NOTIFICATION

Sub: III & IV semester Choice Based Credit System syllabus of M.Sc. in Analytical Chemistry degree programme.

Ref: 1) This office Notification No. MU/ACC/CR6/CBCS-PG(SLB)/2017-18/A2, dated: 17-8-2016.
2) Academic Council decision dated 3-2-2017 vide Agenda No. 3:11 (2016-17)

In continuation to this office Notification cited under ref. (1) above, the syllabus of III & IV semester M.Sc. in Analytical Chemistry degree programme which approved by the Academic Council at meeting held on 3-2-2017 is hereby notified for implementation with effect from the academic year 2017-18 and onwards (for students of 2016-17 batch and onwards).

To:

1) The Chairman of the Department concerned/ The Coordinator of the degree programme concerned.
2) The Principal of the college concerned.
3) The Registrar [Evaluation], Mangalore University.
4) The Chairman of the Board of Studies concerned.
5) The Superintendent [ACC], Office of the Registrar, Mangalore University.
6) Guard file.
Mangalore University
Department of Studies in Chemistry
M. Sc. Degree Programme
(CHOICE BASED CREDIT SYSTEM - SEMESTER SCHEME)

Syllabi for M.Sc., Courses in

ANALYTICAL CHEMISTRY

(From the Academic Year 2016-17 onwards)
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UNIT- I: Acid-base Titrations [15 Hours]


UNIT- II [15 Hours]
Complexometric titrations: Complex formation reactions. Stability of complexes, stepwise formation constants, chelating agents. EDTA- acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, factors affecting the shape of titration curves. Completeness of reactions, indicators for EDTA titrations, theory of common indicators. Titration methods employing EDTA- direct, back and displacement titrations, indirect determinations. Titration of mixture, selectivity, masking and demasking agents. Typical applications of EDTA titrations- hardness of water, magnesium and aluminium in antacids, magnesium, manganese and zinc in a mixture. Titrations involving unidentate ligands- titration of chloride with Hg$^{2+}$ and cyanide with Ag$^+$. 

Precipitation titrations: Titration curves feasibility of precipitation titrations. Factors affecting shape- titrant and analyte concentration. completeness of the reaction. Titrants and standards. Indicators for precipitation titrations involving silver nitrate. The Volhard, the Mohr and the Fajan's methods. Typical applications.

UNIT- III: [15 Hours]
Gravimetric methods: Introduction to gravimetric analysis, precipitation methods, the colloidal state, Supersaturation and precipitate formation, purity of the precipitate: co-precipitation, post-precipitation, Conditions for precipitation, precipitation from homogeneous solution, washing the precipitate. Fractional precipitation, organic precipitants, volatilisation or evolution methods.

References:
1. Fundamentals of Analytical Chemistry-S. A. Skoog, West & Holler
3. Quantitative analysis-Kenner & Busch
4. Analytical Chemistry-Larry G. Hargis
5. Vogel’s Text book of Quantitative Inorganic Analysis- Bessett, Denney, Jeffery & Mendham

CA H 502: BIOANALYTICAL  and  RADIOCHEMICAL TECHNIQUES

UNIT- I: Bioanalytical Techniques -1

UNIT- II: Radio Chemical methods of analysis
Health and safety aspects: Biological effects of radiation, Hazards in radiochemical work, Radiation protection, permissible exposure doses. Radioactive waste management.

UNIT-III : Radio Chemical methods of analysis (Radio analytical techniques)  [15 Hours]
Disintegration theory, rate of disintegration, radioactive tracers, tracer techniques. Application in analytical chemistry, isotopic dilution analysis, activation analysis and prompt gamma neutron activation analysis (PGNAA). Radiometric analysis, radiometric titrations and applications.
Radio immuno assay, measuring radioisotope activity, antigens and antibodies, enzymatic immunoassay, its principle and applications, clinical application of the radioimmunoassay of insulin, Estrogen and progesterone, instrumentation for radiobioassay.

References:

CAH 503: CHROMATOGRAPHIC SEPERATION TECHNIQUES

UNIT-I: Basic concepts [15 Hours]
General description, definitions, terms and parameters used in chromatography. Classification of chromatographic methods. Criteria for selection of stationary and mobile phase-nature of adsorbents, factors influencing adsorbents, nature and types of mobile phases. Theoretical principles of chromatographic technique, development of chromatogram.


