

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

**(20 Hours)**

## **SECTION - D**

### **Cycloalkanes and Conformational Analysis**

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformations of ethane, butane and cyclohexane (Chair, Boat and Twist boat forms). Relative stability and potential energy diagrams.

### **Aromatic Hydrocarbons**

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

**(15 Hours)**

### **Reference Books:**

- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
- Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

## **CHEM HN 102 P**

### **ORGANIC CHEMISTRY LAB**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
  - a. Water
  - b. Alcohol
  - c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
  - a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
  - b. Separation of a mixture of two sugars by ascending paper chromatography
  - c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

#### **Reference Books**

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

**SEMESTER II**  
**CHEM HN 203**  
**PHYSICAL CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION - A**

**Gaseous state:**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of  $\sigma$  from  $\eta$ ; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor,  $Z$ , and its variation with pressure for different gases. Causes of deviation from ideal behaviour.

Van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**(20 Hours)**

**SECTION - B**

**Liquid state:**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Qualitative discussion of structure of water.

**(10 Hours)**

## SECTION - C

### Solid state:

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

(12 Hours)

## SECTION - D

### 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; dissociation constants of mono-, di- and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

(18 Hours)

### Reference Books

- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University 12 Press (2014).
- Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).

CHEM HN 203 P

PHYSICAL CHEMISTRY LAB

TIME ALLOWED: 03 HOURS

Max Marks: 30

Credits - 2

### **1. Surface tension measurements.**

- a. Determine the surface tension by (i) drop number (ii) drop weight method.
- b. Study the variation of surface tension of detergent solutions with concentration.

### **2. Viscosity measurement using Ostwald's viscometer.**

- a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
- b. Study the variation of viscosity of sucrose solution with the concentration of solute.

### **3. Indexing of a given powder diffraction pattern of a cubic crystalline system.**

### **4. pH metry**

- a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
  - b. Preparation of buffer solutions of different pH
    - i. Sodium acetate-acetic acid
    - ii. Ammonium chloride-ammonium hydroxide
  - c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
  - d. Determination of dissociation constant of a weak acid.
- Any other experiment carried out in the class.

### **Reference Books**

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

## CHEM HN 204

### INORGANIC CHEMISTRY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

### SECTION - A

#### General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

#### Acids and Bases

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. (18 Hours)

### SECTION - B

#### Chemistry of s and p Block Elements:

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements.

Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses:

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

(20 Hours)



## SECTION - C

### Noble Gases:

Occurrence and uses, rationalization of inertness of noble gases, Clathrates, preparation and properties of  $\text{XeF}_2$ ,  $\text{XeF}_4$  and  $\text{XeF}_6$ . Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for  $\text{XeF}_2$ ). Molecular shapes of noble gas compounds (VSEPR theory).

(10 Hours)

## SECTION - D

### Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes, Borazines, silicates and phosphazenes, and polysulphates.

(12 Hours)

### Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. Chemistry of the Elements, ButterworthHeinemann. 1997.
- Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

## CHEM HN 204 P INORGANIC CHEMISTRY LAB

TIME ALLOWED: 03 HOURS

Max Marks: 30

Credits - 2

### (A) Iodo/Iodimetric Titrations

- (i) Estimation of Cu(II) and  $\text{K}_2\text{Cr}_2\text{O}_7$  using sodium thiosulphate solution (Iodimetrically).
- (ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
- (iii) Estimation of available chlorine in bleaching powder iodometrically.

### (B) Inorganic preparations

- (i) Cuprous Chloride,  $\text{Cu}_2\text{Cl}_2$
- (ii) Preparation of Manganese(III) phosphate,  $\text{MnPO}_4 \cdot \text{H}_2\text{O}$
- (iii) Preparation of Aluminium potassium sulphate  $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$  (Potash alum)

### Reference Books:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

**SEMESTER III**  
**CHEM HN 305**  
**ORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION - A**

**Chemistry of Halogenated Hydrocarbons:**

**Alkyl halides:** Methods of preparation, nucleophilic substitution reactions –  $S_N^1$ ,  $S_N^2$  and  $S_N^i$  mechanisms with stereochemical aspects and effect of solvent etc.; Nucleophilic substitution vs elimination.

**Aryl halides:** Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution;  $S_N^{Ar}$ , Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**(15 Hours)**

**SECTION - B**

**Alcohols, Phenols, Ethers and Epoxides:**

**Alcohols:** preparation, properties and relative reactivity of  $1^\circ$ ,  $2^\circ$ ,  $3^\circ$  alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

**Phenols:** Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer-Tiemann and Kolbe's-Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

**Ethers and Epoxides:** Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and  $LiAlH_4$ .

**(15 Hours)**

**SECTION - C**

### **Carbonyl Compounds:**

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, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation,  $\alpha$ substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

**(15 Hours)**

### **SECTION - D**

#### **Carboxylic Acids and their Derivatives:**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

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 bromide degradation and Curtius rearrangement.

#### **Sulphur containing compounds:**

Preparation and reactions of thiols, thioethers and sulphonic acids.

**(15 Hours)**

#### **Reference Books:**

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

**CHEM HN 305 P**  
**ORGANIC CHEMISTRY LAB**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
2. Organic preparations:
  - i) Acetylation of one of the following compounds: amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and phenols ( $\beta$ -naphthol, vanillin, salicylic acid) by any one method:
    - a. Using conventional method.
    - b. Using green approach
  - ii) Benzoylation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p-anisidine) and one of the following phenols ( $\beta$ -naphthol, resorcinol, p - cresol) by Schotten-Baumann reaction.
  - iii) Oxidation of ethanol/ isopropanol (Iodoform reaction).
  - iv) Bromination of any one of the following:
    - a. Acetanilide by conventional methods
    - b. Acetanilide using green approach (Bromate-bromide method)
  - v) Nitration of any one of the following:
    - a. Acetanilide/nitrobenzene by conventional method
    - b. Salicylic acid by green approach (using ceric ammonium nitrate).
  - vi) Selective reduction of m-dinitrobenzene to m-nitroaniline.
  - vii) Reduction of p-nitrobenzaldehyde by sodium borohydride.
  - viii) Hydrolysis of amides and esters.
  - ix) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
  - x) S-Benzylisothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
  - xi) Aldol condensation using either conventional or green method.
  - xii) Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

**Reference Books**

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

## SEMESTER III

### CHEM HN 306

#### PHYSICAL CHEMISTRY

Max. Marks: 50

Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION -A

##### Chemical Thermodynamics:

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

**First law:** Concept of heat,  $q$ , work, internal energy,  $U$ , and statement of first law; enthalpy,  $H$ , relation between heat capacities, calculations of  $q$ ,  $w$ ,  $U$  and  $H$  for reversible, irreversible and free expansion of gases (ideal and real) under isothermal and adiabatic conditions.

Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**Thermochemistry:** Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

(15 Hours)

#### SECTION-B

**Second Law:** Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

**Third Law:** Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

**Free Energy Functions:** Gibbs and Helmholtz energy; variation of  $S$ ,  $G$ ,  $A$  with  $T$ ,  $V$ ,  $P$ ; Free energy change and spontaneity.

##### Systems of Variable Composition:

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

**(15 Hours)**

### **SECTION-C**

#### **Chemical Equilibrium:**

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants  $K_p$ ,  $K_c$  and  $K_x$ . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

**(14 Hours)**

### **SECTION-D**

#### **Solutions and Colligative Properties:**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.

Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

**(16 Hours)**

#### **Reference Books**

- Peter, A. & Paula, J. de. Physical Chemistry 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Levine, I.N. Physical Chemistry 6th Ed., Tata McGraw Hill (2010).
- Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006).

## CHEM HN 306 P

### PHYSICAL CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

**Thermochemistry**

- (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
- (b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
- (c) Calculation of the enthalpy of ionization of ethanoic acid.
- (d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
- (e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
- (f) Determination of enthalpy of hydration of copper sulphate.
- (g) Study of the solubility of benzoic acid in water and determination of  $\Delta H$ .
- Any other experiment carried out in the class.

#### **Reference Books**

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).

**SEMESTER III**  
**CHEM HN 307**  
**INORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Coordination Chemistry:**

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of  $10 Dq$  ( $\Delta_o$ ), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of  $10 Dq$  ( $\Delta_o$ ,  $\Delta_t$ ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes. **(15 Hours)**

**SECTION-B**

**Transition Elements:**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. **(15 Hours)**

**SECTION-C**

Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)

**Lanthanides and Actinides:** Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides and actinides (ion-exchange method only). **(13 Hours)**

**SECTION-D**



### **Bioinorganic Chemistry:**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace elements. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron. **(17 Hours)**

### **Reference Books:**

- Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
- Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
- Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A. Chemistry of the Elements, ButterworthHeinemann, 1997.

### **CHEM HN 307 P**

### **INORGANIC CHEMISTRY LAB**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

#### **Gravimetric Analysis:**

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as CuSCN
- iii. Estimation of iron as Fe<sub>2</sub>O<sub>3</sub> by precipitating iron as Fe(OH)<sub>3</sub>.
- iv. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)<sub>3</sub> (aluminium oxinate).

#### **Inorganic Preparations:**

- i. Tetraamminecopper (II) sulphate, [Cu(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>.H<sub>2</sub>O .
- ii. Cis and trans Potassium dioxalatochromate (III) K[Cr(C<sub>2</sub>O<sub>4</sub>)<sub>2</sub>.(H<sub>2</sub>O)<sub>2</sub>].
- iii. Tetraamminecarbonatocobalt (III) ion
- iv. Potassium tris(oxalate)ferrate(III).

#### **Chromatography of metal ions**

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

- i. Ni (II) and Co (II)
- ii. Fe (III) and Al (III)

#### **Reference Book:**

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

**SEMESTER IV**  
**CHEM HN 408**  
**ORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Nitrogen Containing Functional Groups**

Preparation and important reactions of nitro and 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.

**(15 Hours)**

**SECTION-B**

**Polynuclear Hydrocarbons**

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

**(10 Hours)**

**SECTION-C**

**Heterocyclic Compounds**

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis,

Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction

Derivatives of furan: Furfural and furoic acid.

**(15 Hours)**

### **SECTION-D**

#### **Alkaloids**

Natural occurrence, General structural features, Isolation and their physiological action

Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

**(13 Hours)**

#### **Terpenes**

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and  $\alpha$ -terpineol.

**(7 Hours)**

#### **Reference Books:**

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, PrajatiParakashan (2010).

## CHEM HN 408 P

### ORGANIC CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**  
**Max Marks: 30**

**Credits - 2**

1. Detection of extra elements.
2. Functional group test for nitro, amine and amide groups.
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols, amides and carbohydrates).

#### **Reference Books:**

- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

**SEMESTER IV**  
**CHEM HN 409**  
**PHYSICAL CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION-A**

**Phase Equilibria:**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. **(14 Hours)**

**SECTION-B**

Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.

Nernst distribution law: its derivation and applications. **(16 Hours)**

**SECTION-C**

**Chemical Kinetics**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

**(15 Hours)**

#### **SECTION-D**

##### **Catalysis:**

Types of catalysts, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

##### **Surface chemistry:**

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

**(15 Hours)**

##### **Reference Books:**

- Peter Atkins & Julio De Paula, Physical Chemistry 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).
- Zundhal, S.S. Chemistry concepts and applications Cengage India (2011).
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).

#### **CHEM HN 409 P**

#### **PHYSICAL CHEMISTRY LAB**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

- I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
- II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a) simple eutectic b) congruently melting systems.
- III. Distribution of acetic/ benzoic acid between water and cyclohexane.
- IV. Study the equilibrium of at least one of the following reactions by the distribution method:
  - a)  $I_2(aq) + I^- \rightarrow I_3^-(aq)$
  - b)  $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

V. Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
  - a. Acid hydrolysis of methyl acetate with hydrochloric acid.
  - b. Saponification of ethyl acetate.
3. Compare the strengths of HCl and H<sub>2</sub>SO<sub>4</sub> by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption

1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

**Reference Books:**

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**SEMESTER IV**  
**CHEM HN 410**  
**INORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Allowed: 3 Hours**  
**Credits: 4**

**Time**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Theoretical Principles in Qualitative Analysis (H<sub>2</sub>S Scheme)**

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

**(14 Hours)**

**SECTION-B**

**Organometallic Compounds**

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 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.  $\pi$ -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.

**(16 Hours)**

**SECTION-C**



**Metal Alkyls:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

**Ferrocene:** Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

**(15 Hours)**

## SECTION-D

### Reaction Kinetics and Mechanism:

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

### Catalysis by Organometallic Compounds:

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes

**(15 Hours)**

### Reference Books:

- Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996.
- Cotton, F.A.G.; Wilkinson & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India.
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
- Lee, J.D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.
- Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
- Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
- Basolo, F. & Pearson, R. Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution 2nd Ed., John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., Inorganic Chemistry, W.B. Saunders Co. 1977.
- Miessler, G. L. & Tarr, D.A. Inorganic Chemistry 4th Ed., Pearson, 2010.
- Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.

- Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. j New York, NY: John Wiley, 2000.
- Spessard, G. O. & Miessler, G.L. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.

