

Rs. 5/-

**NORTH MAHARASHTRA UNIVERSITY**

**JALGAON - 425 001**

**Syllabus**

**FOR M.Sc. - part I ( Industrial Chemistry )**

**with effect from July 1997**

**DEPARTMENT OF INDUSTRIAL CHEMISTRY**

**SCHOOL OF CHEMICAL SCIENCES**

**SYLLABUS  
FOR  
M.Sc.(INDUSTRIAL CHEMISTRY) w.e.f. JUNE 1997**

**Eligibility :** B.Sc.Chemistry /Industrial Chemistry as principle subject with Mathematics & Physics as subsidiary subjects.

**Course Structure for First Year**

**Semester - I**

**Sub.Code: Title**

ICH 101 : Inorganic Chemistry - I  
ICH 102 : Physical Chemistry - I  
ICH 103 : Organic Chemistry - I  
ICH 104 : Analytical Methods & Use of Computers in Chemistry  
ICH 115 : Laboratory Course - I

**Semester - II**

**Sub.Code: Title**

ICH 201 : Inorganic Chemistry - II  
ICH 202 : Physical Chemistry - II  
ICH 203 : Organic Chemistry - II  
ICH 204 : Introduction to Industrial Chemistry  
ICH 215 : Laboratory Course - II

**Note :** The examination of laboratory courses ICH-115 & ICH-215 will be conducted together at the end of the year.

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**Course Structure for Second Year**

**Semester - III**

**Sub.Code: Title**

ICH 301 : Unit Operations in Chemical Industries  
ICH 302 : Industrial Polymers  
ICH 303 : Unit Processes in Organic Synthesis  
ICH 304 : Chemical Process Industries - I  
ICH 315 : Laboratory Course - III

**Semester - IV**

**Sub.Code: Title**

ICH 401 : Chemical Process Industries - II  
ICH 402 : Industrial Management & Pollution Control  
ICH 403 : Chemical Process Industries - III  
ICH 414 : Project  
ICH 415 : Laboratory Course - IV

**Note :** The examination of laboratory courses ICH-315 & ICH-415 will be conducted together at the end of the year.

**Educational Tour :** Educational tour aiming at giving practical exposure to students is proposed once in two years.

**Inplant Training :** Students are expected to undergo one month practical training (at their own cost) in relevant industries. The said training is proposed after III / IV semester.

## M.Sc.(Industrial Chemistry)

### Semester - I

#### ICH 101 : Inorganic Chemistry - I

(Marks - 60)

1. Chemistry of non transition elements :- Periodicity & general discussion on properties of non transition elements, special features of individual elements, synthesis, properties & their halides & oxides. Polymorphism of carbon. Phosphorus & sulphur. Synthesis, properties & structures of boranes, carboranes, borazines, silicates, carbides, silicones, phosphazenes sulphur-nitrogen compounds, peroxo compounds of boron, carbon & sulphur, oxyacids of nitrogen phosphorus, sulphur & halogens, interhalogen compounds, pseudohalides and noble gas compounds.
2. Chemistry of lanthanides & actinides - Spectral & magnetic properties, uses of lanthanide compounds.
3. Molecular symmetry & group theory - Molecular symmetry, Representation symmetry operations, definition of groups, basic representation - Derivation of character tables for  $C_{2V}$ ,  $C_{3V}$  &  $C_{4V}$  point groups.
4. Solids : Dislocations in solid: Schottky and Frenkel defects. Electrical properties. Insulators and semiconductors, band theory of solids, solid-state reactions.

#### Recommended Books

1. Modern aspects of Inorganic Chemistry - H.J. Emeleus, A.G. Sharp.
2. Inorganic Chemistry - D.F. Shriver, P.W. Atkins, C.H. Langford.
3. Inorganic Chemistry - I.S. Buttlar & S.F. Harrod.
4. Inorganic Chemistry Principles of structure and reactivity- J.E. Huheey ( Harper and Row pub. London 1972)
5. Advanced Inorganic Chemistry - F.A. Cotton & G. Wilkinson.
6. Chemical Application of Group Theory - F.A. Cotton.
7. Symmetry in Chemistry - H.H. Jaffe & M. Orchin (Wiley Eastern Pvt.Ltd. New Delhi 1971)
8. Group theory in chemistry & physics - Arora & Narang
9. Solid State Chemistry - C.N.R. Rao
10. Solid State Chemistry - N.B. Hannay
11. Introduction to Solids - L.H. Azaroff (T.M.H.)

