St. Xavier's College – Autonomous Mumbai

Syllabus for 4th Semester Course in Chemistry (June 2015 onwards)

Contents: Theory Syllabus for Courses:

SYLLABUS UNDER AUTONOMY
CHEMISTRY

SEMESTER IV **COURSE: S.CHE.4.01**

PHYSICAL AND ANALYTICAL CHEMISTRY II **[45 LECTURES]**

LEARNING OBJECTIVES

1. Introducing the concept of phase rule to understand the behaviour of heterogeneous systems.
2. To understand basic principles involved in separation of liquid mixtures by distillation.
3. To understand the concept of steam distillation and its applications.
4. To give latest information and understanding of different types of electrodes used in various galvanic cells.
5. To understand Beer Lambert's law and its applications in various quantitative as well as qualitative analysis and the experimental procedure of spectroscopy.
6. To motivate the students to solve numerical problems.
7. To encourage students to use computer software like spreadsheet to plot the appropriate graph and obtain accurate results from experimental data.

Unit I: Electrochemistry (15 L)

1.1: Introduction to Electrolytic cell and Electrochemical cells (Galvanic /Voltaic cell).

1.2.1: Ion selective and ion specific electrodes, comparison, simple examples.
Types of ion specific electrodes: (i) Metal-metal ion electrode (ii) Gas electrode (including S.H.E.) (iii) Metal- metal insoluble salt electrode (including reference calomel electrode.) (iv) Redox electrode (v) Amalgam electrode.

1.2.2: Cell representation of galvanic cell from cell reactions and vice versa.
Concept of combination electrode : Glass electrode- construction and working (in brief).

1.3.1: Derivation of Nernst equation for the emf of a cell and hence for a single electrode potential, potential of glass electrode and quinhydrone electrode in terms of pH.
Determination of equilibrium constant from EMF measurements.
Thermodynamic parameters [ΔG, ΔH and ΔS] for the reaction taking place in a chemical cell.

1.3.2: Introduction to electrode concentration cell and electrolyte concentration cell.

1.4: Introduction to pH metric titrations. Titration curves for:(i) strong acid vs. strong base (ii) weak acid vs. strong base. Determination of equivalence point from titration curves (pH vs V, $\Delta pH/\Delta V$ vs. mean volume). Determination of K_a for weak monobasic acid. Advantages and limitations of pH-metry.

Self study: Numerical problems on calculation of pH of different types of acids, bases and buffer solutions.

Unit II: Phases in Equilibria (15 L)

2.1: Introduction to the terms in Phase Equilibria
Phase, components, degrees of freedom, Gibb's phase rule, phase diagram (with one suitable example).

2.2: Two component systems

2.2.1: Completely miscible liquid-liquid mixtures: Phase diagrams of ideal mixture: vapour pressure composition and temperature composition diagrams. Raoult's law, ideal solutions. Deviation from Raoult's law, positive and negative deviations (Numerical Problems expected).

2.2.2: Phase diagrams of non- ideal mixtures, azeotropes, distillation of azeotropic mixtures.

2.2.3: Partially miscible liquid-liquid mixtures: only introduction and examples.

2.2.4: Completely immiscible liquid-liquid mixtures: Steam distillation and its applications (Numerical Problems expected).

2.3: Physico-chemical aspect solvent extraction
Nernst distribution law: partition coefficient and distribution ratio, solute undergoing association and dissociation. Derivation of expression for amount of solute remaining unrestricted in the aqueous phase after multiple extractions with an organic solvent (Numerical Problems expected).

Self study: Additional numerical problems on above topics, one component system: CO_2 system, breaking of azeotropes.

Unit III: Visible Spectroscopy and Separation Techniques (15 L)

3.1: Visible spectroscopy (6L)

3.1.1: Recap: Terms involved: radiant power, absorbance, transmittance, wavelength of maximum absorption. Beer – Lambert's Law [derivation expected] , molar absorptivity Deviations from Beer –Lambert's law.

3.1.2: Components of an optical instrument, photometer and spectrophotometer, construction and working of a single beam colorimeter.

3.1.3: Photometric titrations
Basic principles and titration curves. Advantages and Limitations.

3.2: Introduction to Separation Techniques (7L)

3.2.1: Solvent extraction
Principle, separation factor, criteria for selection of solvent.

