

# Chemistry

B.Sc.: Elective

## Outlines of Tests

Paper	Title of Course	Marks
A	Physical Chemistry	50
B	Inorganic Chemistry	50
C	Organic Chemistry	50
D	Practical Physical Chemistry	16
E	Practical Inorganic Chemistry	17
F	Practical Organic Chemistry	17
	<b>Total</b>	<b>200</b>

Note: Medium of Instruction & Examination English

## Syllabi and Courses of Reading

### PAPER A ; PHYSICAL CHEMISTRY

#### 1. STATES OF MATTER

##### a) GASES:

Law of equipartition of energy, collision diameter, collision number, collision frequency and mean free path ; viscosities, of gases, measurements, effect of temperature and pressure on viscosities of gases; Critical phenomenon of gases and experimental determination of  $P_c, V_c$  and  $T_c$ ; Concept of molecular velocities of gases according to Maxwells distribution law and comparison of various velocities.

##### b) LIQUIDS:

The properties of liquids like surface tension, viscosity, refractive index and dipole moment ; Parachor rehochor and molar refraction as additive and constitutive properties ; Measurement of refractive index and dipole moment; Magnetic susceptibility and its measurement by Gouys balance.

##### c) SOLIDS:

Symmetry operations and Bravis lattices ; Concept of X-Ray diffraction, Braggs equation and crystal structure analysis ; powder method of crystal structure analysis ; X-Rays crystallography of sodium chloride crystal ; Heat capacities of solids.

#### 2. QUANTUM MECHANICS AND ATOMIC STRUCTURE:

Elementary treatment of Compton effect and photoelectric effect ; Brief discussion of result of Bohrs model and its detects ; Sommerfields modification and evolution of arimuthal quantum number, Dual nature of matter, verification of dual nature by Davisson and Gerners experiment ; Detail of hcisenbergs uncertainty principle; postulates of quantum mechanics ; brief introduction of operators ; derivation of time independent schrodinger wave equation in terms of polar coordinates and derivation of principle quantum number; energy equation for free motion of particle in one dimensional box ; Eigen values and Eigen functions ; normalization of wqave function ; probability functions, radial distribution probability density functions.

#### 3. CHEMICAL THEMODYNAMICS

Heat capacity as  $C_p$  and  $C_v$ : Difference in  $C_p$  and  $C_v$  towards atomicity: Temperature dependence of heat capacities; Quantitative effect of temperature over enthalpy change and internal energy change; Types of thermodynamical processes ; Isothermal reversible expansion of ideal gases; Adiabatic process of ideal gases; Second law of thermodynamics, Carnot cycle efficiency of heat engine and concept of entropy; Thermodynamic scale of temperature entropy for phase transition, spontaneity and reversibility; Entropy change in reversible and irreversible processes; Temperature dependence of entropy, Variation of entropy with pressure and volume; Concept of free energy; Derivation of Gibbs and Helmholtz equation; Standard free energy of formation; Partial molar quantities, Chemical potential, variation of chemical potential with pressure and temperature. Fugacity;

Thermodynamic of equilibrium, Reaction isochore; Clausius-Clapeyron equation; Molecular basis of entropy and probability.

#### 4. CHEMICAL EQUILIBRIUM

Concept of chemical equilibrium, Derivations of relationship between  $K_c$ ,  $K_p$ ,  $K_x$  and  $K_n$ ; Application of law of mass action to homogeneous equilibria to explain the effect of volume and pressure change on degree of dissociation of certain important reactions as dissociation of  $\text{PCl}_5$ ,  $\text{N}_2\text{O}_4$  and  $\text{NH}_3$ . Application of law of mass action to heterogeneous equilibria; Effect of adding inert gas to gaseous system at equilibrium; Quantitative effect of temperature on chemical equilibrium.

#### 5. CHEMICAL KINETICS

Direction of kinetic expression of zero order, first order, second order (with same and different concentration) and third order reactions (with same concentrations) with suitable examples; Equation for half life periods and determination of rate constants; Methods of measurements of order of reactions giving examples with different techniques; Derivation of Arrhenius equation and measurements of Arrhenius parameters, Measurement of slopes of Arrhenius plots for some important reactions; Bimolecular collision theory of uni-molecular, gas phase reactions (Lindemann mechanism); introduction to transition state theory of reaction rates.