#### ICH 102 : Physical Chemistry - I

(Marks - 60)

1. Thermodynamics: First law of thermodynamics, relation between  $C_p$  and  $C_v$ , enthalpies of physical & chemical changes, temperature dependence of enthalpies, second law of thermodynamics entropy, Gibbs-Helmholtz equation. Third Law of thermodynamics & Calculations of Energy.
2. Chemical Equilibrium: Free energy and entropy of mixing, partial molar quantities, Gibbs- Duhem equation. Equilibrium constant and its temperature- dependence , phase diagram of one and two component system. phase rule.
3. Ideal and Non Ideal Solution: Excess functions; activities, concept of hydration number, activities in electrolytic solution, mean ionic activity coefficient. Debye - Huckel treatment of dilute electrolyte solution.

4. Equilibrium in Electrochemical cells: Cell reaction; Nerst equation, application of cell EMF measurement.

5. Surface phenomena : Surface tension, adsorption solids, electrical phenomena at interfaces including electron kinetics, micelles and reverse micelles; solubilization micro-emulsions, application of photo electron . ESCA and Auger Spectroscopy to the study of surfaces.

#### Recommended Books

1. Principles of Physical Chemistry - S.H. Maron & C.F. Prutton
4. Fundamentals of Physical Chemistry - S.H. Maron & Londe
2. Physical Chemistry - P.W. Atkins. EL/BS 4th Ed.
3. Physical Chemistry - G.M. Barrow
5. Physical Chemistry - I.N. Levine, McGraw Hill International Edition.

#### ICH : 103 Organic Chemistry - I

(Marks - 60)

1. Organic reaction mechanism : Definition & types; Energetics, kinetics, labeling & kinetic isotope effects. Hammett equation (Sigma-Rho relationship); non-classical carbonium ions, covalent bond fission - homo- & hetero fissions, intermediates & stability - carbonium ions, carbanions, free radicals, carbenes, nitrenes, arynes.

2. Common organic reactions & mechanisms : Nucleophilic substitution in sat. aliphatic compounds, electrophilic & nucleophilic substitution in aromatic compounds; determination of organic reaction mechanism (kinetic & non-kinetic methods)

Familiar name reactions : Adol, Perking, Stobbe, Dieckmann condensations, Hofmann, Schmidt, Lossen, Curtius, Beckman & Fries rearrangements, Reimer-Tiemann, Reformatsky & Grignard reactions, Diels-Alder reactions, Claisen rearrangement; Friedel-Craft reaction, Wittig reaction & Robinson annulation, Routine functional group transformations & interconversion of simple functionalities. Hydroboration, Oppenauer oxidation, Clemmensen, Wolf-Kishner, Meerwein-Ponndorf-Varley and Birch reductions.

Selective organic name reactions : Favorskii reaction, Stork examine reaction, Michael addition, Mannich reactions, Sharpless asymmetric epoxidation, Ene reaction, Barton reaction, Hofmann-Löffler-Freytag reaction, Shapiro reaction, Baeyer-villiger reaction, Chichibabin reaction.

3. Aromaticity : Huckel's rule & concept of aromaticity, (n) annulenes & heteroannulenes, fullerenes (C<sub>60</sub>).

4. Stereochemistry : Concept of chirality - Recognition of symmetry elements and chiral structures, R-S nomenclature, diastereoisomerism in acyclic systems, E-Z isomerisms, conformational analysis of simple cyclic (chair & boat cyclohexanes) & acyclic systems. Interconversion of Fischer, Newman and Sawhorse projection.

Stereochemistry & conformational analysis : Newer methods of asymmetric synthesis (including enzymatic & catalytic nexus)

5. Organometallic Compounds : Transition of organometallic Compounds of Palladium, rhodium, Cobalt, iron, Nickel in organic synthesis.

### Recommended Books

1. Organic Chemistry by Morrison Boyd
2. Stereochemistry of Carbon Compounds by E.L. Eliel.
3. Some Modern Methods of Organic Synthesis by W. Carruthers.
4. Guide book to mechanism in Organic Chemistry by Peter Sykes.
5. Principles of Organometallic Chemistry by P. Powell.
6. Principals of Organometallic Synthesis by R.O. C. Norman
7. Model Synthesis reactions - Herbert O. House
8. Organometallics in Organic Synthesis by Swan & Black.