UNIT-II: Planar chromatography and separation techniques [15 Hours]


UNIT-III: Column Chromatography [15Hours]


References:
2. Chromatography Today- D.F.Poole and S. K. Poole,

CA S 504: THERMO & SPECTRO ANALYTICAL TECHNIQUES

UNIT- I: Thermoanalytical Techniques [12 Hours]

UNIT- II: [12 Hours]

UNIT –III [12Hours]
Spectro analytical Methods
Colorimetric: Beer and Lambert's law – terminology – condition for a satisfactory colorimetric analysis – method of colour measurement or comparison – principles of colorimetric determinations of NH₃, Cr, Cu, Fe, Mn – simultaneous spectrophotometer determination of Cr and Mn.
1H NMR and 13 C NMR elucidation of pharmaceutical drugs and its application with mass spectrophotometric studies. Use of electron spectroscopy, X-ray emission and Liminescence in analytical studies.

References
1. Fundamentals of Analytical Chemistry – S.A. Skoog, West & Holler
6. Quantitative analysis-C. T. Kenner and Kenner W. Busch
8. Analytical Chemistry- Larry G. Hargis

CA S 505: ANALYTICAL CHEMISTRY OF POLYMERS

UNIT- I: [12 Hours]
Basic concepts-Monomers, repeat units, degree of polymerization. Polydispersion, average molecular weight and size concept-number average, weight average, viscosity average and Z-average molecular weights. Average end to end distance and radius of gyration, Practical significance of molecular weight, Geometrical structure. Glass transition and melting transitions, Effect of polymer structure on Tg and Tm temperature, Tg-transitions and associated properties, importance of Tg, Effect of crystallinity on the properties of polymers and Tg.

UNIT -II: [12 Hours]
Advanced polymeric materials: Polymer blends interpenetrating Networks & composites – Types, preparation techniques, properties & application.
Environmental stability and testing-Photo, oxidative and biodegradation. Solvent resistance testing. Polymer additives & roles-fillers, plasticizers, antioxidants, coloring agents, UV stabilizers, heat stabilizers and flame retardants.
UNIT III:  
**Determination of molecular weight** – End group analysis, viscosity, light scattering, osmometry, cryoscopy, ebulliometry and ultra centrifugation method. **Thermal Characterization:** Thermal properties: Techniques of measurement of transition temperatures and stability, Dilatometry, DSC, DTA, DTG, TGA. Measurement of thermal conductivity, thermal expansion and heat deflection temperature.


**References:**
2. Textbook of Polymer Science, F.W. Billmeyer, Wiley, Newyork;
7. Plastics- Chemistry and technology, W.E. Driver

**CH E 506 : ANALYTICAL AND GREEN CHEMISTRY**

UNIT- I:  
**UV/Electronic Spectroscopy:** Basic principles, Beer-Lambert law, types of absorption bands, Factors affecting the positions of UV bands. Theoretical prediction of \( \lambda_{\text{max}} \) for polyenes, \( \alpha,\beta \)-unsaturated aldehydes, ketones (Woodward-Fieser rules) and substituted benzenes.

**IR Spectroscopy:** Basic principles, Application of infrared spectroscopy in the structural study-identity by finger printing and identification of functional groups. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines). Study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides and acids). Factors affecting band positions and intensities

**Nuclear Magnetic Resonance Spectroscopy:** Basic principles, Solvents used, chemical shift and its measurements, factors affecting chemical shift. Integration of NMR signals, spin-spin coupling, coupling constant. Shielding and deshielding. High resolution \(^1\text{H}\) NMR. Applications of NMR spectroscopy in structure elucidation of simple organic molecules.

