Syllabus

BACHELOR OF SCIENCE (HONOURS)

IN

BIOTECHNOLOGY

(3-YEAR DEGREE VOCATIONAL COURSE)

Curriculum: Hons Papers

B.SC. PART I (HONS)

Paper I (75 Marks)

Biochemistry

- Introduction to Biochemistry
- Nature of biological Material
- Brief mention of various micro and macro biomolecules
- General properties of organic and inorganic compounds
- Molecules involved in generation of mechanical stability : peptidoglycans, polysaccharies and membrane lipids
- Molecules involved in information storage and retrieval : nucleic acids
- Molecules executing mediator and catalytic functions : the proteins
- The Signal molecules
- Enzymes : Introduction, classification, protein and non-protein enzymes, role of enzymes in biosynthetic and degradative cellular functions. Mechanism and mode of action of enzymes, inhibition and regulation of enzyme action, Enzyme kinetics, In vitro activity of purified enzyme, application of enzyme in industry, food processing and medicine.

Cell Biology

- Cell as basic unit of living systems. The cell theory
- Precellularevoluation : Artificial creation of “cell”

- Broad classification of cell types : PPLOs, bacteria, eukaryotic microbes, plant and animal cells. A detailed classification of cell types within an organism. Cell, tissue, organ and organism as different levels of organization of otherwise genetically similar cells.
- Ecological amplitude of cell in high altitude, sediments, arctic, hot spring, arid, brackish and fresh water environments.
- Biochemical composition of cells : proteins, lipids, carbohydrate, nucleic acids and the metabolic pool.
- Ultra structure of the cell membrane
- Structure and function of cell organelles, ultra structure of cell membrane, cytosol,Golgi bodies, endoplasmic reticulum (rough and smooth), ribosomes, cytoskeletal structures (actin, microtubules etc). Mitochondria, chloroplast, lysosomes, peroxysomes, nucleus (nuclear membrane, nucleoplasm, nucleolus, chromatin).
- Cell division and cell cycle (including cell synchrony and its application)
- Cell-cell interaction.
- Cell locomotion : amoeboid, flagellar and ciliar
- Muscle and nerve cells
- Cell senescence and death
- Cell differentiation in plants and animals

Microbiology

- Development of Microscopy (optical, TEM and SEM)
- Contributions of eminent microbiologists.
- Concept and methods of Sterilization.
- Different types of bacteria and bacterial cell structure.
- Nature of Microbial Cell Surface.
- Gene transfer in microorganisms.
- Archaebacteria and Rickettsiane.
- PPLOs.
- Reference to phages.
- Prokaryotic and Eukaryotic Microbial Cells
- Nutritional Classification of bacteria.
- Microbes in extreme environment : Thermophiles and alkalophiles.
- Pathogenic microorganisms.
- Symbiosis and Antagonism among microbial populations
- N2- Fixing microbes in agriculture - (Rhizobium)
- Microbial Metabolism (Respiration and Photosynthesis)
- Fermentation products of bacteria.
- Significance of bacteria.

Paper II (75 Marks)

Genetics (40 Marks) :

- Nature of genetic material, Nucleic acids, DNA replication.
- Mendelian laws of inheritance, gene interactions.
- Sex determination in plants and animals, sex linkage, non disjunction as a proof of chromosomal theory of inheritance.
- Linkage: mapping genes, interference, coincidence in pro and eukaryotes.
- Chromosomes: chemical composition, structural organization of chromatids, centromeres telomeres, chromatin, nucleosome organization, eukaryote and hetrochromatin, special chromosome (e.g. Polytene and lampbrush chromosome), banding patterns in human chromosomes.
- Structural and numerical aberrations involving chromosomes, evolution of wheat, cotton and rice. Hereditary defects: Kleinefelter. Turner, Cri-du-chat and Down's syndromes.
- Mutations: spontaneous and induced, chemical and physical mutagens, induced mutation in plants, animals and microbes for economic benefit of man.
- Basic microbial genetics, conjunction, transduction, transformation, isolation of auxotrophs, replica plating techniques, analysis of mutations in biochemical pathways, one gene- one enzyme hypothesis.
- Extra chromososomal inheritance, mitochondrial and chloroplast genetic systems.
- Population genetics : Hardy-Weinberg equilibrium, gene and genotypic frequencies.