## CHEM HN 410 P

### INORGANIC CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

- I. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

$\text{CO}_3^{2-}$ ,  $\text{NO}_2^-$ ,  $\text{S}^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}_2\text{O}_3^{2-}$ ,  $\text{CH}_3\text{COO}^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{BO}_3^{3-}$ ,  $\text{C}_2\text{O}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NH}_4^+$ ,  $\text{K}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$

Mixtures should preferably contain one interfering anion, or insoluble component ( $\text{BaSO}_4$ ,  $\text{SrSO}_4$ ,  $\text{PbSO}_4$ ,  $\text{CaF}_2$  or  $\text{Al}_2\text{O}_3$ ) or combination of anions e.g.  $\text{CO}_3^{2-}$  and  $\text{SO}_3^{2-}$ ,  $\text{NO}_2^-$  and  $\text{NO}_3^-$ ,  $\text{Cl}^-$  and  $\text{Br}^-$ ,  $\text{Cl}^-$  and  $\text{I}^-$ ,  $\text{Br}^-$  and  $\text{I}^-$ ,  $\text{NO}_3^-$  and  $\text{Br}^-$ ,  $\text{NO}_3^-$  and  $\text{I}^-$ . Spot tests should be done whenever possible.

II.

- i. Measurement of  $10 Dq$  by spectrophotometric method
- ii. Verification of spectrochemical series.
- iii. Controlled synthesis of two copper oxalate hydrate complexes: kinetics thermodynamic factors.
- iv. Preparation of acetylacetonato complexes of  $\text{Cu}^{2+}/\text{Fe}^{3+}$ . Find the  $\lambda_{\text{max}}$  of the complex.
- v. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonate, DMG, glycine) by substitution method.

#### Reference Books

- Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla. Pearson Education, 2002.
- Marr & Rockett Practical Inorganic Chemistry. John Wiley & Sons 1972.

**SEMESTER V**  
**CHEM HN 511**  
**ORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Carbohydrates**

Occurrence, classification and their biological importance.

**Monosaccharides:** Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Inter conversion of aldoses and ketoses; Killiani Fischer synthesis and Ruff degradation;

**Disaccharides:** Structure elucidation of maltose, lactose and sucrose.

**Polysaccharides:** Elementary treatment of starch, cellulose and glycogen. **(15 Hours)**

**SECTION-B**

**Nucleic Acids**

Components of nucleic acids, Nucleosides and nucleotides;

Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides. **(13 Hours)**

**SECTION-C**

**Amino Acids, Peptides and Proteins**

Amino acids, Peptides and their classification.

**$\alpha$ -Amino Acids:** Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis;

**Study of peptides:** Determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

**Enzymes:** Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition). **(18 Hours)**

#### SECTION-D

**Lipids:** Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

**Concept of Energy in Biosystems:** Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD<sup>+</sup>, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. Overview of catabolic pathways of fat and protein. Inter relationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types. **(14 Hours)**

#### Reference Books:

- Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) Biochemistry. 6th Ed. W.H. Freeman and Co.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) Principles of Biochemistry. IV Edition. W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.

#### CHEM HN 511 P

#### ORGANIC CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

#### Reference Books:

- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. V. Quantitative Organic Analysis, Pearson

## SEMESTER V

### CHEM HN 512

### PHYSICAL CHEMISTRY

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

#### **Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION -A

##### **Conductance - I**

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-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. **(15 Hours)**

#### SECTION-B

##### **Conductance - 2**

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications 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) conductometric titrations, and (v) hydrolysis constants of salts.

**(15 Hours)**

#### SECTION-C

##### **Electrochemistry**

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.

Chemical 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  $\text{SbO/Sb}_2\text{O}_3$  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). **(16 Hours)**

## SECTION-D

### Electrical & Magnetic Properties of Atoms and Molecules:

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation. **(14 Hours)**

### Reference Books:

- Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- Rogers, D. W. Concise Physical Chemistry Wiley (2010).
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).

## CHEM HN 512 P

### PHYSICAL CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

#### Conductometry

- I. Determination of cell constant
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
- III. Perform the following conductometric titrations:
  - a. Strong acid vs. strong base
  - b. Weak acid vs. strong base
  - c. Mixture of strong acid and weak acid vs. strong base
  - d. Strong acid vs. weak base

#### Potentiometry

- I. Perform the following potentiometric titrations:
  - a) Strong acid vs. strong base
  - b) Weak acid vs. strong base

- c) Dibasic acid vs. strong base
- d) Potassium dichromate vs. Mohr's salt

**Reference Books:**

- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**SEMESTER VI**  
**CHEM HN 613**  
**ORGANIC CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Organic Spectroscopy**

General principles Introduction to absorption and emission spectroscopy.

**UV Spectroscopy:** Types of electronic transitions,  $\lambda_{\max}$ , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of  $\lambda_{\max}$  for the following systems:  $\alpha$ ,  $\beta$  unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

**IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.  
**(15 Hours)**

**SECTION-B**

**NMR Spectroscopy:** Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Applications of IR, UV and NMR for identification of simple organic molecules. **(15 Hours)**

**SECTION-C**

**Dyes:** Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples. **(14 Hours)**



## SECTION-D

**Polymers:** Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

**Polymerisation reactions:** Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based 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; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples. **(16 Hours)**

### Reference Books:

- Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
- Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, PrajatiPrakashan (2010).
- Kemp, W. Organic Spectroscopy, Palgrave.
- Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India Ed. (2015).

## CHEM HN 613 P

### ORGANIC CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.

5. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

**Reference Books:**

- Vogel, A.I. Quantitative Organic Analysis, Part 3, Pearson (2012).
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press (2000).

**SEMESTER VI**

**CHEM HN 614**

**PHYSICAL CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION -A**

**Quantum Chemistry I**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. 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, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

**(15 Hours)**

## **SECTION-B**

### **Quantum Chemistry II**

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

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).

**Chemical bonding:** Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $H^{2+}$ . Bonding and antibonding orbitals. Qualitative extension to  $H_2$ . Comparison of LCAO-MO and VB treatments of  $H_2$  (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic ( $BeH_2$ ,  $H_2O$ ) molecules. Qualitative MO theory and its application to  $AH_2$  type molecules. **(15 Hours)**

## **SECTION-C**

### **Molecular Spectroscopy:**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born - Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

**Vibrational spectroscopy:** Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

**Raman spectroscopy:** Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

**Electronic spectroscopy:** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. **(15 Hours)**

### SECTION-D

**Nuclear Magnetic Resonance (NMR) spectroscopy:** Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

### Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence. **(15 Hours)**

### Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).

### CHEM HN 614 P

### PHYSICAL CHEMISTRY LAB

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

### UV/Visible spectroscopy

- I. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units (J molecule<sup>-1</sup>,  $\text{kJ mol}^{-1}$ ,  $\text{cm}^{-1}$ , eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

### Colourimetry

- I. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- II. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.