#### 6. SOLUTIONS AND COLLOIDS

Thermodynamic derivation of colligative properties at lowering of vapor pressure, elevation of boiling point, depression of freezing point; Relationship between lowering of vapor pressure with  $\Delta T_b$  and  $\Delta T_f$  Osmotic pressure and their determination; concept of semipermeable membrane, Isotonic solution, theory of osmosis, laws of osmotic pressure, relationship between vapor pressure and osmotic pressure. Abnormal colligative pressure; Abnormal colligative properties describing association and disassociation of solutes; Fractional distillation and idea of azeotropes in detail; Concept of colloids; Classification of colloids; Preparation of colloids, their properties with reference to dialysis electro dialysis, sedimentation, precipitation, ultra filtrations; Suspensions and gels; Tyndal cone effect; Macromolecules and micelles.

#### 7. ELECTROBIOCHEMISTRY

Electrolytic conduction and its measurement; Specific, equivalent and molar conduction of strong and weak electrolytes; Ionic mobilities and their determination; Kohlrausch's law and its application; Faraday's law (first and second) and their significance; Transport number, Hittort's rule, Determination of transference number by Hittort's method. Applications of conductance measurement, EMF of the chemical cells; Electrode potential and its measurement with reference to Weston standard, glass electrode, calomel electrode and quinhydrone electrode; Nerst equation; Thermodynamics of cells; Concentration of cells with liquid junction and without liquid junction.

#### 8. SURFACE CHEMISTRY

Introduction to adsorption, Difference between physical and chemical adsorption, adsorption of gases by solids; Different types of adsorption isotherms with special reference to Langmuir adsorption isotherm and its applications; Brief introduction to catalysis; Theories of catalysis; Activation energy for catalyzed reactions. Kinetics of enzyme catalysis.

### PAPER A : PRACTICAL CHEMISTRY

1. Determination of percentage composition by surface tension, viscosity and refractive index method.
2. Determination of heat of solution for solids and liquids.
3. Quantitative measurement of colored salt of  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$  in colorimeter
4. Verification of first law of Faraday by electroplating of  $\text{CuSO}_4$ ,  $\text{NiSO}_4$ ,  $\text{Cr}_2(\text{SO}_4)_3$ ,  $\text{Ag} + \text{CN}$  and  $\text{Au} + \text{CN}$ .
5. Conductometric and potentiometric titration using conductivity bridge and pH meter.
6. Measurement of reduction potential using of Zn, Cu, Ag, Al etc, by using calomel electrode.
7. Study of first order reaction:
  - a) Study of hydrolysis of methylacetate
  - b) Measurement of rate constant.
8. Verification of Langmuir Isotherm.
9. Thin layer chromatography
10. Measurement of molecular weight by; Depression of Freezing point.

11. Determination of transition temperature of  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ :  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ :  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ .

**Recommended Books:**

1. Adamson A.W. "Understanding Physical Chemistry" 3<sup>rd</sup> Ed., Benjamin Cummings Publishing Company Inc.
2. Akhtar M.N. & Ghulam Nabi, "Textbook of Physical Chemistry" Ilmi Kutab Khana, Lahore.
3. Bhatti H.N & K.Hussain, "Principles of Physical Chemistry" Carwan Book House, Lahore
4. Maron S.H. & B. Jerome, "Fundamentals of Physical Chemistry Macruthan publishing Co., Inc New York.(Also Published by National Book Foundation).
5. Atikins P.W.& M.J.Clugston, "Principles of Physical Chemistry" Pitman Publishing Company(1988)
6. Moore W.J. "Physical Chemistry" 5<sup>th</sup> Ed. Longmans Publishers.
7. Jones M. "Elements of Physical Chemistry" Addison-sesky Publishing company.
8. G.M.Barrow, International six Edition "Physical Chemistry".
9. Ira.N.Levine fourth edition "Physical Chemistry".
10. Alberty and Danials, "Physical Chemistry"
11. Castallon "Physical Chemistry"
12. Laidler & Meiser "Physical Chemistry"
13. Friemental "Chemistry in Action"
14. Francis Marion Miller "Structure and Dynamics"
15. Denbigh, "The principle of Chemical Equilibrium"
16. B.H.Mahan, "Elementry Chemical Thermodynamics"
17. E-F Caldin, "An Introduction of Chemical Thermodynamic"
18. Sample Glass Tone "Introduction of Electrochemistry"
19. Bokris and K.N. ready "Electrochemistry"
20. Milner "electrochemistry"
21. Reinhold 3<sup>rd</sup> Ed., "The Physical Chemistry of electrolytic Solution"
22. H.S Harned and B.B. Owen "The Physical Chemistry of Electrolytic Solution"