Maths and Computers (35 Marks)

- The set theory : properties of subsets.
- Linear and geometric functions. Limits and derivatives of functions.
- The binomial theorem
- Logarithm
- Differentiation &Intergration
- Probability Calculation
- Method of sampling, confidence level
- Measurement of central tendencies and deviations
- Computers : general introduction of computers, organization of computers, digital and analog computers, computer algorithm.
- Computers in online monitoring and automation
- Application of computers in coordination of solute concentration, pH and temperature etc of a fermenter in operation.
- Demonstration of the above utilities (along with above lectures).

Practicals (50Marks)

Biochemical Techniques

- Quantitative estimation of sugar in given solutions and sugar in biologicalsamples

- Extraction and separation of lipids
- Estimation of proteins
- Estimation of DNA / RNA
- Isolation and purification of proteins
- Assay of enzyme activity
- Kinetic study of enzymes
- Chromatographic methods for separation of macromolecules

Microbiological Techniques

- Cleaning of glassware
- Preparation of media, cotton plugging and sterilization
- Personal hygiene-microbes from hands, tooth scum and other body parts
- Isolation of microorganisms from air, water and soil samples. Dilution and porplating.Colony purification
- Enumeration of microorganisms. Total vs. viable counts
- Identification of isolated bacteria. Gram staining, other staining methods, metabolic characterization (e.g. IMVic test)
- Growth curve of microorganisms
- Antibiotic sensitivity of microbes, use of antibiotic discs
- Testing of water quality
- Test for antibodies against given bacteria
- One step growth of bacteriophage
- Culture from body fluids : stool, urine, blood
- Alcoholic and mixed acid fermentation

The student are to undergo one month “on-the-job training in a clinic / a fermentation plant/ brewery or bakery after completion of classes / exams. They would have to submit its report. A certificate would be issued by the department with grading from the institution providing the training.

B.Sc. Part II (Hons.)

Paper III (75 Marks)

Molecular biology

- Molecular basis of life.
- Structure of DNA
- DNA replication in prokaryotes and eukaryotes.
- DNA recombination molecular mechanisms in prokaryotes and eukaryotes.
- Insertion elements and transposons.
- Structure of prokaryotic genes.
- Prokaryotic transcription.

- Prokaryotic translation.
- Prokaryotic gene expression (lac, his,trp, catabolic repression).
- Structure of eukaryotic genes.
- Eukaryotic transcription.
- Eukaryotic translation.
- Eukaryotic gene expression. Transcription factors and translation factors.
- Gene expression in yeast.
- Gene expression in protozoan parasites.
- Gene organization and expression in mitochondria and chloroplasts.
- Post translation regulation of gene expression.
- Developmental and environmental regulation of gene expression.

Recombinant DNA technology

- What is gene cloning and why do we need to clone a gene?
- Tools and techniques, plasmids and other vehicles, genomic DNA, handling of DNA, RNA and c-DNA, RT enzymes and other reagents techniques, laboratory requiremen.
- Safety measures and regulations for recombinant DNA works.
- Choice and selection of the tools and techniques.
- Vehicles: Plasmids and bacteriophages, available phagemids, cosmids, viruses.
- Purification of DNA from bacterial, plant and animal cells.
- Manipulation of purified DNA.
- Introduction of DNA into living cells.
- Cloning vectors for E.coli.
- Cloning vectors for organisms such as yeast, fungi, for plants – Agrobacterium sps. And plant viruses, animal viruses.
- Application of cloning in gene analysis (How to obtain a clone of a specific gene ? Studying gene location and structure, studying gene expression).
- Gene cloning and expression of foreign genes in research and biotechnology (Production of protein from cloned genes).
- Gene cloning in medicine (Pharmaceutical compounds, artificial insulin gene, recombinant vaccine, diagnostic reagents).

Paper IV (Marks)

Biophysics

- Energetic of a living body. Sources of heat limits to temperature. Heat dissipation and conservation.
- Lambert –Beer law. Spectrophotometry and colorimetry. Primary events in photosynthesis.
- Strategies of light reception in microbes, plant and animals.
- Correction of vision faults.
- Electrical properties of biological compartments. Electricity as a potential signal.
- Generations and reception of sonic vibrations. Hearing aids.