### ICH 104 : Analytical Methods & Use of Computers in Chemistry (Marks - 60)

#### Section-I

1. Advance Chromatography Technique - Gas Chromatography - Gas Chromatographs, Detectors, Optimization of Experimental Conditions, Gas-Solid Chromatogapy. High Performance Liquid Chromatography Methods - Adsorption Chromatography, Liquid-Liquid Partition Chromatography, Ion-Exchange HPLC, Exclusion Chromatography.
2. IR Spectroscopy - Molecular vibrations, Factor influencing vibrational frequencies, instrumentation, IR sources, optical system, detectors process analysis, sampling techniques. interpretation of spectra - Quantitative analysis, ATR & MIR reflectance, FTIR spectroscopy.
3. UV & Visible spectroscopy - Theory of electronic spectroscopy, instrumentation & sampling applications, visual spectroscopy, visual calorimetry, Photometric filter photometry, spectrophotometry, simultaneous spectrophotometry, differential spectrophotometry, photometric titrations.
4. NMR Spectroscopy - Proton NMR spectroscopy, The NMR phenomenon, theory . Chemical shifts and its measurement, factors influencing chemical shifts, sample handling & instrumentation, solvent used in NMR, spin spin coupling, spin spin splitting, Bond multiplicity, applications, derivative curves of values, Hyperfine splitting. Introduction to C13 NMR.
5. Mass Spectrometer - Components of Mass Spectrometers, Resolution, Mass Spectrometers.
6. Interpretation of spectra obtained from various techniques.

#### Recommended Books

- 1) Instrumental Methods of Chemical Analysis - Willard, Merit, Dean
- 2) Application of Absorption Spectroscopy of Organic Compounds-John R.Dyer, Prentice Hall of India
- 3) Spectroscopy Methods of Organic Chemistry - Williams Fleming
- 4) Organic Spectroscopy - William Kemp
- 5) Mass Spectroscopy - by K.G. Das
- 6) Instrumental Methods of Analysis - Chatwal & Anand
- 7) Basic concepts in Analytical Chemistry - S.M.Khopkar.

## Section-II

1. Introduction to Computers :  
Hardware components; CPU, Computer memory, I/O devices; information storage, software components; computer programs; stored program concept; operating system; DOS and its use. Algorithms program flowcharts and pseudo-code.
2. Fortran-77 :  
Character set. Identifiers. Data types. Arithmetic expressions and operations. Library functions. Input/Output functions. Formatted input and output statements. Control structures (Sequence, relational operations and expressions simple and nested blocks) Loop control (Do WHILE AND REPEAT UNTIL, DO..... CONTINUE and nested loops). Function and subroutine subprograms. Shared variables and constants. One dimensional and multidimensional arrays character data manipulation. File and data manipulation (OPEN, CLOSE, INQUIRE, REWIND, BACKSPACE, ENDFILE)  
Programming examples to handle the following numerical methods in chemistry should be done; such as least squared fit, solution of simultaneous equation, polynomial equation, polynomial equation fitting, matrix inversion and diagonalisation and numerical differentiation and integration. Splines and data smoothing. Elements of parallel processing and its use in chemistry.
3. Use of software packages in Chemistry:
  - a) Spreadsheet Application Least squares fit, kinetics, potentiometric titrations and end point location. Fitting curves and plotting functions.
  - b) Data-base applications in Chemistry
4. Writing FORTRAN -77 programs for the following problems
  1. Finding largest/smallest of the given numbers using array & with out array
  2. Arranging given numbers in ascending and descending order using array & with out array
  3. Matrix multiplication.
  4. Finding GCD of given numbers.
  5. Finding molecular weight of given compound.
  6. Finding molecular formula from elemental analysis
  7. Calculation of pH from given concentration.
  8. Conversion of temperature from oF to oC
  9. Finding rate constant of reaction from given data
  10. Finding out strength of acid/base from titration reading.
  11. pH of a weak acid bases titration (with graphics)
  12. Potentiometric end point determination (with graphics)

### Recommended Books

1. R.N. Reddy & C.A. Ziegler : Fortran-77 (JAICO Book, 1989).
2. P.C. Jurs, T.L. Isenhour & C.L. Wilkens - BASIC programming for Chemists (J.Wiley , 1987).
3. K. Ebert, H. Ederer, T.L. Isenhour - Computer Applications in Chemistry.
4. G.I. Duchi - Spreadsheet Applications for Scientists & Engineers (Addison Wesley 1988).
5. G.Beech - FORTRAN IV in Chemistry - An introduction to Computer assisted methods (J.Wiley & Sons) 11
6. P.S. Grover - Programming & Computing with Fortran-77/80 (Allied pub. 1992).
7. V. Rajaram - Elements of Parallel Processing (Printice Hall 1990).