- III. Study the kinetics of iodination of propanone in acidic medium.
- IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- V. Determine the dissociation constant of an indicator (phenolphthalein).
- VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
- VII. Analysis of the given vibration-rotation spectrum of HCl(g)

#### **Reference Books**

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

**Skill Enhancement Courses**

**(any two)**

**One Each in Semesters**

**(3<sup>rd</sup> and 4<sup>th</sup>)**

**(Credit: 04 each)**

**SEMESTER - III**  
**CHEM HN SEC 301**  
**BASIC ANALYTICAL CHEMISTRY**

**Max. Marks: 80**  
**Credits: 4**

**Time allowed: 03 Hours**

**Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Section E will be of 20 marks and consists of 10 objective type questions (in MCQ/true and false / fill in the blanks) of one mark each and 5 short answer questions of two marks each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION – A**

**Introduction:** 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:** 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 as Calcium carbonate by complexometric titration. **(15 Hours)**

**SECTION – B**

**Analysis of water:** 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:** 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, chilli powder, turmeric powder, coriander powder and pulses, etc. b. Analysis of preservatives and colouring matter. **(18 Hours)**

**SECTION – C**

**Chromatography:** Definition, general introduction on principles of chromatography, paper chromatography, TLC etc. a. Paper chromatographic separation of mixture of metal ion ( $\text{Fe}^{3+}$  and  $\text{Al}^{3+}$ ). b. To compare paint samples by TLC method. Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible). **(12 Hours)**

## SECTION - D

**Analysis of cosmetics:** 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. **Suggested Applications (Any one):**

a. To study the use of phenolphthalein in trap cases. b. To analyze arson accelerants. c. To carry out analysis of gasoline.

**Suggested Instrumental demonstrations:**

a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink  
**(15 Hours)**

**Reference Books:**

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.
2. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
5. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
10. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Prentice Hall.
11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).



**SEMESTER – III**  
**CHEM HN SEC 302**  
**FUEL CHEMISTRY**

&  
**CHEMISTRY OF COSMETICS & PERFUMES**

**Max. Marks: 80**

**Time allowed: 03 Hours**

**Credits: 4**

**Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Section E will be of 20 marks and consists of 10 objective type questions (in MCQ/true and false / fill in the blanks) of one mark each and 5 short answer questions of two marks each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION-A**

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

Coal: 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, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications. **(18 Hours)**

**SECTION-B**

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

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) and their determination. **(18 Hours)**

**SECTION-C**

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. **(12 Hours)**

**SECTION-D**

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. **(12 Hours)**

**Reference Books:**

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

4. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990). 2.
5. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
6. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

## SEMESTER – VI CHEM HN SEC 403

### CHEMICAL TECHNOLOGY & SOCIETY and BUSINESS SKILLS FOR CHEMISTRY

Max. Marks: 80  
Credits: 4

Time allowed: 03 Hours

#### Note for Examiners and Students:

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 15 marks each and may contain more than one part. Section E will be of 20 marks and consists of 10 objective type questions (in MCQ/true and false / fill in the blanks) of one mark each and 5 short answer questions of two marks each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION-A

##### Chemical Technology

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.  
(18 Hours)

#### SECTION-B

##### Society

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.  
(18 Hours)

#### SECTION - C

##### Business Basics

Key business concepts: Business plans, market need, project management and routes to market.

## **Chemistry in Industry**

Current challenges and opportunities for the chemistry-using industries, role of chemistry in India and global economies. **(12 Hours)**

### **SECTION – D**

**Making money** - Financial aspects of business with case studies

**Intellectual property** - Concept of intellectual property, patents. **(12 Hours)**

#### **Reference Books:**

1. [www.rsc.org](http://www.rsc.org)
2. John W. Hill, Terry W. McCreary & Doris K. Kolb, Chemistry for changing times 13th Ed.

# SEMESTER VI

## CHEM HN SEC 404

### PESTICIDE CHEMISTRY & PHARMACEUTICAL CHEMISTRY

Max. Marks: 80  
Credits: 4

Time allowed: 03 Hours

#### Note for Examiners and Students:

1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **15** marks each and may contain more than one part. Section E will be of **20** marks and consists of 10 objective type questions (in MCQ/true and false / fill in the blanks) of **one** mark each and 5 short answer questions of **two** marks each covering the entire paper.
2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.

#### SECTION-A

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship. **(12 Hours)**

#### SECTION-B

Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion ); Carbamates (Carbofuran and carbaryl); Quinones ( Chloranil), Anilides (Alachlor and Butachlor). **(15 Hours)**

#### SECTION - C

Drugs & Pharmaceuticals Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, antiinflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine). **(18 Hours)**

#### SECTION -D

Fermentation Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C. **(15 Hours)**

#### Reference Books:

1. G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK
2. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.

3. William O. Foye, Thomas L., Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.
5. Cremlyn, R. Pesticides. Preparation and Modes of Action, John Wiley & Sons, New York, 1978.

**Discipline Specific Electives (DSE) Courses**

**DSE-1-DSE-6**

**(Four papers: two each in 5<sup>th</sup> and 6<sup>th</sup> semester)**

**(Credits: Theory-04/Practical-02)**

**SEMESTER - V**  
**CHEM HM DSE 501**  
**POLYMER CHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of **10** marks each and may contain more than one part. Section E will be of **10** marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of **one** mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION - A**

**Introduction and history of polymeric materials:**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers. Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems. **(15 Hours)**

**SECTION - B**

**Kinetics of Polymerization:**

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

**Crystallization and crystallinity:**

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships. **(15 Hours)**

**SECTION - C**

Determination of molecular weight of polymers ( $M_n$ ,  $M_w$ , etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass transition temperature ( $T_g$ ) and determination of  $T_g$ , Free volume theory, WLF equation, Factors affecting glass transition temperature ( $T_g$ ).

**Polymer Solution** – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory-Huggins theory, Lower and Upper critical solution temperatures. **(16 Hours)**

## SECTION - D

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene). **(14 Hours)**

### Reference Books:

1. Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, 1981.
2. Odian, G. Principles of Polymerization, 4th Ed. Wiley, 2004.
3. Billmeyer, F.W. Textbook of Polymer Science, 2nd Ed. Wiley Interscience, 1971.
4. Ghosh, P. Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
5. Lenz, R.W. Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1967.

## LAB COURSE

CHEM HN DSE 501 P

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

### I. Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).

a. Purification of monomer

b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutyronitrile (AIBN)

2. Preparation of nylon 66

3. Redox polymerization of acrylamide

4. Precipitation polymerization of acrylonitrile

5. Preparation of urea-formaldehyde resin

6. Preparations of novalac resin/resold resin.

7. Microscale Emulsion Polymerization of Poly(methylacrylate).



## II. Polymer characterization

1. Determination of molecular weight by viscometry:

(a) Polyacrylamide-aq. NaNO<sub>2</sub> solution

(b) (Poly vinyl propylidene (PVP) in water

2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.

3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group). 4. Testing of mechanical properties of polymers. 5. Determination of hydroxyl number of a polymer using colorimetric method.

\*At least 7 experiments to be carried out.