3.2.2: Chromatography
Introduction to chromatographic techniques, basic principles, classification of chromatographic techniques**.**

3.3: Introduction to analytical method validation (2L)
Performance characteristics of an analytical method: accuracy, precision, detection limit, dynamic range, sensitivity, selectivity, use of calibration curve for quantitative analysis.

Self Study: Applications of Colorimetry and numerical problems based on Spectroscopy.

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3. Physical Chemistry : G.K. Vemulapalli (1997)Prentice Hall of India Pvt. Ltd., New Delhi.
4. Physical Chemistry: G.W. Castellan, 3rd ed., Narosa Publishing House, New Delhi.
5. Text Book of Physical Chemistry, S. Glasstone, Affiliated East-West press Pvt.Ltd., New Delhi.
6. Thermodynamics for Chemist: S. Glasstone Affiliated East-West Press Pvt. Ltd., New Delhi.
7. Physical Chemistry: K.J. Laidler and J.H. Meiser, 2nd ed.(First Indian ed.1999) CBS Publishers and Distributors, New Delhi.
8. Physical Chemistry: Ira N.Levine (1995), 4th ed., McGraw Hill, Inc
9. Phase equilibria –Reisman Arnold, Edited by Ernest M. Loebe, New York and London Academic Press.
10. Phase Rule: F.D. Ferguson and P.K. Jones, (Bitterworth Publisher).
11. Properties of Liquids and Solution: J.N. Murrell and E.A. Boucher, Wiley, 1982.
12. Introduction to Principles of Heterogeneous Catalysis: Thomas J.M., and Thomas W.J. Academic, 1967.
13. An Introduction to Electrochemistry – Samuel Glasstone Affiliated East-West Press.
14. Modern Electrochemistry: J. O'M Bokris and A.K.N. Reddy,Maria Gamboa – Aldeco, 2nd ed, 1st Indian reprint, Springer, (2006) .
15. Principles and Applications of Electrochemistry : D.R.Crow, 4th ed., Blackie, London, (1994) .
16. Instrumental Methods of Chemical Analysis: Chatwal and Anand, 5th ed.,Himalaya Publication.
17. 2000 Solved Problems in Physical Chemistry : S.R.Metz, Tata McGraw Hill Publishers, New Delhi.
18. A Textbook of Physical Chemistry, K.L. Kapoor, MacMillan India Ltd.
19. Physical Chemistry: N.B.Singh, Shiva Saran Das, Rmji Singh, New Age International Pvt. Ltd.,Publishers, New Delhi. (2003).
20. D. A. Skoog, D.M.West, F.J.Holler Fundamantal Analytical Chemistry, , 7th ed. Philadelphia, Saunders college Publishing, 1996
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4th Semester Syllabus for Core Component Course in Chemistry, St. Xavier's College – Autonomous, Mumbai.

CIA I: Short answer questions **20 MARKS**

CIA II: Numerical Problems **20 MARKS**

Template of Question Paper

PHYSICAL AND ANALYTICAL CHEMISTRY II **COURSE: S.CHE.4.01**

OBJECTIVES

UNIT	KNOWLEDGE	UNDERSTANDING	APPLICATION	TOTAL MARKS
I	5 - 7	6 - 8	7 - 9	20
II	5 - 7	6 - 8	7 - 9	20
III	6 - 8	6 - 8	6 - 8	20
TOTAL MARKS PER OBJECTIVE	16 - 22	18 - 24	20 - 26	60
% WEIGHTAGE	27 – 37	30 – 40	37 – 43	100

END SEMESTER PAPER PATTERN:

Total Marks: 60 **Maximum Time: 2 hours**

Total number of questions: 3 [all compulsory] of 20 marks each
1 question per unit
Questions set out of 30 marks [50 % internal choice]
Sub questions will not exceed 5 marks

SYLLABUS UNDER AUTONOMY
CHEMISTRY

SEMESTER IV **COURSE: S.CHE.4.02**

INORGANIC AND INDUSTRIAL CHEMISTRY II **[45 LECTURES]**

LEARNING OBJECTIVES

1. To introduce students to Co-ordination Chemistry, elucidating concepts like the theories involved in "bonding" and features of coordination compounds.
2. To introduce students to organometallic compounds.
3. To understand a few bioinorganic molecules.
4. To introduce students to the basic concepts involved in metallurgy and corrosion.
5. To study Environmental Chemistry with reference to some common pollutants.

UNIT I: (15L)

1.1: Co-ordination Chemistry (8L)

1.1.1: Introduction to Co-ordination Compounds. Distinction between Double salts and Co-ordination compounds.