Minimum 12 experiments pertaining to the course will be conducted

Inorganic Chemistry

1. Analysis of dolomite w.r.t. - Magnesium/ Calcium
2. Analysis of Cement - Silica/ Calcium/ Magnesium
3. Analysis of alloy -solder alloy - estimation of tin & lead
4. Analysis of plaster of paris - calcium
5. Analysis of pigment - Estimation of potassium (volumetrically)
6. Estimation of uranium in mineral by colorimetry.
7. Estimation of percentage of sodium carbonate in commercial washing soda.
8. Determination of sulphate / chloride by turbidimetry
9. Thermogravimetric studies on calcium oxalate.
10. Thermochemistry -determination of lattice energy of binary salts by heat of dissolution.
11. Synthesis of potassium trioxalato aluminate & estimation of metal ion.

Physical Chemistry

1. Determination of Na, K, Li & Ca by Flame photometry.
2. Determination of % composition of A & B from a given mixture AB by Refractometrically.
3. Determine the molar refraction of Methyl acetate, Ethyl acetate, n-Hexane, Carbon tetra chloride and to calculate atomic refractions of C,H & Cl atoms.
4. Determination of calorific value of given sample by Bomb Calorimeter.
5. Determination of dissolved oxygen present in a waste water sample.
6. Determine magnetic susceptibility by Guoy method.
7. Determination of exact normality of acid from a mixture of acids by pH metry.
8. To verify Ostwald's dilution law.

Organic Chemistry

a) Mixture Separation - Separation of at least two three component mixture, which involves separation of low boiling compounds water soluble compounds, amines, phenols, acids, neutral compounds, nitrophenols, aminophenol & also compounds containing other elements & functional group.

b) Two stage preparations of two compounds.

Determination of  $r_f$  values of TLC of each compound prepared.

**Recommended Books**

1. A Textbook of Practical Organic Chemistry, A - I Vogel
2. Practical Organic Chemistry - Raj K. Bansal
3. Systematic Experimental Physical Chemistry - Rajbhoj & Chondhekar, Anjali Publications.
4. Frindlay's Practical Physical Chemistry - B.P.Levit , Longman Publications

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## Semester -II

### ICH 201 : Inorganic Chemistry - II

(Marks - 60)

1. Chemistry of transition elements - Coordination chemistry of transition metal ions, stability constants of complexes their determination, stabilisation of usual oxidation states stereochemistry of coordination compounds, Ligand field theory, splitting of d-orbitals in low symmetry environments, Jahn Teller effect, interpretation of electronic spectra including charge transfer spectra, spectrochemical series, nephelaugetic series, Magnetism - dia-, para-, ferro- & antiferromagnetism, quenching of orbital angular momentum spin orbit coupling, Inorganic reaction mechanism - Substitution reactions, trans & electron transfer reactions, photochemical reactions of chromium, ruthenium complexes. Fluxional molecules/iso & heteropoly acids, metal clusters spin cross over in coordination compounds.

2. Organometallic Chemistry & Catalysis - Structure & bonding Organometallic compounds in organic synthesis & in homogeneous catalytic reactions like - hydrogenation, hydroformylation, isomerisation & polymerization  $\pi$ - acid metal complexes, activation of small molecules by coordination.

3. Bioinorganic Chemistry - Inorganic elements in biological system, Alkali & Alkaline earth metal ions - role & molecular mechanism of ion transport across membranes, ionophores, chlorophyll in photosynthesis, Biological nitrogen fixation, Metal complexes as oxygen carriers - Haemoglobin, Myoglobin, Hemerythrin, Hemocyanin, Electron Transfer Proteins - Cytochromes, & Ferredoxins.