### Reference Books:

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

**SEMESTER - V**  
**CHEM HN DSE 502**

**INDUSTRIAL CHEMICALS AND ENVIRONMENT**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION - A**

**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 Hours)**

**SECTION - B**

**Industrial Metallurgy**

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.

Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process. Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

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 SO<sub>2</sub>, CO<sub>2</sub>, CO, NO<sub>x</sub>, H<sub>2</sub>S and other foul smelling gases. Methods of estimation of CO, NO<sub>x</sub>, SO<sub>x</sub> 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. **(16 Hours)**

### SECTION - C

**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.

Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water. **(16 Hours)**

### SECTION - D

#### 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.

Biocatalysis: Introduction to biocatalysis: Importance in “Green Chemistry” and Chemical Industry. **(14 Hours)**

#### 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).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).

# LAB COURSE

CHEM HN DSE 502 P

TIME ALLOWED: 03 HOURS

Max Marks: 30

Credits - 2

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ( $\text{AgNO}_3$  and potassium chromate).
6. Estimation of total alkalinity of water samples ( $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ) using double titration method.
7. Measurement of dissolved  $\text{CO}_2$ .
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

## 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.

**SEMESTER - V**  
**CHEM HN DSE 503**

**QUANTUM CHEMISTRY, SPECTROSCOPY & PHOTOCHEMISTRY**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

- 1. The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- 2. The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION – A**

**Quantum Chemistry**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, 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, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

**(16 Hours)**

**SECTION - B**

**Molecular Spectroscopy**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental

frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. **(16 Hours)**

### SECTION - C

#### Raman spectroscopy

Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

#### Electronic spectroscopy

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

**Nuclear Magnetic Resonance (NMR) spectroscopy:** Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: It's principle and hyperfine structure, ESR of simple radicals. **(16 Hours)**

### SECTION - D

#### Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence. **(12 Hours)**

#### Reference Books:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
5. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).

## LAB COURSE

### CHEM HN DSE 503 P

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

- I. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units (J molecule<sup>-1</sup>, kJ mol<sup>-1</sup>, cm<sup>-1</sup>, eV).
- II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.
- IV. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4$ /  $\text{KMnO}_4$ /  $\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
- V. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
- VI. Study the kinetics of iodination of propanone in acidic medium.
- VII. Determine the amount of iron present in a sample using 1,10-phenanthroline.
- VIII. Determine the dissociation constant of an indicator (phenolphthalein).
- IX. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide. VII. Analyse the given vibration-rotation spectrum of  $\text{HCl}(\text{g})$

### Reference Books

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

# SEMESTER - VI

## CHEM HN DSE 604

### CHEMISTRY OF MAIN GROUP ELEMENTS, THEORIES OF ACIDS AND BASES

Max. Marks: 50

Time Allowed: 3 Hours

Credits: 4

Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION-A

##### Acids and Bases

Arrhenius, Bronsted and Lowry, Lewis, Lux flood and solvent system concepts of acids and bases. Classification of acids and bases as hard and soft. Pearson's HSAB concept, application of HSAB principle. Relative strength of acids and bases and effect of substituents and solvent on their strength. (12 Hours)

#### SECTION - B

##### Hydrogen

Unique position of Hydrogen in the periodic table, isotopes, ortho and para hydrogen, Industrial production, Hydrides and their chemistry, Heavy water, Hydrogen bonding, Hydrates.

##### S-Block Elements

Periodicity of elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity( Pauling Scale). General characteristics of s-block elements like density, melting points, flame colouration and reducing character, solvation and complexation tendencies and solutions of metals in liquid ammonia. (16 Hours)

#### SECTION – C

##### P- Block Elements

Comparative studies including diagonal relationship of group 13 and 14 elements. Borohydrides, Hydrides, oxide and oxy-acids and halides of boron, borax, Borazine, allotropic forms of carbon, fullerenes, carbides of calcium and silicon, silanes, structure of silicate minerals and silicones. Hydrides, oxides, oxoacids and halides of nitrogen. Allotropic forms of phosphorous. Hydrides, halides, oxides and oxyacids of phosphorous. Basic properties of halogens and inter halogen compounds, pseudohalogens and poly halides. (20 Hours)

#### SECTION – D

##### Noble Gases

Occurrence of noble gases, History of discovery of noble gases and isolation of noble gases from air. Preparation properties and structure of important compounds of noble gases-fluorides, oxides, oxyfluorides of xenon (valence bond structure only). Krypton difluoride and clathrate compounds of noble gases. (12 Hours)



**Books Recommended:**

1. Concise inorganic Chemistry 4<sup>th</sup> Edn. By J. D.Lee.
2. Inorganic Chemistry by T. Moeller.
3. Advanced Inorganic Chemistry by Cotton And Wilkinson.
4. Inorganic Chemistry by J.E.Huheey.
5. Theoretical Inorganic Chemistry by Day & Selbin.
6. Canham, G.R. & Overton, T. Descriptive inorganic chemistry. Freeman & Co. 2006.
7. Purecell, K.F. & Kotz J.C. Inorganig Chemistry. W.B. Saunders & Co. 1977.
8. Basolo, F. & Pearson, R.C. Mechanisms of Inorganic chemistry. John Wiley 7 Sons, NY, 1967.
9. Chemistry of Elements by Greenwood, N.N. & Earnshaw. Butterworth – Heinemann 1997.

**LAB COURSE****CHEM HN DSE 604 P****TIME ALLOWED: 03 HOURS****Max Marks: 30****Credits - 2**

1. Iodometric estimation of potassium dichromate and copper estimate.
2. Iodimetric estimation of antimony in tartaremetic.
3. Estimation of amount of available chlorine in bleaching powder and household bleachers .
4. Estimation of iodine in iodized salts
5. Iodimetric estimation of ascorbic acid in fruit juices .
6. Gravimetric estimation of sulphate in barium sulphate.
7. Gravimetric estimation of aluminum in oximato complex.
8. Inorganic preparation of
  - i) Potash alum
  - ii) Chrome alum
  - iii) tetraamminecopper(II) sulphate
  - iv) potassium trioxalatoferate(III)
  - v) hexaammine nickel(II) chloride

## SEMESTER - VI

### CHEM HN DSE 605

#### ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

##### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION - A

##### Chemistry of elements of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr,  $K_2Cr_2O_7$ ,  $KMnO_4$ ,  $K_4[Fe(CN)_6]$ , sodium nitroprusside,  $[Co(NH_3)_6]Cl_3$ ,  $Na_3[Co(NO_2)_6]$ .

##### Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). (16 Hours)

#### SECTION - B

##### Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to  $Na^+$ ,  $K^+$  and  $Mg^{2+}$  ions: Na/K pump; Role of  $Mg^{2+}$  ions in energy production and chlorophyll. Role of  $Ca^{2+}$  in blood clotting, stabilization of protein structures and structural role (bones). (14 Hours)

#### SECTION - C

##### Polynuclear and heteronuclear aromatic compounds

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.  
Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon). (12 Hours)

### SECTION - D

#### Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions,  $\lambda_{\max}$ . &  $\epsilon_{\max}$ . chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating  $\lambda_{\max}$ . of conjugated dienes and  $\alpha$ ,  $\beta$  – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on  $>C=O$  stretching absorptions). (18 Hours)

#### Reference Books:

1. James E. Huheey, Ellen Keiter & Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
2. G.L. Miessler & Donald A. Tarr: Inorganic Chemistry, Pearson Publication.
3. J.D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
4. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley & Sons.
5. I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
6. John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
7. R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
8. R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
9. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

## LAB COURSE

### CHEM HN DSE 605 P

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits – 2**

1. Separation of mixtures by chromatography: Measure the  $R_f$  value in each case. (Combination of two ions to be given) Paper chromatographic separation of  $Fe^{3+}$ ,  $Al^{3+}$  and  $Cr^{3+}$  or Paper chromatographic separation of  $Ni^{2+}$ ,  $Co^{2+}$ ,  $Mn^{2+}$  and  $Zn^{2+}$

2. Preparation of any two of the following complexes and measurement of their conductivity:

- (i) tetraamminecarbonatocobalt (III) nitrate                      (ii) tetraamminecopper (II) sulphate
- (iii) potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl,  $MgCl_2$  and  $LiCl_3$ .

3. 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: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

**SEMESTER -VI**

**CHEM DSE 606**

**MOLECULES OF LIFE**

**Max. Marks: 50**  
**Credits: 4**

**Time Allowed: 3 Hours**

**Note for Examiners and Students:**

1. *The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
2. *The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

**SECTION – A**

**Carbohydrates**

Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

**Lipids**

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). **(18 Hours)**

**SECTION – B**

**Amino Acids, Peptides and Proteins**

Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of

peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis. **(14 Hours)**

### **SECTION - C**

#### **Enzymes and correlation with drug action**

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action(Including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non- competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group,-NH<sub>2</sub> group, double bond and aromatic ring, **(13 Hours)**

### **SECTION - D**

#### **Nucleic Acids**

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

#### **Concept of Energy in Biosystems**

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates. **(15 Hours)**

#### **Recommended Texts:**

1. Morrison, R. T. & 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. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

**LAB COURSE**  
**CHEM HN DSE 606 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits – 2**

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

**Recommended Texts:**

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

**Generic Elective Papers (GE)**  
**(Minor-Chemistry) (Any four: 1 in each**  
**semester 1-4) for other Departments/**  
**Disciplines: (Credit: 06 each)**

## SEMESTER - I

### CHEM HN GE 101

#### ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC

#### HYDROCARBONS

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION - A

##### Atomic Structure

Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Schrodinger wave equation and meaning of various terms in it. Significance of  $\psi$  and  $\psi^2$ . Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, Shapes of s, p and d atomic orbitals, nodal planes.

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations. Slater rules and applications. **(14 Hours)**

#### SECTION - B

##### 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, trigonalbipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules up to Ne



(including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO<sup>+</sup>. Comparison of VB and MO approaches. **(16 Hours)**

## SECTION - C

### Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule. **(8 Hours)**

### Stereochemistry

Conformations with respect to ethane, 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) and E / Z Nomenclature (for upto two C=C systems). **(10 Hours)**

## SECTION – D

### 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<sub>4</sub>) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

**Alkynes:** (Upto 5 Carbons) Preparation: Acetylene from CaC<sub>2</sub> 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<sub>4</sub>, ozonolysis and oxidation with hot alk. KMnO<sub>4</sub>. **(12 Hours)**

### Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
5. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).

6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
8. Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
9. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
10. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
11. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

### **LAB COURSE**

### **CHEM HN GE 101 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

#### **I. 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  $\text{KMnO}_4$ .
3. Estimation of water of crystallization in Mohr's salt by titrating with  $\text{KMnO}_4$ .
4. Estimation of Fe (II) ions by titrating it with  $\text{K}_2\text{Cr}_2\text{O}_7$  using internal indicator.
5. Estimation of Cu (II) ions iodometrically using  $\text{Na}_2\text{S}_2\text{O}_3$ .

#### **II. Organic Chemistry**

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements)
2. Separation of mixtures by Chromatography: Measure of  $R_f$  value of a mixture of o-nitroaniline and p-nitroaniline.

#### **Reference Books:**

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

## SEMESTER - II

### CHEM HN GE 202

#### CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION - A

##### Chemical Energetics

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

(12 Hours)

#### SECTION - B

##### Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between  $\Delta G$  and  $\Delta G^\circ$ , Le Chatelier's principle. Relationships between  $K_p$ ,  $K_c$  and  $K_x$  for reactions involving ideal gases.

(6 Hours)

##### 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.

(10 Hours)

#### SECTION - C

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

## Aromatic hydrocarbons

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

Reactions: (Case benzene): Electrophilic 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).

**Alkyl Halides** (Upto 5 Carbons) Types of Nucleophilic Substitution ( $SN_1$ ,  $SN_2$  and  $SN_i$ ) reactions.

**Preparation:** from alkenes and alcohols.

**Reactions:** hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation, 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  $NaNH_2/NH_3$ ).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(17 Hours)

## SECTION - D

### Alcohols, Phenols and Ethers (Upto 5 Carbons)

**Alcohols:** Preparation: Preparation of  $1^\circ$ ,  $2^\circ$  and  $3^\circ$  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: Cumenehydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten – Baumann Reaction.

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

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

**Preparation:** From acid chlorides and from nitriles.

**Reactions:** Reaction with HCN, ROH,  $NaHSO_3$ ,  $NH_2-G$  derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorff-Verley reduction. (15 Hours)

### Reference Books:

1. Graham Solomon, T.W., Fryhle, C.B. & Snyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).

4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
7. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
8. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
9. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
10. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
11. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).

### **Lab Course**

### **CHEM HN GE 202 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

#### **I. Thermochemistry**

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts ( $\text{KNO}_3$ ,  $\text{NH}_4\text{Cl}$ ).
5. Determination of enthalpy of hydration of copper sulphate.

#### **II. Ionic equilibria: pH measurements**

1. 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.

2. Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

#### **III. 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 of organic compounds – Iodoform and Glucosozone

#### **Reference Books**

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

## SEMESTER - III

### CHEM HN GE 303

#### SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION - A

##### 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.

##### 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) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, NaCl-H<sub>2</sub>O and Mg-Zn only). (15 Hours)

#### SECTION - B

##### Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acidbase).

##### 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:  $\Delta G$ ,  $\Delta H$  and  $\Delta S$  from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).  
**(15 Hours)**

### SECTION - C

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

**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.

#### Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons - Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, HofmannBromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with  $\text{HNO}_2$ , Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.  
**(15 Hours)**

### SECTION - D

#### Amino Acids, Peptides and Proteins

**Preparation of Amino Acids:**Strecker synthesis using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and Electrophoresis.