**FOR PRACTICALS :**

1. Crocleford H.D. H.W.Biard, F.W.Getzen & K.W. Nowell, "Laboratory Maual of physical chemistry" 2<sup>nd</sup> Ed., John Wiley Sons London.
2. Das R.C. and B.Behera, "Experimental Physical Chemistry" Tata McGraw Hill publishing Company Limited.
3. Levitt B.P., "Findlays Practical Physical Chemistry" 9<sup>th</sup> Ed., Longman Group Limited.

**PAPER B : INORGANIC CHEMISTRY**

1. **Periodicity**

Modern periodic table; Similarities and differences in first row elements, their diagonal and vertical relationship with other elements ; Electrongativity of elements (Pauling and Mulliken scales) ; Polarizability and polarizing power of ions ; periodicity in the properties of transition and inner transition elements.

2. **Theories of Chemical Bonding:**

Nature and types of chemical bonding ; Modern concept of valence bond theory (VTB), molecular orbital theory (MOT) and their applications to homo and hetero di-and polyatomic inorganic molecules, explaining the conventional and modified MO diagrams; Valence shell electron pair repulsion theory (VSEPR), explaining the shapes of inorganic molecules (i.e. AB<sub>2</sub>, AB<sub>3</sub>, AB<sub>2</sub>E, AB<sub>4</sub>, AB<sub>3</sub>E, AB<sub>2</sub>E<sub>2</sub>, AB<sub>5</sub>, AB<sub>4</sub>E, AB<sub>3</sub>E<sub>2</sub>, AB<sub>2</sub>E<sub>3</sub>, AB<sub>6</sub>, AB<sub>5</sub>E, AB<sub>4</sub>E<sub>2</sub>) and directed valence theory (Hybridization), Metallic bonds (detailed Concept).

3. **Acid-Base Concept:**

General concept of acids and bases. Detail of \Lewis concept f acids and bases, soft and hard acid-base (SHAB) concept and its applications. Relative strength of acids and bases based on Pk values. Reactions of acids and bases relationship between redox reactions and acid base reactions, Indicators and theory of indicators.

4. **Chemistry of D-Block Elements:**

GC University, Faisalabad

Electronic configuration and oxidation states of transition elements Metallurgy of chromium, nickel and copper. Theories of coordination compounds, valence bond theory (VBT), Molecular orbital theory (MOT) and crystal field theory (CFT) for tetrahedral and octahedral complexes. Nomenclature and Isomerism in coordination compounds. Chelates, Application compounds.

#### 5. **Nuclear Chemistry:**

Phenomena of radioactivity ; Natural radioactivity Radioactive, disintegration series, rate of disintegration and half like period, Mass defect and binding energy, nuclear stability ; measurement of nuclear radiation, Wilson cloud chamber and Geiger-Muller counter, Carbon dating ; Artificial radioactivity and nuclear transformations, Nuclear reactions (Fission and fusion), Uses of radioactive isotopes ; Biological effect of nuclear radiation.

#### 6. **Solvent Extraction and Chromatographic Techniques:**

Basis of solvent extraction process; Distribution law and distribution co-efficient; Simple of extraction, double extraction and multiple extraction systems; Applications of solvent extraction in chemistry and industry: Basic principles of chromatographic techniques; c Classifications of chromatographic techniques on the basis of Mobile and stationary phases; Introduction to column and thin layer chromatography.

#### 7. **Evaluation of Analytical Data and Essentials of Chemical Analysis :**

Some fundamental concepts like mole, activity and activity co-efficient; Concepts of mean, median, accuracy, precision, significant figures; Standard deviation; Relative standard deviation. Law of mass action and its applications; Precipitation and solubility product; common ion effect; Co-precipitation; Fractional precipitation.