#### Recommended Books

1. Inorganic Chemistry - D.F. Shriver, P.W. Atkins, C.H. Langford.
2. Inorganic Chemistry: Principles & Applications - I.S. Buttlar & S.F. Harrod.
3. Principles of Organometallic Chemistry - P. Powell
4. Inorganic Chemistry of Biological Processes - M.N. Hughes (2nd Ed., Wiley)
5. Inorganic Chemistry - A.G. Sharpe (ELBS Ed., 1984)
6. Basic Inorganic Chemistry - F.A. Cotton & G. Wilkinson
7. Advanced Inorganic Chemistry - F.A. Cotton & G. Wilkinson
8. Introduction to ligand fields - B.N. Figgis
9. Coordination Compounds - S.F.A. Kettle
10. Coordination Chemistry - F. Basolo & R. Johnson
11. Organotransition Metal Chem. Applications to Organic Synthesis - S.G. Devis.
12. Reaction Mechanism in Inorganic & Organometallic Systems - R.B. Jordan.
13. Magnetochemistry - R.L. Carlin
14. Magnetic Susceptibility - L.N. Mulev

### ICH 202 : Physical Chemistry - II

(Marks - 60)

Statistical Thermodynamics :

1. Thermodynamic probability of entropy; Maxwell - Boltzmann distribution of velocities; average, most probable and root-mean-square velocities. Maxwell - Boltzmann, Bose - Einstein and Fermi Dirac Statistics. Partition function; rotational, translational, vibrational and electronic partition functions for



diatomic molecules calculations of thermodynamic functions and equilibrium constant. Theories of specific heat for solids.

2. Reaction Kinetics: Methods of determining rate laws, mechanisms of photochemical, chain and oscillatory reactions, collision theory of reaction rates, Steric factor, treatment of unimolecular reactions, Theory of absolute reaction rates, comparison of results with Eyring and Arrhenius equations, Ionic reactions; salt effect, Homogeneous catalysis and Michaelis - Menten Kinetics, heterogeneous catalysis.

3. Fast Reactions : Study of kinetics by stop-flow technique, relaxation method, flash photolysis and magnetic resonance method.

4. Nuclear Chemistry : Radioactive decay and equilibrium. Nuclear reaction: Q value, cross-sections, types of reactions, Chemical effects of nuclear transformations, fission and fusion, fission products and fission yields. Radioactive techniques, tracer techniques, neutron activation analysis, counting techniques, such as G.M., ionization and proportional counters.

#### Recommended Books

1. Physical Chemistry - P.W. Atkins, Oxford University Press  
ELBS Edition London.
2. Essential of Nuclear Chemistry - H.J Arnikar, Wiley Eastern
3. Basic Chemical Kinetics - G.L.Agrawal, Tata McGraw Hill  
Publishing Company, New Delhi.
4. Kinetics & Mechanism - A.A.Frost and R.G.Pearson John Wiley  
& Sons.
5. Chemical Kinetics - Laidler, Tata McGraw Hill Publishing  
Company, New Delhi.
6. Statistical Thermodynamics - M.C.Gupta, Wiley Eastern.

#### ICH 203 : Organic Chemistry -II

(Marks - 60)

1. Heterocyclic chemistry : Synthesis and reactivity of Furan, Thiophene, Pyrrole, Pyridine, Quinoline, Isoquinoline and Indole, Skraup synthesis, Fischer Indole synthesis.

2. Pericyclic reactions: Selection rules and stereo chemistry of electrocyclic reactions, cycloaddition and sigmatropic shifts, Sonnet, Hauser, Cope and Claisen rearrangement.

3. Reagent in organic synthesis : Use of the following reagents in organic synthesis and functional group transformations, complex metal hydrides, Gilman's reagent, Lithium dimethyl copper, Lithium diisopropylamide, Dicyclohexyl carbodiimide, 1,3 dithiane, Trimethylsilyliodide, Tri-n-butyl-tinhydride, Woodward and Prevost hydroxylation, Osmiumtetroxide, DDQ, Selenium dioxide, Phase transfer catalyst, Crown ethers and Merrifield resins, Peterson's synthesis, Wilkinson's catalyst, Baker yeast

4. Chemistry of natural products, Familiarity with methods of structural elucidation and biosynthesis of alkaloids, terpenoids, steroids, carbohydrates and proteins.

5. Bioorganic chemistry : Elementary structure and function of biopolymers such as proteins and nucleic acid.

6. Photochemistry . Cis trans isomerization, Paterno-Buchi reaction, Norrish type I & II reactions, photoreduction of ketones, di-pinene rearrangement, photochemistry of arenes.