1.1.2: Terms involved in Co-ordination Chemistry: Co-ordination Compound, central metal atom or ions, complex compound, Complex ion, Ligand: Definition, Classification, Chelates and chelating agents, Co-ordination Sphere, Co-ordination Number, Charge of the complex ion, calculation of oxidation and coordination number of metal etc.

1.1.3: Werner's Theory – postulates.

1.1.4: IUPAC nomenclature of Co-ordination compounds.

1.1.5: Sidwick Model (Eighteen electron rule), EAN rule limitations.

1.1.6: Isomerism in Co-ordination compounds:
Structural isomerism (ionization, hydrated, linkage ligand, coordination position, polymerization isomers) and Geometrical isomerism and optical isomerism.

1.2: Bonding in Co-ordination Compounds: (7L)

1.2.1: Pauling's Valence Bond Theory – Assumptions, concept of hybridization, Limitations and Drawbacks.

1.2.2: Bonding in tetrahedral, square planer, trigonal bipyramidal and octahedral complexes with examples.

1.2.3: Inner and outer orbital complexes.

1.2.4: Electroneutrality principle and Back (Multiple) bonding.

1.2.5: Applications of Co-ordination Compounds (complexes) in different fields

UNIT II: (15L)

2.1: Organometallic Compounds (7L)

2.1.1: Introduction to Organometallic compounds and Definition.

2.1.2: Classification on the basis of Hapticity and Nature of Metal – Carbon bond.

2.1.3: 18-electron rule and its application to: carbonyls (including carbonyl hydrides and carbonylates), nitrosyls, cyanides, metal-carbon sigma and pi-bonded organometallics of transition metals.

2.1.4: Classification of metal carbonyls: Mononuclear, polynuclear, non-bridged and bridged carbonyls. General methods of preparation of carbonyls. Molecular orbital configuration of CO molecule. CO molecule acts as terminal and bridging carbonyl group.

2.2: Bioinorganic Chemistry: (8L)

2.2.1: Essential and trace elements in biological processes; Role of metal in bioinorganic chemistry (Na+,K^+,Ca^{2+},Mg^{2+},Fe^{3+}/Fe^{2+},Cu^{2+}/Cu^+,Zn^{2+}).

2.2.2: Metalloporphyrins with special reference to active site structures and biofunctions of cytochromes and Heme proteins-myoglobin and haemoglobin. Functions of oxygen transfer, Fe (II) complex of porphyrin, oxygen binding O_2 transfer, partial pressure, pH dependence. Nature of oxyheamoglobin and deoxyheamoglobin, geometry of complex.

2.2.3: Photosynthesis – PS-I and PS-II.

2.2.4: Metal ion induced toxicity and chelation therapy; metal ions as drugs (cisplatin and a few gold drugs).

UNIT III: Industrial Inorganic Chemistry: (15L)

3.1: Corrosion (5L)

3.1.1: Introduction to Corrosion [including the economics and importance of corrosion].

3.1.2: Types of Corrosion.

3.1.3: Electrochemical Theory of Corrosion.

3.1.4: Methods of Protection of Metals : (i) Coating (ii) Electroplating (iii) Cathode Protection (iv) Anodizing (v) Sacrificial Coating.

3.1.5: Passivity of metals: Definition, Theories of passivity - (i) oxide film theory (ii) Gaseous film theory (iii) Physical film theory, valence theory, catalytic theory, Allotropic theory, electrochemical passivity.

3.2: Environmental Chemistry (5 L)

3.2.1: Basic properties of chemicals in the environment.

3.2.2: Environmental transformations and degradation processes.

3.2.3: Contaminants in the environment- pesticides, soaps and detergents, organometallic compounds, polychlorinated biphenyls and dioxin.

3.2.4: Radioactive pollution.

3.3: Metallurgy (5L)

3.3.1: Metallurgical operations-Pulverisation, calcination, roasting and refining.
3.3.2: Physicochemical principles involved in hydrometallurgy, pyrometallurgy and electrometallurgy.