#### 8. **Spectroscopy:**

Electromagnetic radiation and its interaction with matter: Nature of different transitions possible in atoms and molecules; Electronic, vibrational, rotational and other possible transitions by absorption of radiation by molecules and atoms, Development of spectroscopic analytical techniques employing various transition. Classification of spectroscopic techniques on the basis of type of radiation, phenomenon occurring and the nature of the matter. Basic introduction to atomic and molecular spectroscopic techniques including flame emission, spectrophotometry, UV and IR spectroscopy.

#### 9. **Chemistry Industries:**

Glass, Soda ash and Soap.

### **PAPER B: PRACTICAL INORGANIC CHEMISTRY**

#### **PREPARATIONS**

1. Ferric Alum
2. Potassium Thiosulfate
3. Sodium Thiosulfate
4. Amm. Copper (II) Sulphate

#### **QUALITATIVE ANALYSIS**

Separation & Identification of mixture of four radicals (cations and anions) by semimicro analysis technique.

#### **ARGENTOMETRY**

##### **MOHR'S METHOD**

1. Determine the % age purity of NaCl (Rock Salt)
2. Determine the amount of NaCl in the commercial sample of soda ash.

##### **VOLHARD'S METHOD**

1. Determination of %age purity of HCL.
2. Determination of silver in the given sample, using KSCN or NH<sub>4</sub> SCN.

#### **IODOMETRY**

1. Determination of iodide and KI in the given sample solution.
2. Standardization of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.5H<sub>2</sub>O solution.
3. Determination of amount/dm<sup>3</sup> of Cu<sup>2+</sup> and CuSO<sub>4</sub>. 5H<sub>2</sub>O using Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and KI.

- Determination of no. of water molecules (x) in  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$  iodometrically.

#### **REDOX TITRATIONS** (By using both internal and external indicators)

- Determination of amount/dm<sup>3</sup> of  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  with  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- Determination of %age purity of  $\text{K}_2\text{Cr}_2\text{O}_7$  by using standard solution of Moher's salt.
- Determination of no. of water molecules (x) in  $\text{FeSO}_4 \cdot x\text{H}_2\text{O}$  using  $\text{K}_2\text{Cr}_2\text{O}_7$ .
- Determination of  $\text{Ca}^{2+}$  by  $\text{KMnO}_4$ .
- Determination of %age of Iron in Ferric Alum  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{Fe}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$  using  $\text{K}_2\text{Cr}_2\text{O}_7$ .

#### **COMPLEXOMETRY**

- Standardization of EDTA solution by magnesium/zinc sulfate solution.
- Fine out the amount of  $\text{Ca}^{2+}$  in the given sample of marble (lime stone).
- Determination of  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  in the sample by using EDTA.

#### **Recommended Books**

- Cotton, F, Albert, Geoffrey Wilkison and Paul L. Gaus, "Basic Inorganic Chemistry", John, Wiley & Sons Inc, 3<sup>rd</sup> Edition (1995).
- Lee, J.D., "Modern Inorganic Chemistry", Chapman & Hall, 5<sup>th</sup> Edition (1996).
- Jolly, William, L, "Modern Inorganic Chemistry", McGraw Hill, 2<sup>nd</sup> Edition (1991).
- Shriver, D.F., P.W. Atkins and C.H. Langford, "Inorganic Chemistry", Oxford, 2<sup>nd</sup> Edition (1996).
- Sharp, A.G. "Inorganic Chemistry", Longman, 3<sup>rd</sup> Edition (1992).
- Rayner Canham, Eeof., "Descriptive Inorganic Chemistry" & Co. (1995).
- Jefferey, G.H., j. bassett, J. Mendham and R.C. Denney, "Vogel's text book of Quantative Chemical Analysis", 5<sup>th</sup> Education, Benjamin Cummings (1989).
- Vogel, "A.I.A. Text Book of Macro and Semi-micro Qualitative Inorganic Analysis", Longman Green & Co. (1995).
- Skoog, D.A., D.M. West and F.J. Holler, "Analytical Chemistry", 6<sup>th</sup> Edition, Saunders College Publications, (1994).
- Javed Iqbal, Amin, "Theory and Practice of Chromatography", Higher Education Commission, Islamabad, (2002).