**UNIT- II:**  
[12 Hours]

Hydrologic cycle, sources, chemistry of sea water, criteria and standards of water quality- safe drinking water, maximum contamination levels of inorganic and organic chemicals, radiological contaminants, turbidity, microbial contaminants. Public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, chloride, residual chlorine, sulphate, fluoride, phosphate and different forms of nitrogen in natural and polluted water. Chemical sources of taste and odour, treatment for their removal, sampling and monitoring techniques. Determination and significance of DO, BOD, COD and TOC. Water purification for drinking and industrial purposes, disinfection techniques, demineralization, desalination processes and reverse osmosis. Treatment of liquid radioactive wastes

**UNIT- III:**  
[12 Hours]

**Green Chemistry:** Definition and principles, planning a green synthesis in a chemical laboratory, Green preparation-Aqueous phase reactions, solid state (solventless) reactions, photochemical reactions, Phase transfer catalyst catalysed reactions (Quaternary ammonium salts & Crown ethers), enzymatic transformations & reactions in ionic liquids.

**Sonochemistry:** Introduction, instrumentation, the phenomenon of cavitation, Sonochemical esterification, substitution, addition, oxidation, reduction and coupling reactions.

**Microwave induced organic synthesis:** Introduction, reaction vessel and reaction medium, concept, specific effect, atom efficiency, % atom utilisation, advantages and limitations, alkylation of active methylene compounds, N-alkylation, condensation of active methylene compounds with aldehydes, Diels-Alder reaction, Leuckardt reductive amination of ketones, ortho ester Claissen rearrangement.

**References:**

5. Spectroscopic Methods in Organic Chemistry - Williams and Fleming, TMH.
11. S.M.Khopkar, Environmental Pollution Analysis, (Wiley Eastern).

CA P 507: ANALYTICAL CHEMISTRY PRACTICAL – III

1. Analysis of Na₂CO₃ and NaHCO₃ in baking soda by acid base titration
2. Determination of Calcium in limestone by redox titration
3. Determination of total hardness of water by EDTA titration
4. Analysis of copper/Calcium by PFHS method
5. Analysis of chloride in natural and polluted water samples by argentimetric titration
6. Assay of calcium in milk powder by EDTA titration
7. Assay of Vitamin – C by iodine titration and by bromination using KBrO₃
8. Determination of iron and sodium in water by spectrophotometry.
9. Assay of iron in pharmaceutical preparation by visual & potentiometric titration by Ce(SO₄)₂
10. Iodometric determination of antimony.
11. Quantitative analysis of mixtures: a) Chloride and iodide; b) iodide volumetrically using KIO₃ & ii) total halide gravimetrically
12. Analysis of Calcium and lead-using EDTA

CA P 508: ANALYTICAL CHEMISTRY PRACTICALS – IV

1. Estimation of iron in razor-blade by potentiometric & visual titration using sodium vanadate.
2. Determination of water in hydrated calcium sulphate by Karl-Fischer titration
3. Determination of chloride content in tap water by Spectrophotometry.
4. Estimation of sulphate in urine by precipitation titration following ion-exchange separation.
5. Determination of 1, 2-glycols or glycerol by periodates oxidation.
6. Determination of aluminium and magnesium in antacids by EDTA Titration
7. Determination of mercury in algaecide by EDTA titration
8. Determination of Iron in mustard seed by spectrophotometry
10. Determination of copper by potentiometric titration using EDTA.
11. Conductometric determination of total acidity of waste water.
12. Conductometric determination of chloride content of a sample of industrial effluent
13. Conductometric determination of total alkalinity of waste water.
CA P 509: ANALYTICAL CHEMISTRY PRACTICALS – V

1. Analysis of alloys: Solder – lead and tin using EDTA.
2. Analysis of Copper-Nickel alloy i) Copper volumetrically using KIO₃ & ii) Nickel gravimetrically using DMG
3. Analysis of Brass - Cu gravimetrically using α- benzoinoxime and Zn complexometrically
4. Analysis of Stainless steel-Ni gravimetrically using DMG, Fe volumetrically using Ce(IV), Cr volumetrically by persulphate oxidation,
5. Paper chromatographic separation of i) iron and nickel; ii) copper and nickel
6. Separation and determination of chloride and bromide on an ion-exchanger.
7. Estimation of total cation concentration in water by ion-exchange method.
9. Analysis of copper in ore/alloy by iodometric titration
10. Analysis of ores – chalcopryite, ilmenite.
12. Computational Chemistry Laboratory: Windows and Linux; MSOFFICE; Statistical Data Processing and Curve Fitting by EXCEL, GRAPHER, SURFER and MATHEMATICA; Chemical Structure Drawing by ISIS Draw, CHEMWIND, ACD Labs and CHEMDRAW; Molecular Modeling by ACD Labs, PCWIN and CHEM 3D; Chemical Databases; Animations and Virtual Chemical Experiments.