- Intra-and intermolecular interactions in biological systems. Spatial and charge compatibility as determinant of such interactions.
- Physical methods applied to find out molecular structure : X-ray crystallography and NMR.
- Physical methods of imaging intact biological structures : Ultrasound, optical filters, X-ray, CAT scan, ECG, EEG, NMR Imagigng.

Immunology

- The Immune system and Immunity along with historical perspective.
- Antigens and antibodies and their structure.
- The organs and the cells of the immune system and their function.
- Antigen-antibody interaction.
- Humoral and cell mediated immunity (role of MHC and genetic restriction).
- Origin of diversity in the immune systems.
- Effector mechanisms.
- Immunity to infectious diseases and vaccines.

Practical (50 Marks)

Immunological methods

- Purification of antigens.
- Raising polyclonal antibodies.
- Purification of antibodies.
- Conjugation and labeling of antibodies.
- Enzyme linked immunoassay.
- Radio immunoassay.
- Radial immunodiffusion analysis.
- Generation of ascetic fluids.
- Diagnosis of infectious disease by immunoassay.

Cellular biology

- Cytological preparations:
    - Fixation, dehydration and staining
    - Squash in stain
    - Embedding and sectioning
- Cell counting methods : the hemocytometer and other aids
- Measurements with the aid of light microscope:
    - Calibration of ocular micrometer
    - Finding out average cell size
    - Chromosome lengths
- Separation of cell types from blood
- Separaation of cell organelles:

- Method for cell lysis: rupture / osmotic / chemical / enzymatic lysis of cells followed by centrifugation. Monitoring cell lysis by release of cellular material and change in light scattering etc.
- Mechanical rupture of cells: Ultrasonic vibrations, French pressure cell followed by centrifugation for cell organelles.

One month (Summer) "on-the-job training" in an immunology / veterinanry / virology institute. Report by students.

B.Sc Part III Hons.

Paper V (100 Marks)

Animal cell culture

- History of development of cell cultures.
- The natural surroundings of animal cells.
- Metabolic capabilities of animal cells.
- Simulating natural condition for growing animal cells.
- Importance of growth factors of the serum.
- Primary cultures. Anchorage dependence of growth. Non-anchorage dependent cells.
- Secondary cultures. Transformed animal cells : Established / continuous cell lines.
- Commonly used animal cell lines – their origin and characteristics.
- Growth kinetics of cells in culture.
- Applications of animals cell culture for studies on gene expression.
- Organ culture.
- Transfection of animalcells : Selectable markers, HAT selection, antibiotic resistance etc.
- Cell fusion.
- Transplantation of cultured cells.
- Differentiation of cells.

Animal Cell Biotechnology

- General metabolism.
- Special secondary metabolites / products : Insulin, growth hormones, interferon, t-plasminogen activator, factor VIII etc.
- Expressing cloned proteins in animal cells. Over production and processing of chosen protein.
- The need to express in animal cells.
- Production of monoclonal antibodies.
- Growth factors promoting proliferation of animal cells : EFG, FGF, PDGF, 1L-1, 1L-2, NGF, erythroprotein etc.

- Bioreactors for large scale culture of cells.
- Transplanting cultured cells.

Paper VI (100 Marks)

Plant Biotechnology

- Introduction to in vitro-methods. Terms and definitions. Use of growth regulators.
- Beginning of in vitro cultures in our country: ovary and ovule culture, in vitro pollination and fertilization
- Embryo culture, embryo rescue after wide hybridization and its application.
- Introduction to processes of embryogenesis and organogenesis and their practical applications.
- Clonal multiplication of elite species (micropropagation), axillary bud shoot tip and mersidtem culture.
- Haploids and their applications. Somaclonal variations and applications (treasure yourexceptions)
- Endosperm culture and production of triploids.
- Practical applications of tissue and organ culture (summarizing the practical applications of all the above techniques)
- Single cell suspension cultures and their applications in selection of variants / mutants with or without mutagen treatment (of haploid cultures preferably)
- Introduction to protoplast isolation : principles and applications
- Testing of viability of isolated protoplasts
- Various steps in regeneration of protoplasts
- Somatic hybridization – an introduction
- Various methods for fusing protoplasts: chemical, electrical
- Use of markers for selection of hybrid cells.
- Practical applications of somatic hybridization : hybrids vs. cybrids
- Use of plant cells, protoplasts and tissue culture for genetic manipulation of plants. Introduction to A. tumefaciens.
- Tumor formation in plants using A. tumefaciens. (monocots vs. dicots)
- Root formation using A. rizogenes
- Practical application of genetic transformation