### **PAPER C : ORGANIC CHMISTRY**

#### **1. Basic Concepts in Organic Chemistr**

Hybridization of orbitals of carbon atoms in alkanes, alkenes, alkynes and arenes. Hybridization of orbitals of nitrogen, oxygen and sulfur atoms in various functional groups, Localized and delocalized chemical bonding; Conjugation and hyperconjugation; Resonance, rules of resonance, reasons energy, resonance bybrid, factor effecting the resonance; Inductive effect, applications of inductive effect and resonance on various properties of organic compounds; Steric effect of and its applications, Hydrogen bonding and its effects on various properties organic compounds, Tautomerism.

#### **2. Nomenclature or Organic Compounds**

Nomenclature of alkanes, alkenes, alkynes, cycloalkanes, bicycloalkanes, spiro alkanes, Monofunctional and polyfunctional derivatives; Heterocyclic compounds; Polysubstituted benzenes; Polycyclic hydrocarbons such as naphthalene, anthracene, phenanthrene and there derivatives; Heterocyclic compounds.

#### **3. Hydrocarbons**

##### **a) Alkanes and Cycloalkanes**

Preparation of alkanes from alkyl halides, coupling of alkyl halide and alkylboranes, reduction of carbonyl compounds, Kolbe's electrosynthesis, Corey-house-synthesis, hydrogenation of alkenes and alkynes.

Reactions of alkanes with halogens, their mechanism and comparison of reactivities of halogens; combustion, isomerization, nitration and sulfonation. Preparations of cycloalkanes by Freud synthesis, Hydrogenation of cycle alkenes;, Structure and stability of cycloalkanes; Reaction of cycloalkanes.

##### **b) Alkenes and Alkynes**

Preparation of alkenes from elimination reaction of alkyl halides and alcohols; Mechanism and orientation of elimination; Dehalogenation of vicinal dihalides with mechanism: Pyrolytic eliminations.

Reactions of alkene; relative stability and reactivity; Addition of halogens, additions of halogen acids and the rules governing these reactions, hydration reactions, oxidation reactions including epoxidation and hydroxylation, polymerization; Semon-Smith and Diels-Alder reactions.

Preparation of alkynes by carbide process, dehydrohalogenation of dihalides and alkylation of terminal alkynes.

Reactions of alkynes: addition reactions with mechanisms, hydration reactions, oxidation, reduction, hydroboration, formation of metal acetylides, polymerization (linear and closed chain).

#### c) **Aromatic Hydrocarbons**

Structure of benzene, Resonance energy of benzene, Aromaticity, criteria for aromaticity, Evidences of aromaticity; Natural sources of aromatic hydrocarbons: Preparation of aromatic hydrocarbons by different methods.

Reactions of aromatic hydrocarbons; electrophilic aromatic substitution reactions, i.e. nitration, halogenation, Friedel-Crafts reaction and its limitations, sulfonation; orientation and reactivity of substituted benzenes;

Nucleophilic aromatic substitution reactions; reaction such as addition, hydrogenation,, Birch reduction, and oxidation reactions of side chains.

Polycyclic aromatic hydrocarbons like naphthalene, anthracene and phenanthrene, their resonance structures and relative stabilities; Synthesis of naphthalene; Electrophilic substitution reactions of naphthalene; Oxidation and reduction reactions; Brief description of orientation and reactivity of naphthalenes.

#### 4. **Isomerism**

**Conformational isomerism:** Conformational analysis of ethane, n-butane, cyclohexane, mono-and di-substituted cyclohexanes.

**Optical isomerism:** Optical activity, chirality and optical activity; enantiomers, diastereomers; racemates and their resolution: D, L and R, S conventions; Optical Isomerism in cyclohexanes, biphenyls and allenes.

**Geometrical Isomerism:** Cis and trans isomers; E-Z convention; Determination of configuration of the isomers; Inter-conversion of geometrical isomers; Geometrical isomerism in cyclic compounds.