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3. James E. Huheey, Inorganic Chemistry, 3rd edition, Harper & Row Publishers, Asia, Pvt Ltd., 1983.
4. Shriver Atkins Inorganic Chemistry, P. W. Atkins, Overton, Rourke Weller, Armstrong, 5th edition, Oxford University Press.
5. Introduction to coordination , solid state and descriptive inorganic chemistry, Glen E. Rogers.
6. Chemistry Science of change, 3rd edition, D.W. Oxtoby, W.A. Freeman, T.F. Block.
7. The Organometallic chemistry of transition metals, R.H. Crabtree, 5th edition, Wiley.
8. Fundamental transition metal, Organometallic chemistry, C.M. Lukehart.
9. Chemistry-The molecular science, J.W. Moore, C.L. Stanitski and P.C. Jurs, 3rd edition, Thomson Publishers.
10. Advanced Inorganic Chemistry, Bahl, Anand & Tuli, Vol 1 & 2.
11. Chemistry, McMurray and Fay.
12. Organometallic chemistry, R.C. Mehrotra and A. Singh.
13. Inorganic chemistry, Gary Wulfsberg.
14. Principles of Organometallic chemistry, 2nd edition, P. Powell.
15. Bionorganic Chemistry: Inorganic elements in the chemistry life, Wiley, 2nd edition, W. Kaim, B.Schwederski, A. Klein.
16. Environmental chemistry, Lewis publishers, D. W. Connell.
17. Inorganic Chemistry (Biological and environmental aspects), A.K. Das.
18. Metal ions in Biochemistry, Narosa Publishing House, P. K. Bhattacharya.
19. An introduction to electrochemistry, Samuel Glasstone.
20. Metallic corrosion passivity and protection, U. R. Evans.
21. Basics of corrosion chemistry, Norio Sato.
22. Extractive Metallurgy, Newton.

4th Semester Syllabus for Core Component Course in Chemistry, St. Xavier's College – Autonomous, Mumbai.

CIA I: Short answer questions **20 MARKS**

CIA II: MCQ **20 MARKS**

Template of Question Paper

INORGANIC AND INDUSTRIAL CHEMISTRY II **COURSE : S.CHE.4.02**

OBJECTIVES

UNIT	KNOWLEDGE	UNDERSTANDING	APPLICATION	TOTAL MARKS
I	6-8	6-8	6-8	20
II	6-8	6-8	6-8	20
III	6-8	6-8	6-8	20
TOTAL MARKS PER OBJECTIVE	18-24	18-24	18-24	60
% WEIGHTAGE	30 – 40	30 – 40	30 – 40	100

END SEMESTER PAPER PATTERN :

Total Marks: 60 **Maximum Time: 2 hours**

Total number of questions: 3 [all compulsory] of 20 marks each.
1 question per unit.
Questions set out of 30 marks [50% internal choice].
Sub questions will not exceed 5 marks.

SYLLABUS UNDER AUTONOMY
CHEMISTRY

SEMESTER IV **COURSE: S.CHE.4.03**

ORGANIC AND INDUSTRIAL CHEMISTRY II **[45 LECTURES]**

LEARNING OBJECTIVES

1. To study the preparations, reactions and applications of aromatic nitrogen and amino compounds, aromatic aldehydes and ketones, aromatic carboxylic and sulphonic acids with mechanisms of certain reactions.
2. To understand stereochemistry including assignment of descriptors to chiral centres and resolution of racemates.
3. To logically predict structures of organic compounds and plan multi-step syntheses.
4. To understand the concepts of 'clean and green' reactions and techniques that is becoming increasingly significant in making organic synthesis environment friendly.

UNIT I: Aromatic nitrogen compounds, heterocycles and stereochemistry (15 L)

1.1: Aromatic nitro compounds (3 L)

1.1.1: Preparation: Nitration using mixed acid (mechanism). Preparation of mononitro and dinitro compounds through nitration of benzene, nitrobenzene, toluene, chlorobenzene and anisole.

1.1.2: Reactions: Reduction of aromatic nitro compounds by – catalytic hydrogenation, dissolving metal reduction using – Fe-HCl, Sn-HCl and Zn- AcOH and partial reduction using NaHS.

1.2: Aromatic amino compounds (2 L)

1.2.1: Preparation: Reduction of nitro compounds , amination of halobenzenes and Hoffmann bromamide reaction.

1.2.2: Reactions: Basicity of aromatic amines, effect of substituents on basicity of aniline, salt formation, N-alkylation and N-acylation.

1.3: Aromatic diazonium salts (2 L)

1.3.1: Preparation: Diazotization of aromatic primary amines (mechanism).

1.3.2: Reactions: (i) Replacement of diazo group by -H, -OH, -CN, Sandmeyer, Gattermann and Gomberg reaction (ii) Azo-coupling reaction with phenols/ naphthols and aromatic amines and (iii) Reduction of diazonium salt to aryl hydrazine.