Paper VII (100 Marks)

Environmental Biotechnology

- Renewable and non-renewable resources
- What is renewable should be bioassimilable / biodegradable
- Major consumer items : food, fuel and fibers
- Conventional fuels and their environmental impact: firewood, plant / animal wastes, coal gas and animal oils
- Modern fuels and their environmental impact : methanogenic bacteria and biogas, microbial hydrogen production, conversion of sugar to ethanol – gasohol experiment, solar energy

converters – hopes from the photosynthetic pigments, plant based petroleum industry, cellulose degradation for combustible fuel

- Biotechnological inputs in producing good quality natural fibers: transgenic sheep and transgenic plants
- Microbiological quality of food and water
- Treatment of municipal waste and industrial effluents
- Degradation of pesticides and other toxic chemicals by microorganisms
- Thuringiensis toxin as natural pesticide
- Biological control of other insects swarming the agricultural fields
- Enrichment of ores by microorganisms
- Bio fertilizers. Nitrogen fixing microorganisms enrich the soil with assimmilable nitrogen

Paper VIII – Practicals (100 Marks)

Molecular & Cellular Biology

- Separation of cell types from blood
- Separation of cell organelles : Method for cell lysis : osmotic / chemical / enzymatic lysis of cells followed by centrifugation. Monitoring celllysis by release of cellular material and change in light scattering etc.
- Mechanical rupture of cells: Ultrasonic vibrations, French pressure cell followed bycentrifugation for cell organelles
- Separation of constituent molecules of the extract in aqueous buffer : Gel filtration, Ion exchange chromatography
- Thin layer chromatography of extracted material
- Isolation of chromosomal and plasmid DNA from bacteria
- Restriction digestion of DNA and assigning restriction sites (may be done as ademonstration)
- Making competent E. coli
- Transfection of plasmid DNA and selection for transformants

Culture methods

- Initiating plant tissue culture : dedifferentiation of explants
- Growth of plant cell into undifferaentiated mass
- Large cultivation of plant cells in suspension
- Induction of differentiation by modulating the hormonal balance
- Culture of lymphocytes from blood samples: Preparation of media, filter sterilization,monitoring microbial contamination (bacteria, fungi and mycoplasma), cloning of animal cells by cell and colony purification
- Fusion of cultured cells with myeloma cell
- Production of monoclonal antibodies at a large scale
- Demonstration / operation of large scale fermenters

Project Works

The student of 2nd year (Biotechnology) would be assigned to generate data on certain research projects and / or compile available information from literature on a given topic of biotechnological relevance under a chosen faculty member towards their end. They would have to submit their draft at their practical exams.

Entrepreneurship

The student will be delivered lecture on how to select for a product line, design and develop processes, economies on material and energy requirement, stock the product and release the same for marketing etc. They should also be apprised of basic regulation of excise.

Practise in a project draft :Student will also be asked to survey the demand for a given product, feasibility of its production under the given constraints of raw material, energy input, financial situation, export potential etc. Procedural details on how to select process, how to move for loans, how to operate and how to reply the loans in a phasic manner should also be highlighted. The year would end with submission of a draft project by the students.

Curriculum : Subsidiary papers

The subsidiary course will be common with that of other Honours courses and the syllabus to be followed would be the one provided by Patliputra University, Patna. An outline of the syllabus is provided below.

B.Sc Part I Hons.

Botany I Theory (75 Marks)

Student are required to answer five question out of total ten.