References:
1. A text Book of Quantitative Inorganic Analysis – A.I Vogel
2. Vogel’s Text Book of Quantitative inorganic Analysis, Basset, Denney, Jeffery & Mendham
UNIT- I: Drugs and Pharmaceutical Analysis  
Importance of quality control; drugs and pharmaceuticals. Sources of impurities in pharmaceutical chemicals. Analytical quality control in finished/final products. Common methods of assay.
Analysis of common drugs: Analgesics- aspirin, paracetamol, Antihelmentics-mebendazole; Antiallergies–chlorpheneramine malleate; antibiotics- penicilin, chloromecytin; Anti-inflammatory agents-Oxyphenbutazone; Antimalarias-primazine phosphate; Antituberculosists-1 NH; Narcotics-nicotine, morphine; Expectorants-benadryl; sedatives-diazepam; vitamins-A,B1, B2, B6, C, niacin & folic acid.

UNIT- II: Biomedical and forensic analysis  
Composition of body fluids and detection of abnormal levels of certain constituents leading to diagnosis of disease. Sample collection and preservation of physiological fluids, Analytical methods for the constituents of physiological fluids (blood, serum urine). Blood-Estimation of cholesterol, haemoglobin and bilirubin. Urine –Urea, Uric acid, creatinine calcium phosphate, sodium, potassium and chloride. Biological significance, analysis and assay of enzymes (pepsin, monoaminoxide); Vitamins (thiamine, vitamin A).
Forensic analysis: General discussion of poisons with special reference to mode of action of cyanide, organophosphates and snake venom. Estimation of poisonous (materials such as lead, mercury and arsenic in biological materials). Forensic Toxicology :Analysis of various types of poisons (corrosive, analgesic, hypnotic, narcotic, stimulants, paralytic, antihistamine).

UNIT III: Food Analysis  
Oils and fats- General composition of edible oils, detection of purity, rancidity of fats and oil, estimation of rancidity, tests for common edible oils like groundnut oil, castor oil, cottonseed oil
and mustard oil. Tests for adulterants like aregemone oil and mineral oils. Significance of value of iodine value and saponification value of oils and fats.

**Beverages** – soft drinks, alcoholic drinks, tea, coffee and fruit juices. **Food additives, adulterants and contaminants** – food preservatives like benzoates, propionates, sorbates, bisulphites. **Artificial sweeteners** like saccharin, dulcin and sodium cyclamate. Flavours-Vanillin, esters (fruit flavours) and monosodium glutamate. Artificial food colourants- coal tar dyes and non-permitted colours and metallic salts. Pesticide residues in food.

**References:**

7. The Quantitative Analysis of Drugs – D.C Garratt, Chappman and Hall, New York
10. Analysis of Foods – H.E. Cox;
UNIT –I: Atomic Spectroscopy [15 Hours]
Flame photometry-Emission and atomic absorption spectroscopy – Introduction, principle, flames and flame spectra, variation of emission intensity with the flame, flame temperature, chemical reactions in flame, metallic spectra in flame, flame background. Total consumption and premix burners, role of temperature on absorption, emission and fluorescence. Effect of organic solvents. Comparative study of the basic components and difference in the instrumental design for atomic absorption and flame photometry. Precision and accuracy of AAS and FES. Relationship between AAS and FES, advantages over FES, devices used for the formation of an atomic vapour, applications, determination of sodium in different samples by flame photometry.

UNIT -II: Molecular Luminescence [15 Hours]
Fluorometry and phosphorimetry: Introduction, fluorescence and phosphorescence, factors affecting fluorescence and phosphorescence, internal conversion, intersystem crossing (radiationless processes) quenching. theory, relationship between intensity of fluorescence and concentration, instrumentation– basic differences in the measurement of fluorescence and phosphorescence, filter fluorometers, spectrofluorometers, advantages, limitations and precautions. Selection of excitation wavelength for analysis, reporting fluorescence spectra. Application of fluorometric analysis of inorganic, organic, Special fluorometric and phosphorimetric applications. chemiluminescence.