#### 5. **Alkyl halides.**

Preparation of alkyl halides from alcohols and carboxylic acids;

Chemical reactions; Aliphatic nucleophilic substitution reactions, SN1 and SN2 mechanism, effects of the nature of substrate, attacking nucleophilic, leaving group and the nature of solvent. Elimination reactions, E1 and E2 mechanisms, orientation of elimination (Hoffmann and Saytzeff rules).

Grignard Reagents; synthesis, structure, and reactions with active hydrogen compounds, carbonyl compounds such as aldehydes, ketones, esters, and acid halides and CO<sub>2</sub>; Reactions with nitriles, ethylene oxide, sulphur and oxygen.

#### 6. **Chemistry of Hydroxyl Group containing Compounds 2<sup>nd</sup> Ethers**

**Alcohol:** Physical properties; Preparation of alcohols by the reduction of carbonyl compound; Reactions of alcohol with metals, organic and inorganic acids, Oxidation of alcohols; Distinction between primary, secondary and tertiary alcohols; Preparation of diols, triols and their important reaction and uses.

**Phenols:** Physical properties; Synthesis of phenols; Reactions of phenols such as acylation, Friedel-Crafts reaction, nitration, sulfonation, carbonation, formylation and diazo coupling.

**Ethers:** Physical properties; Preparation of ethers from alcohols alkyl halides and alkenes; Reactions of ethers; Brief introduction of crown ethers and polyethers.

### 7. Chemistry of Carbonyl Compounds

Preparation of aldehydes and ketones by pyrolysis of calcium salts of acids, acylation of alkenes and arenes reduction of acid halides and nitriles.

Physical properties of aldehydes and ketones, Structure and reactivity of carbonyl group; Comparison of the reactivity of aldehydes and ketones; Nucleophilic additions of water, alcohols, ammonia and its derivatives, hydrogen cyanide, bisulfite, reduction and oxidation reactions; Aldol condensation and related reactions; Cannizzaro's reactions; Wittig reaction; Oxidation reactions, Chemical tests of aldehydes and ketones.

### 8. Chemistry of Carboxylic Acids and Their Derivatives

Physical properties of carboxylic acids; Effects of different parameters on the acid strengths of aliphatic and aromatic carboxylic acids. Chemical properties, like salt formation nucleophilic acyl substitution, reduction of carboxylic acids, decarboxylation, Hunsdiecker reaction, Kochi reaction, substitution at

### 9. Chemistry of Amines and Heterocyclics

Preparations of primary, secondary and tertiary amines by alkylation of  $\text{HN}_3$ ; Gabriel synthesis; Reductive amination; Reduction of amides, nitriles and the nitro compounds.

Physical properties of amines, Basicity of amines and effects of different parameters on basic strength of amines; Reactions of amines such as a salt formation, alkylation (including exhaustive methylation and Hofmann degradation), acylation and sulfonation; Reaction with nitrous acid, Formation of isonitriles. Synthesis and application of arenediazonium salts, Synthesis and applications of quaternary ammonium salts.

Synthesis of pyrrole and its derivatives from acetylene, succinimide and furan, Paal Knorr synthesis. Knorr pyrrole synthesis and Hantzsch synthesis. Basicity of pyrrole, its aromatic character and stability. Reaction of pyrrole i.e. salt formation, reduction, electrophilic substitution reaction and polymerization.

Synthesis of pyridine from acetylene, pentamethylenediamine and Hantzsch synthesis. Basicity of pyridine, its aromatic character and stability. Reactions of pyridine with acid as a nucleophilic reagent, electrophilic substitution reactions, nucleophilic substitution reactions, reduction and oxidation. Comparison of reactivity of pyridine and benzene.

## PAPER C: PRACTICAL ORGANIC CHEMISTRY

### 1. Compound Analysis

Identification of organic compounds containing only one functional group with special emphasis on compounds containing following functional groups.

$-\text{COOH}$ ,  $-\text{OH}$ ,  $\text{C}=\text{O}$ ,  $-\text{NH}_2$ , and  $-\text{CONH}_2$ .