1. Microbiology : A general account of bacteria, viruses and their economic importance. Role of microbes in fermentation and nitrogen fixation.
2. Thallophyta : Structure, function and diagnostic features.
   Algae :Nostoc , Oedogonium , Chara, Vaucheria, Fucus and Batrachospermum
   Fungi :Albugo, Peziza and Puccinia.
   Lichens : General account and economic importance
3. Bryophyta : Structure and life history of Marchantia, Anthoceros and Sphagnum.
4. Pteridophyta : Structure and life history of Selaginella, Equisetum and Marsilea.
5. Gymnosperm :Sructure and life history of Pinus.
6. Cytology, Genetics and plant breeding : (a) Structure of cell as seen under as electron microscope (b) Mitosis and meiosis (c) Structure of chromosome, crossing over and mutation (d) Nature, structure and replication of genetic material (DNA).

7. Economic Botany:
   (a) Cereal : wheat, maize, rice
   (b) Oils : mustard, groundnut, linseed
   (c) Sugar : sugarcane
   (d) Spices : coriander, chilli, turmeric
   (e) Beverages : tea
   (f) Drugs : Rauwolfia
   (g) Fibres : cotton, jute

Botany Practical (25 Marks)

1. Morphology and structure details of algae, fungi and bryophytes inclided in thesyllabus and their temporary stained microscopic slides (6 Marks)
2. Morphological and anatomical study of pteridophytes / gymnosperms included in the syllabus and their microscopic preparation (temporary) (8 Marks)
3. To identify and comment upon spots (6 Marks)
4. Class records (5 Marks)

Chemistry I Theory (75 marks)

Group A (Physical Chemistry)

1. The States.
   (a) Gaseous state : Kinetic theory of gases, derivation of kinetic gas equation, deduction of gas laws, calculation of gas constants and kinetic energy.
   (b) Types of solid, crystal forces, law of constancy of angles, seven crystal systems, law of rational indices, bragg's law, Lattice energy, Born Haber cycle.
2. Thermochemistry :
   Heat in chemical reactions, reaction enthalpy, standard enthalpy chages, Hess law, Kirchoff law, bond energies and determination.
3. Ionic equilibrium:
   Ionic product of water, pH, pka and pkw, buffer solution, idea of buffer solution in day to day life.
   Solubility productand its applications in salt analysis, common ion effect , conductance specific,equivalent and molar.
4. (a) Chemical Kinetics :
   Rate of reaction, order and molecularity, expression for specific rate constant of first order reaction, half life period, unit.
   (b) Colligative properties :
   Colligative properties, osmosis, osmotic pressure and its determination, vapourpreesure, Roult's law of lowering of vapour pressure, relation between osmotic pressure and lowering ofvapour pressure.

Group B (Inoragnic Chemistry)

1. Atomic structure and bonding :
   Features of H- spectra and bohr's theory, shapes or orbitals and their labellings, idea of quantum number, Pauli's exclusion principle, Hund's rules, Aufban principal, electronic configuration of elements.
   Idea of ionic and covalent bonds, I.P.E.N. and E.A. ,Fajan's rule.
2. Chemistry of the following elements :
   Li, Sn, Fluorine, Cholorine, Iodine.
3. Principles involved in the volumetric and gravimetric estimation of Cu++ and iron.
4. Isotopes : Brief idea of detection and separation, tracer techniques, radiocarbon dating.

Group C (Oragnic Chemistry)

1. Structure and mechanism :
   Hybridization, bond angle, bond length, idea of bonds, inductive effect, electromeric effect, monomeric effect, bond fission and fission products, elementary idea of reagents and types of reactions.
2. Nomenclature:
   Acquaintance with IUPAC nomenclasture of aliphatic and aromatic compounds.
3. (a) Alcohols : monohydric. (b) Grignard's reagent.
4. Idea of purification of compounds : Criteria of purity, Choromatography.

Chemistry practical (25 Marks)

Group A

1. Volumetric analysis
   (a) Acidimetry and alkalimetry. (b) Use of potassium permagnate and potassium dichromate, iodometry.

Group B

2. Organic detection : detection of nitrogen, sulpher and halogen organic compounds, detection of the following functional groups of organic compounds: (i) OH (phenolic), (ii) CHO, (iii) C=O, (iv) COOH, (v) NH_2, and (Vi) NO_2 : 8 marks
3. Records of class work and viva-voce. 5 marks

B.Sc. Part II Hons.

Botany II Theory (75 Marks)

Students are required to answer two questions from group A and group B each and one from group C out of total ten (four form group A and group B each and two from group C).