UNIT-III: [15 Hours]
Nephelometry and Turbidimetry: Light scattering, nephelometry and turbidimetry, choice between nephelometry and turbidimetry, turbidimetry and colorimetry, nephelometry and fluorometry. Theory effects of concentration, particle size and wavelength on scattering instruments and application of nephelometry and turbidimetry. Turbidimetric titrations.

Photoelectron spectroscopy: Introduction, instrument, source, target, electron energy analyzer, detector, technique and application of photoelectron spectroscopy in elemental, quantitative, gas and structural analysis. Study of core binding energy, charge distribution in bonds and molecules, surface chemistry and study of metal complexes.
References:


CA H 553: PROCESS ANALYTICAL CHEMISTRY

UNIT -I: Automation of Analytical Methods

An overview of automated systems- Definition-Distinction between automatic and automated systems- Advantages and disadvantages by automation- Types of automated techniques. NM-discrete techniques, Segmented flow methods and basic equipment, special techniques and devices, theoretical considerations and problems. Applications, Single/channel and multi channel auto analysers, BUN analysers, automatic glucose analyzer, ammonia in water analyzer. COD analyzer, CFA in iodometry.

UNIT II: Non-segmented flow methods


UNIT III: Good Laboratory Practice Terms

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for
working with substance that pose hazards, flammable or explosive hazards – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals.


References:
3. Environmental Chemistry – A.K De;
5. Technical Methods of Analysis – R.C. Griggin
10. Stoichiometry for Chemical Engineers – William and Jhonson.
11. Transport processes and Unit Operations C.J Geankopils, Prentice Hall (1977);
12. Manning: A Text Book of chemical Industry;

CA S 554: ENVIRONMENTAL AND PROCESS ANALYTICAL CHEMISTRY

UNIT- I: Soil and Fuel analysis [12 Hours]


UNIT II: Air Pollution and Analysis and control [12 Hours].


UNIT-III: Air Pollution control Methods [12 Hours].
Source Correction methods—raw materials changes, process changes, equipment modification or replacement. Particle emission control—gravitational setting chambers, cyclone collector, electrostatic precipitator, fabric filters and wet scrubbers. Control of gaseous emissions. SO$_2$—desulpharization of fuels, sulphur reduction during combustion and desulpharization of flue gases. NOx—modification of operating conditions, effluent gas treatment methods. CO—industrial sources and transportation sources. Hydrocarbons—incineration, absorption, adsorption and condensation methods, two-stage catalytic converters for mobile sources.

References:
5. Technical Methods of Analysis – R.C. Griggin
10. Stoichiometry for Chemical Engineers – William and Jhonson.
11. Transport processes and Unit Operations C.J Geankopils, Prentice Hall (1977);
12. Manning : A Text Book of chemical Industry;
CA S 555: PHARMACO & NANOMATERIALS

Unit-I: Pharmacokinetics [12 Hours]
Pharmacokinetics: Introduction – Compartment models – study of the methods of estimation, significance of the following parameters, biological half-life, apparent volume of distribution, renal clearance, total body Clearance, absorption rate, AUC - Mathematical expressions describing the variation in blood concentrations following I.V. and oral routes. Introduction to dosage regimen. Non-linear Pharmacokinetics: Non-linear Pharmacokinetics with special reference to one compartment model after IV drug administration, Michaelis-Menten equation.

Unit-II :Nano Materials-I [12 Hours]

Unit-II: Nano Materials-II [12 Hours]

References:
4. Nano-Forensic analysis to identify, individualize and evaluate evidence using nanophase materials
5. Scratch resistance enhancement study of polymer containing nanoparticles
6. Pharmacokinetics by Gibaldi
8. Pharmacokinetics by Ritschal
9. Modern Pharmaceutics by G.S.Banker
10. Applied Biopharmaceutics and Pharmacokinetics, Leon Shargel
11. Clinical Pharmacokinetics; Concepts and applications by T.Rowland and Tozer
12. Magnetic separation/identification studies of thermally-blocked nanoparticles
CA S 556: Separation Techniques

UNIT-I: [12Hours]

**Solvent Extraction:** Definition, types, principle and efficiency of extraction. Sequence of extraction process. Factors effecting extraction-pH, oxidation state, modifiers, synergistic, masking and salting out agents. Techniques-batch and continuous extraction. Application.