1.4: Aromatic heterocycles (4 L)

1.4.1: Electronic structure and aromatic character of furan, thiophene, pyrrole and pyridine.

1.4.2: Reactivity towards electrophilic substitution on the basis of stability of intermediates.

1.4.3: Comparison of basicity of pyrrole, pyridine and piperidine.

1.5: Stereochemistry (4 L)

1.5.1: Assigning stereodescriptors to chiral centres: Cahn-Ingold-Prelog (CIP) Rules of assigning absolute configuration (R and S) to stereogenic centres. Assigning absolute configuration to molecules having maximum two chiral carbon atoms.

1.5.2: E and Z stereodescriptors to geometrical isomers.

1.5.3: Chemical Resolution of enantiomers.

UNIT II: Aromatic carbonyl and acidic compounds, structure determination and multi-step syntheses (15 L)

2.1: Aromatic carbonyl compounds (6 L)

2.1.1: Preparation of aromatic aldehydes: Gattermann-Koch reaction, Gattermann reaction, Vilsmeier-Haack reaction, Reimer-Tiemann reaction (mechanism), oxidation of methyl arenes and Rosenmund reduction.

2.1.2: Preparation of aromatic ketones: Friedel-Crafts acylation using acid chloride and acid anhydride (mechanism).

2.1.3: Reactions with mechanism: Knoevenagel , Claisen-Schmidt , Cannizzaro and Reformatsky reactions with applications.

2.2: Aromatic carboxylic acids (3 L)

2.2.1: Preparation of mono- and di-carboxylic acids: Side-chain oxidation of alkyl benzenes, reaction of Grignard reagents with solid carbon dioxide, hydrolysis of aryl nitriles and Kolbe-Schmidt reaction.

2.2.2: Reactions: (i) Acidity and effect of substituents on the acidity of benzoic acid (ii) Acid- catalysed esterification, (iii) Conversions to acid chloride, amide and anhydride (iv) Reduction and (v) Decarboxylation.

2.3: Aromatic sulfonic acids (2 L)

2.3.1: Preparation of aromatic sulfonic acids: Commonly used sulfonating agents. Sulfonation of benzene (with mechanism) and mono-substituted benzenes.

2.3.2: Reactions: Acidity of arene sulfonic acids. Comparative acidity of carboxylic acids and sulfonic acids, salt formation, desulfonation and Ipso substitution. – SO_3H as a solubilizing and blocking group, preparation of sulfonate esters.

2.4: Structure Determination and Multistep Syntheses (4 L)

2.4.1: Structure determination through a series of reactions.
2.4.2: Planning multistep synthesis of polysubstituted benzenes.

UNIT III: Green Chemistry and Environment friendly techniques (15 L)

3.1: Green Chemistry (8 L)

3.1.1: Definition, need and importance of Green Chemistry. 12 principles of Green Chemistry with relevant examples, concepts and simple calculations on – yield and selectivity, E-factor, atom economy.
3.1.2: Examples of Green Chemistry in Industry : (i) Green Starting Materials (ii) Green Reagents (iii) Green Chemical Solvents (iv) Green Chemical Products (v) Green Catalysts.

3.2: Environment friendly techniques: (7 L)
3.2.1: The use of Phase Transfer Catalysis and Polymer Support.
3.2.2: Synthesis using microwave and ultrasound.

REFERENCES

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2. Organic Chemistry, Francis A Carey, Pearson Education, 6th Edition, Special Indian Education, 2008.
3. Organic Chemistry, R.T. Morrison and R.N. Boyd, 6th Edition, Pearson Education.
4. Organic Chemistry, Finar Vol. I.
5. Fundamentals of Organic Chemistry, G. Marc Loudon, 4th Edition, Oxford University Press, 2006.
6. Organic Chemistry, L.G. Wade Jr. and M.S. Singh, 6th Edition, Pearson Education, New Delhi, 2008.
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12. Organic Reaction Mechanism, 3rd Edition, V.K. Ahluwalia and R.K. Parashara, Narosa Publications.
13. Stereochemistry, P.S. Kalsi, New Age International Ltd., 4th Edition, 2006.
14. An Introduction to Green Chemistry, V.K. Ahluwalia, Vishal Publishing Co.

4th Semester Syllabus for Core Component Course in Chemistry, St. Xavier's College – Autonomous, Mumbai.