**Reactions of Amino acids:** ester of  $-\text{COOH}$  group, acetylation of  $-\text{NH}_2$  group, complexation with  $\text{Cu}^{2+}$  ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

**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, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.  
**(15 Hours)**

#### Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

**LAB COURSE**  
**CHEM HN GE 303 P**

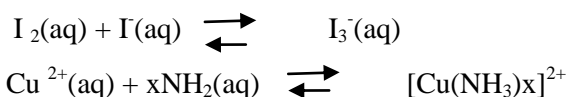
**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

**I. Distribution Law**

Study of the equilibrium of one of the following reactions by the distribution method:



**II. Conductance**

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

or

**III. Potentiometry - Perform the following potentiometric titrations:**

- Strong acid vs. strong base
- Weak acid vs. strong base
  - Potassium dichromate vs. Mohr's salt

**IV. Organic Chemistry**

- Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
- Any Two of the following:
  - Separation of amino acids by paper chromatography
  - Determination of the concentration of glycine solution by formylation method.
  - Titration curve of glycine
  - Action of salivary amylase on starch
  - Effect of temperature on the action of salivary amylase on starch.
  - Differentiation between a reducing and a nonreducing sugar.



**Reference Books:**

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

## SEMESTER - IV

### CHEM HN GE 404

#### TRANSITION METAL & COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

##### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION - A

##### Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

**Lanthanides and actinides:** Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

##### Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC nomenclature of coordination compounds. **(16 Hours)**

#### SECTION - B

##### Crystal Field Theory

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of CF splitting, Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry.

Jahn-Teller distortion, Square planar coordination.

**(14 Hours)**

#### SECTION - C

##### 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<sub>2</sub>.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision properties - collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

### **Liquids**

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 only). **(16 Hours)**

## **SECTION - D**

### **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.

### **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). **(14 Hours)**

### **Reference Books:**

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
7. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
8. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
9. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

**LAB COURSE**  
**CHEM HN GE 404 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Semi-micro qualitative analysis of inorganic mixture using  $H_2S$  of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following: Cations :  $NH_4^+$ ,  $Pb^{2+}$ ,  $Ag^+$ ,  $Bi^{3+}$ ,  $Cu^{2+}$ ,  $Cd^{2+}$ ,  $Sn^{2+}$ ,  $Fe^{3+}$ ,  $Al^{3+}$ ,  $Co^{2+}$ ,  $Cr^{3+}$ ,  $Ni^{2+}$ ,  $Mn^{2+}$ ,  $Zn^{2+}$ ,  $Ba^{2+}$ ,  $Sr^{2+}$ ,  $Ca^{2+}$ ,  $K^+$   
Anions :  $CO_3^{2-}$ ,  $S^{2-}$ ,  $SO_3^{2-}$ ,  $S_2O_3^{2-}$ ,  $NO_2^-$ ,  $CH_3COO^-$ ,  $Cl^-$ ,  $Br^-$ ,  $I^-$ ,  $NO_3^-$ ,  $SO_4^{2-}$ ,  $PO_4^{3-}$ ,  $BO_3^{3-}$ ,  $C_2O_4^{2-}$

(Spot tests should be carried out wherever feasible)

**2. Gravimetry**

Estimate the amount of nickel present in a given solution as bis(dimethylglyoximate) nickel(II) or aluminium as oximate in a given solution gravimetrically.

**3. Colorimetry**

Draw calibration curve (absorbance at  $\lambda_{max}$  vs. concentration) for various concentrations of a given coloured compound ( $KMnO_4$ /  $CuSO_4$ ) and estimate the concentration of the same in a given solution.

**4. Complexometric titrations**

- a) Estimation of (i)  $Mg^{2+}$  or (ii)  $Zn^{2+}$  by complexometric titrations using EDTA.
- b) Estimation of total hardness of a given sample of water by complexometric titration.

**5. 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.

**6. Viscosity measurement** (use of organic solvents excluded).

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

**7. Chemical Kinetics**

Study the kinetics of the following reactions.

- a) . Initial rate method: Iodide-persulphate reaction
- b) . **Integrated rate method:**
  - i). Acid hydrolysis of methyl acetate with hydrochloric acid.
  - ii). Saponification of ethyl acetate.

c). Compare the strengths of  $HCl$  and  $H_2SO_4$  by studying kinetics of hydrolysis of methyl acetate

**Reference Books:**

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

## CHEM HN GE 5

### GE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBON AND UV, IR SPECTROSCOPY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION-A

##### Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties);

Peroxo compounds of Cr,  $K_2Cr_2O_7$ ,  $KMnO_4$ ,  $K_4[Fe(CN)_6]$ , sodium nitroprusside,  $[Co(NH_3)_6]Cl_3$ ,  $Na_3[Co(NO_2)_6]$ . (6 Hours)

##### Organometallic Compounds 1

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. (6 Hours)

#### SECTION-B

##### Organometallic Compounds 2

Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). (6 Hours)

##### Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to  $Na^+$ ,  $K^+$  and  $Mg^{2+}$  ions: Na/K pump; Role of  $Mg^{2+}$  ions in energy production and chlorophyll. Role of  $Ca^{2+}$  in blood clotting, stabilization of protein structures and structural role (bones). (12 Hours)

#### SECTION-C

##### Polynuclear and heteronuclear aromatic compounds

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. (6 Hours)

##### Active methylene compounds

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon). (6 Hours)

#### SECTION-D

##### Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions,  $\lambda_{max}$  &  $\epsilon_{max}$ , chromophore, auxochrome, bathochromic and

hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating  $\lambda_{\text{max}}$  of conjugated dienes and  $\alpha, \beta$  – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on  $>\text{C}=\text{O}$  stretching absorptions).

**(18 Hours)**

**Reference Books:**

- James E. Huheey, Ellen Keiter & Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
- G.L. Miessler & Donald A. Tarr: Inorganic Chemistry, Pearson Publication.
- J.D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
- F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley & Sons.
- I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
- R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
- R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

**LAB COURSE  
CHEM HN GE 5 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

**I. Inorganic Chemistry**

1. Separation of mixtures by chromatography: Measure the  $R_f$  value in each case.

(Combination of two ions to be given)

- i) Paper chromatographic separation of  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$  and  $\text{Cr}^{3+}$  or
- ii) Paper chromatographic separation of  $\text{Ni}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Zn}^{2+}$

2. Preparation of any two of the following complexes and measurement of their conductivity:

- a. tetraamminecarbonatocobalt (III) nitrate
- b. tetraamminecopper (II) sulphate
- c. potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl,  $\text{MgCl}_2$  and  $\text{LiCl}_3$ .