7. Spectroscopy : Applications of UV-VIS, IR, NMR, and Mass Spectroscopy for structural elucidation of compounds.

#### Recommended Books

1. Organic Chemistry by Morrison, Boyd
2. Some Modern Methods of Organic Synthesis by W. Carruthers.
3. Spectroscopic Methods in Organic Synthesis by William Fleming
4. Reaction Mechanism & Reagents in Organic Chemistry by G.R. Chatwal.
5. Spectroscopic identification of Organic Compounds by Silverstein.
6. Absorption Spectroscopy of Organic Molecules by Parikh.
7. Mass Spectroscopy by K.G. Das & James.
8. Principles of Modern Heterocyclic Chemistry by Faquette.
9. Conservation of Orbital Symmetry by R.B. Woodward & R. Hoffmann.
10. Modern Molecular Photochemistry by Nicholas J. Turro. &

**ICH 204 : Introduction to Industrial Chemistry (Marks - 60)**

1. Material balance :
  - a) Without chemical reaction.
  - b) With chemical reaction.
  - c) With recycle & bypass
2. Energy balance :  
Heat of reaction, heat capacity determination, enthalpy determination for adiabatic reaction.
3. Mass transfer :  
Diffusion phenomenon, Distillation (with & without reflux) Mc-Cabe & Thiele method of determination of number of plates, Liquid-liquid extraction & leaching. Equipment, Equipments for crystallization & drying.
4. Flow of Fluids :  
Bernoulli's equation & its application.
5. Heat transfer :  
Various mode of heat transfer - conduction, convection & radiation. Different types of Heat Exchanger - Double pipe, shell & tube, plate, spiral. Evaporators - single effect & multiple effect.

#### Recommended Books

1. Unit Operation in Chemical Engineering - Mc-Cabe & Smith
2. Chemical Engineering Vol. I & II - Richardson & Coulson
3. Heat Transfer - D.Q. Kern

**ICH 215 : Laboratory Course - II (Marks - 60)**

Minimum 12 experiments pertaining to the course will be conducted

#### Inorganic Chemistry

1. Analysis of Ilmenite ore - estimation of silica, iron, titanium.

2. Analysis of Bauxite ore - estimation of silica, aluminium, Iron.
3. Analysis of steel - estimation of iron, nickel & chromium.
4. Analysis of pigment - estimation of chromium
5. Preparation of trioxalato ferrate(III) trihydrate
6. Preparation of Zinc ferrite
7. Preparation of trans bis ethylene diamine cobalt chloride
8. Kinetics of aquation of trans bis ethylene diamine cobalt chloride
9. Kinetics of aquation of tris(1,10-phenanthroline) iron (II) in acid solution by spectrophotometry.
10. Magnetochemistry - Determination of magnetic susceptibility of given complexes.
11. Colorimetric analysis of mixtures of Co(II) & Ni(II)
12. Determination of number of water molecules from the given hydrated compounds.
13. Determination of stability constant of metal complexes by Bjerrum's (potentiometric) method or spectrophotometric method.
14. Determination of metal, ligand ratio by Jobb's method.
15. Analysis of IR spectrum of transition metal complexes [Bis acetyl acetonato copper (II)].

#### Physical Chemistry

1. Determination of Flash and Fire Point of the given lubricating oil.
2. Determination of capacity of ion exchange resin.
3. Determination of chemical oxygen demand of given waste water sample.
4. Determination of Biochemical oxygen demand of waste water sample.
5. Determination of moisture content by karl fischer titration.
6. Determination of turbidity of waste water by using Nepheloturbidity meter.
7. Analysis of flue gas by orsat gas analyser.
8. To determine radius of a molecule by viscometry.
9. To determine formal redox potential of Fe ions.
10. To determine basicity & pKa value of an organic acid potentiometrically.

#### Organic Chemistry

- A) Estimation of number of functional groups in -
  - a) amines    b) acetylesters    c) aldehydes    d) carboxylic acids
- B) Use of synthetic reagents in organic synthesis
  - a) Sodium borohydride
  - b) N-Bromo succinamide
  - c) Unhydrous Aluminium Chloride
  - d) Poly phosphoric acid

#### **Recommended Books**

1. Practical Organic Chemistry - F.G.Mann, R.C.Saunders
2. Textbook of Practical Organic Chemistry A - I Vogel
3. Practical Organic Chemistry - Raj K. Bansal

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