CIA I: Short answer questions **20 MARKS**

CIA II: MCQ **20 MARKS**

Template of Question Paper

ORGANIC AND INDUSTRIAL CHEMISTRY II **COURSE : S.CHE.4.03**

OBJECTIVES

UNIT	KNOWLEDGE	UNDERSTANDING	APPLICATION	TOTAL MARKS
I	7	7	6	20
II	7	7	6	20
III	6	7	7	20
TOTAL MARKS PER OBJECTIVE	20	21	19	60
% WEIGHTAGE	33	35	32	100

END SEMESTER PAPER PATTERN :

Total Marks: 60 **Maximum Time: 2 hours**

Total number of questions: 3 [all compulsory] of 20 marks each.
1 question per unit.
Questions set out of 30 marks [50% internal choice].
Sub questions will not exceed 5 marks.

4th Semester Syllabus for Core Component Course in Chemistry, St. Xavier's College – Autonomous, Mumbai.

PRACTICAL CHEMISTRY **Course No.: S.CHE.4.PR**

LEARNING OBJECTIVES:

1. To learn to perform experiments that have specific aims with correct techniques.
2. To develop skills of observation, recording and analysing data.
3. To learn to present the experimental work in a systematic manner.

SEMESTER IV: COURSE 1
Instrumentation
Commercial Analysis

SEMESTER IV: COURSE 2
Gravimetric estimation
Volumetric estimation

SEMESTER IV: COURSE 3
Organic Spotting

COURSE I:

1. **POTENTIOMETRY**:
Determination of E^0_{cell}, free energy and equilibrium constant for a cell having cell reaction **:**
$Ag^+ + Cu \rightarrow Ag + Cu^{++}$

2. pH METRY:

pH metric titration of weak acid versus strong base and to determine pK_a value.

3.CONDUCTOMETRY:
Conductometric titration of a mixture of a strong and weak acid versus strong base.

4. CONDUCTOMETRY:
Verification of Ostwald's dilution law for weak electrolyte (Acetic acid).

5. COLORIMETRY:

Determination of λ_{max} for potassium permanganate solution using photometer, determination of unknown concentration by calibration curve method.

6. **COMMERCIAL ANALYSIS:**

Assay of commercial sample of aspirin using phenol red indicator.

COURSE II

1. VOLUMETRIC ESTIMATION:

a) Iodometry and Iodimetry:

(i) Estimation of tincture iodine.

(ii) Estimation of Cu^{2+}

b) Complexometry : estimation of Mg^{2+}/ Zn^{2+}, Cu^{2+} using EDTA

c) Estimation of Fe^{3+} using Internal Indicator.

2. GRAVIMETRIC ESTIMATION :

a) Ba^{2+} as $BaSO_4$

b) Ba^{2+} as $BaCrO_4$

c) Fe^{3+} as Fe_2O_3

d) Ni^{2+} as Ni-DMG

COURSE III

ORGANIC SPOTTING

Identification of an Organic Compound: The identification should be done through: preliminary tests, solubility, element detection, functional group tests, physical constant determination. The analysis should be done by micro-scale techniques. For the identification of an organic compound about 500mg of any compound with not more than two functional/neutral groups be given belonging to the following categories: Acids (carboxylic acids/sulphonic), phenols, aldehydes/ketones, alcohols, esters, amines (primary, secondary and tertiary), carbohydrates, hydrocarbons, halo/nitro hydrocarbons.

Note: A minimum of 12 compounds be given for the identification: at least one from each of the categories mentioned above.

CIA AND END SEMESTER PRACTICAL EXAMINATION

CIA: 20 MARKS PER COURSE PER SEMESTER: Total: **60 MARKS**

COURSE 4.01: 15 MARKS oral presentation on instrumentation
5 MARKS: journal

COURSE 4.0 2: 15 MARKS: exercise to test a quantitative practical skill
5 MARKS: journal

COURSE 4.03: 15 MARKS: exercise to test a qualitative practical skill
5 MARKS: journal

END SEMESTER EXAMINATION: 30 MARKS PER COURSE
Total: **90 MARKS**

The practical exam will be conducted for 3 sessions (one per course) of 3 hours duration each.

Course 4.01: 25 Marks and 5 Marks written test

Course 4.02: 25 Marks and 5 Marks written test

Course 4.03: 25 Marks and 5 Marks written test

Batch Size: Maximum 20 students per batch.