### 2. Preparation of Organic Compounds

1. Filtration
2. Simple and fractional distillation
3. Solvent extraction
4. Sublimation
5. Re-crystallization
6. Column Chromatography

### 3. Estimations (volumetric)

1. Determination of molecular weight of a carboxylic acid.
2. Estimation of amide group and glucose.

### Recommended Books

1. C.K. Ingold, "Structure and mechanism in organic chemistry", C.B.S.
2. I.L. Finar. "Organic Chemistry". Vol. I. Pearson Education, L.P.E.
3. I.L. Finar. "Organic Chemistry". Vol. II. 5<sup>th</sup> Edition, L.P.E.

4. Jerry March, "Advanced Organic Chemistry. Reaction, Mechanism and Structure", 5<sup>th</sup> Edition Wiley Inter Science.
5. Morison and Boyd, "Organic Chemistry", 6<sup>th</sup> Edition, Prentice Hall.
6. Seyhan N. Ege, "Organic Chemistry Structure and Reactivity", 3<sup>rd</sup> Edition. The University of Michigan, A.I.T.B.S. Publishers & Distributors (Regd.).
7. Thomas H. Lowry, Kathleen Schueller Richardson "Mechanism and Theory in Organic Chemistry", 3<sup>rd</sup> Edition, Harper and Row Publishers, New York.
8. Alder, Baker, Brown, "Mechanism in Organic Chemistry", Wiley Publishers.
9. Atkins Carey 'Organic Chemistry' A brief Course, 2<sup>nd</sup> Edition.
10. Peter Sykes, "A guide book to mechanism in organic chemistry", 6<sup>th</sup> Edition, Pearson Education , Singapore.
11. Carruthers, "Modern Methods of Organic Synthesis", Cambridge low Priced Edition, Cambridge.
12. Harris, Wamser, "Fundamentals of Organic Reaction Mechanism", Wiley Publishers.
13. G. Malcolm, Dyson, "A Manual of Organic Chemistry", Vol. I.
14. Canat Blat, "The Chemistry of Organic Compound", 5<sup>th</sup> Edition.
15. R. Panico, W.H. Powell, Jean-Calude Richer, "A guide to UPAC Nomenclature of Organic Compounds", Blackwell Sci. Publication, 1993.
16. J.G. Traynham, "Organic Nomenclature, A Programmed Introduction", Prentice Hall. Inc. 1997.
17. R.C. Chan and O.C. Dermer, "Introduction to Chemical Nomenclature", 5<sup>th</sup> Edition, Butterworths, Inc. 1979.
18. M.B. Smith and J. March "Advanced Organic Chemistry", 5<sup>th</sup> Edition, John Wiley and Sons, New York.
19. R.O. Norman and J.M. Coxon, "Principles of Organic Synthesis", 3<sup>rd</sup> Edition, Chapman and Hall, 2001.
20. G. Solomons and Craig Fryhle, "Organic Chemistry", 7<sup>th</sup> Edition, John Willey and Sons, 2000.
21. John McMurry. "Organic Chemistry", 5<sup>th</sup> Edition, Brooks, 2000,.
22. M. Younas, "A Text-book of Organic Chemistry", Ilmi Kitab Khana, Lahore.
23. Noller, "Basic Principles of Organic Chemistry".
24. Robberts, "Basic Principles of Organic Chemistry".
25. Younas. M., "Text Book of Organic Chemistry", Ilmi Kitab Khana, Lahore.
26. Rehman, A., "Text Book of Organic Chemistry", Karwan Book House, Lahore."

#### **For Practicals**

1. K.M. Ibne Raza, M.A Rehman, Abdur Rehman, "Organic Chemistry". Karwan Book House, Lahore.
2. B.S. Furniss, "Vogel's E.B of Practical Organic Chemistry", Addison Wesley Longman, Inc 1989.
3. Frederick George Mann and Saunder, "Practical Organic Chemistry", The English Language Book Society, 1960.
4. Daniel R. Palleras, "Experimental Organic Chemistry", John Willey & Sons, Inc., 2000."
5. James A. Moore, "Experimental methods in Organic Chemistry", Holt Saunders Inc., 1983.
6. R.L. Shriner, R.C. Fuson, D.V. Curtin and T.C. Morrill. "The systematic identification of organic compounds, 6<sup>th</sup> ed. John Willey & Sons, 1979."