**Affinity Chromatography:** Definitions. separation mechanism- matrices, matrix activation, role of spacer arms and applications.


UNIT-II: [12Hours]


UNIT-III: [12Hours]

**Ultracentrifugation:** Principle sedimentation constant, sedimentation equilibrium, sedimentation velocity, methodology and applications.

**Capillary electrophoresis:** Overview, types, the basis for electrophoretic separations, migration rates and plate heights, electro-osmotic flow, instrumentation, capillary zone electrophoresis, capillary gel electrophoresis, capillary isoelectrophoresis, capillary isoelectric focusing.

**Capillary electrochromatography:** Packed column electochromatography, micellar electrokinetic capillary chromatography and applications.

**References:**
2. Chromatography Today- D.F.Poole and S. K .Poole,
CA P 557: ANALYTICAL CHEMISTRY PRACTICALS – IV
(A minimum of twelve experiments are to be carried out)

1. Potentiometric determination of equivalent weight and Ka of a pure unknown acid.
2. Nephelometric determination of sulphate in ground water samples.
3. Nephelometric determination of chloride in brackish waters.
4. Determination of Phosphate in domestic waste water by spectrophotometry.
5. Determination of Vitamin A in Vanaspathi by UV spectroscopy.
7. Determination of sodium and potassium in soil by flame photometry.
8. Estimation of potassium in agricultural water supplies by flame photometry.
9. Determination of NH$_3$-N/NO$_2$-N/NO$_3$-N in soil & waste waters by spectrophotometry.
10. Fluorimetric determination of Quinines, cadmium aluminium and zinc.
11. Determination of sulpha-drugs by potentiometry
15. Polarographic determination of Cd and zinc in solutions individually and in a mixture
17. Analysis of mercury/lead in industrial effluents by spectrophotometry.
18. Analysis of DO, BOD and COD of a waste water sample by titrimetry

CA P 558: ANALYTICAL CHEMISTRY PRACTICALS – V
(A minimum of twelve experiments are to be carried out)

1. Determination of ascorbic acid in goose berry/bitter gourd by titrimetry & spectrophotometry.
2. Catalytic determination of iodide/selenium by spectrophotometry.
3. Enzymatic determination of glucose in blood by spectrophotometry.
4. Determination of urinary reducing sugar, chlorides, urea and uric acid by titrimetry.
5. Estimation of blood cholesterol by spectrophotometry.
6. Determination of blood urea and uric acid by spectrophotometry.
8. Isolation of Casein and lactose from milk.
9. Isolation of caffeine from tea.
10. Preparation of 6-10 Nylon poly (hexamethylene) sebacamide) by interfacial polymerization and its characterization by m.p, inherent viscosity and IR studies.
13. Analysis of phenol-formaldehyde reaction products by TLC

Computer related experiments: The following exercise may be given to illustrate the use of Softwares such as Excel and Origin in calculation and plotting curves using the data generated in regular lab experiments.

1. Use of mathematical functions to calculate parameters such as ionic strength, rate constants, dissociation constants, energy of activation, standard deviation, average molecular weights of polymer samples or any other similar calculation.

2. Use of software to make linear plots and calculate constants from slope and intercept-data from experiments such as verification of beer’s law, determination of pKa of weak acids from pH data, determination of energy of activation, viscosity with concentration for determination of unknown concentration/average molecular weight of polymers or any other similar data sets.

3. Use of software to fit multiple set of data obtained in different series of experiments on the same chart- pKa of different weak acids, kinetic data with different ionic strength conditions etc or any other series of data may be given.

4. Use of software to fit non-linear curves with data from experiments such as absorbance vs. wavelength, first derivative curves of potentiometric and pH titrations, radioactive decay or any other similar experiments.

References:
1. A text book of quantitative Inorganic Analysis – A.I. Vogel
2. Vogel’s text book of quantitative Inorganic analysis – Basset, Denney, Jeffery, & Mendham
3. Colorimetric Determination of Traces of Metals – E.B. Sandell

CA P 559: PROJECT WORK AND DISSERTATION