**II. 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:**

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

## CHEM HN GE 6

### PHYSICAL CHEMISTRY

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

### SECTION-A

#### Quantum Chemistry - I

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, 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, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

(14 Hours)

### SECTION-B

#### Quantum Chemistry - II

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

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).

**Chemical bonding:** Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of  $H_2^+$ . Bonding and antibonding orbitals. Qualitative extension to  $H_2$ . Comparison of LCAO-MO and VB treatments of  $H_2$  (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in

VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH<sub>2</sub>, H<sub>2</sub>O) molecules. Qualitative MO theory and its application to AH<sub>2</sub> type molecules. (18 Hours)

### SECTION-C

#### Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; BornOppenheimer approximation.

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

**Vibrational spectroscopy:** Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

**Raman spectroscopy:** Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

**Electronic spectroscopy:** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. (14 Hours)

### SECTION-D

**Nuclear Magnetic Resonance (NMR) spectroscopy:** Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: It's principle, hyperfine structure, ESR of simple radicals.

#### Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence. (14 Hours)

#### Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).



**LAB COURSE**  
**CHEM HN GE 6 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

**I. UV/Visible spectroscopy**

1. Study the 200-500 nm absorbance spectra of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  (in 0.1 M  $\text{H}_2\text{SO}_4$ ) and determine the  $\lambda_{\text{max}}$  values. Calculate the energies of the two transitions in different units ( $\text{J molecule}^{-1}$ ,  $\text{kJ mol}^{-1}$ ,  $\text{cm}^{-1}$ , eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of  $\text{K}_2\text{Cr}_2\text{O}_7$ .
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

**II. Colourimetry**

1. Verify Lambert-Beer's law and determine the concentration of  $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$  in a solution of unknown concentration
2. Determine the concentrations of  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenanthroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
7. Analysis of the given vibration-rotation spectrum of  $\text{HCl}(\text{g})$

**Reference Books**

- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

## CHEM HN GE 7

### MOLECULES OF LIFE

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION-A

##### Carbohydrates

Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides, structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation. **(10 Hours)**

#### SECTION-B

##### Amino Acids, Peptides and Proteins

Classification of Amino Acids, Zwitter ion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C-terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (tbutyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis. **(12 Hours)**

#### SECTION-C

##### Enzymes and correlation with drug action

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition (Competitive and Non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure-activity relationships of drug molecules, binding role of -OH group, -NH<sub>2</sub> group, double bond and aromatic ring **(12 Hours)**

##### Nucleic Acids

Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation. **(10 Hours)**

## SECTION-D

### Lipids

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). **(8 Hours)**

### Concept of Energy in Biosystems

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates. **(8 Hours)**

### Recommended Texts:

- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

**LAB COURSE**  
**CHEM HN GE 7 P**

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

**Recommended Texts:**

- Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

## CHEM HN GE 8

### CHEMISTRY OF MAIN GROUP ELEMENTS, THEORIES OF ACIDS AND BASES

Max. Marks: 50  
Credits: 4

Time Allowed: 3 Hours

#### Note for Examiners and Students:

- The question paper will consist of five sections A, B, C, D and E. Section E will be compulsory. Examiner will set nine questions in all, selecting two questions from section A, B, C, and D of 10 marks each and may contain more than one part. Section E will be of 10 marks and consists of objective type questions (MCQ/true and false / fill in the blanks etc.) of one mark each covering the entire paper.*
- The candidate will be required to attempt five questions in all i.e. selecting one question from each section including the compulsory question. The duration of the examination will be 3 hours.*

#### SECTION-A

##### Acids and Bases

Arrhenius, Bronsted and Lowry, Lewis, Lux flood and solvent system concepts of acids and bases. Classification of acids and bases as hard and soft. Pearson's HSAB concept, application of HSAB principle. Relative strength of acids and bases and effect of substituents and solvent on their strength.

**(12 Hours)**

#### SECTION-B

##### Hydrogen

Unique position of Hydrogen in the periodic table, isotopes, ortho and para hydrogen, Industrial production, Hydrides and their chemistry, Heavy water, Hydrogen bonding, Hydrates.

##### S-Block Elements:

Periodicity of elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electronegativity (Pauling Scale). General characteristics of s-block elements like density, melting points, flame colouration and reducing character, solvation and complexation tendencies and solutions of metals in liquid ammonia.

**(16Hours)**

#### SECTION-C

##### P- Block Elements

Comparative studies including diagonal relationship of group 13 and 14 elements. Borohydrides, Hydrides, oxide and oxy-acids and halides of boron, borax, Borazine, allotropic forms of carbon, fullerenes, carbides of calcium and silicon, silanes, structure of silicate minerals and silicones. Hydrides, oxides, oxoacids and halides of nitrogen. Allotropic forms of phosphorous. Hydrides, halides, oxides and oxyacids of phosphorous. Basic properties of halogens and inter halogen compounds, pseudohalogens and poly halides.

**(20 Hours)**

## SECTION –D

### Noble Gases

Occurrence of noble gases, History of discovery of noble gases and isolation of noble gases from air. Preparation properties and structure of important compounds of noble gases-fluorides, oxides, oxyfluorides of xenon (valence bond structure only). Krypton difluoride and clathrate compounds of noble gases. **(12 Hours)**

### Books Recommended:

1. Concise inorganic Chemistry 4<sup>th</sup>Edn. By J. D.Lee.
2. Inorganic Chemistry by T. Moeller.
3. Advanced Inorganic Chemistry by Cotton And Wilkinson.
4. Inorganic Chemistry by J.E.Huheey.
5. Theoretical Inorganic Chemistry by Day & Selbin.
6. Canham, G.R. & Overton, T. Descriptive inorganic chemistry. Freeman & Co. 2006.
7. Purecell, K.F. & Kotz J.C. Inorganic Chemistry. W.B. Saunders & Co. 1977.
8. Basolo, F. & Pearson, R.C. Mechanisms of Inorganic chemistry. John Wiley & Sons, NY, 1967.
9. Chemistry of Elements by Greenwood, N.N. & Earnshaw. Butterworth – Heinemann 1997.

## LAB COURSE

### CHEM HN GE 8 P

**TIME ALLOWED: 03 HOURS**

**Max Marks: 30**

**Credits - 2**

1. Iodometric estimation of potassium dichromate and copper estimate.
2. Iodometric estimation of antimony in tartaremetic.
3. Estimation of amount of available chlorine in bleaching powder and household bleachers .
4. Estimation of iodine in iodized salts
5. Iodometric estimation of ascorbic acid in fruit juices .
6. Gravimetric estimation of sulphate in barium sulphate.
7. Gravimetric estimation of aluminum in oximate complex.
8. Inorganic preparation of
  - i) Potash alum
  - ii) Chrome alum
  - iii) tetraamminecopper(II) sulphate
  - iv) potassiumtrioxalatoferate(III)
  - v) hexaammine nickel(II) chloride