Group A : (Angiosperms)

(A) Morphology and taxonomy : Importance of classification of angiosperms with reference to Bentham and Hooker and Hutchinson systems. Naming of genus and species. Diagnostic features, affinities and economic importance of ranunculaceae, Cucurbitaceae, Euphorbiaceae, Amranthaceae, Acanthaceae, Lamiaceae, Apocynaceae, Poaceae and cyperaceae.

(B) Anotony : Cell structure and tissue systems. Meristems. Root stem transition. Initiation and activity of cambium including abnormal behavior, primary and secondary growth in roots and stems.

(C) Embryology : Life cycle of a typical flowering plant based on the major events in the development of anther, microspore, ovule, embryo sac, fertilization, endosperm, embryo and seed.

Group B : (Plant physiology)

- Water relation, absorption of water and salts
- Transpiration
- Mineral nutrition – role of major and minor elements
- Enzymes – nature properties and classification
- Photosynthesis – photophosphorylation, Carlvin cycle and factors affecting photosynthesis
- Translocation of organic substances
- Respiration – glycoysis, Kreb's cycle and factors affecting respiration
- Nitrogen metabolism – nitrogen fixation and protein synthesis

Group C (Environmental biology)

- Pollution
- Soil – types, water holding capacity reclamation
- Plant communities and ecosystem
- Succession (Hydrosere and xerosere)

Botany Practical (25 Marks)

1. To comment upon a plant physiology experiment set up from the following experiments (5 marks)
   (a) T/ A ratio
   (b) Ganong's photometer : rate of transpiration
   (c) Farmer's photometer : rate of transpiration
   (d) Unequal transpiration by $CaCl_2$ method
   (e) Oxygen evolution during photosynthesis
   (f) Rate of photosynthesis by Wilmott's bubbler
   (g) Moll's experiment
   (h) Anaerobic respiration

2. Discription and identification of plants of families studied (5 marks)
3. Microscopic preparation of anatomical specimens (5 marks)
4. To identify and comment upon spot covering the courses (5 marks)
5. Practical records based on class work and fieds studies (5 marks)

Chemistry II Theory (75 marks)

Group A (Physical Chemistry)

1. States of Matter
   (a) Gaseous state :
   Vander Wall equation (no derivation), critical constants, collision number, collision frequency, mean free path.
   (b) Solid state :
   Bravais lattices and ;attice planes, elementary idea of types of lattices, stoichiometric and non-stoichiometric defects in simple ionic solids.
2. Thermodynamics
   Definitions of terms : system, extensive, intensive properties, first and second law of thermodynamics, Carnot theorum and Carnot cycle.
3. (a) Ionic equilibrium : Ostwald's dilution law, conductance measurement of dissociation constant of acetic acid , slat hydrolysis, idea of theory of acid-base indicators.
   (b) Phaserule : terms, equation (no derivation required), H_2O system, S-sytem.
4. Chemical kinetics :
   Second order reaction, expression for specific rate constant of second order reaction, half life period and its unit, effect of temperature on reaction rate, Arrhenius equation, idea of catalytic activity at surfaces and catalytic processes such as hydrogenation, oxidation, cracking and reforming.

Group B (Inorganic chemistry)

1. (a) Atomic structure and bonding :
   Idea of duality and matter waves, de Broglie relation, Schrodinger equation (no derivation) and idea of its applications idea of orbital overlap, hybridization of orbitals, Vander Wall forces, metallic bonding.
   (b) Idea of complex formation : double salts and complexes. Werner's postulates.
2. Intoductory transition metal chemistry:
   General features including variable oxidation states, idea of complexes, magnetism of transition metals.
3. Chemistry of group14 elements : C, Si, Basic introduction to fullerences and zeolites, idea of major chemical pollutants in environment.
4. Chemistry of the following elements and their important compounds :

(a) Fe, Co, Ni. (b) Cr (c) Mn

Group C (Organic Chemistry)

1. Structure and mechanism :

Different types of isomerism, idea of E-Z notations, electrophilic substitution in benzene nucleus and mechanism of nucleophilic substitution at saturated carbon (general idea).

2. Naural products :
   (a) Carbohydrates : nomenclature, classification, non-detailed structure of glucose and fructose, elementary idea of glycosides.
   (b) Elementary idea of alkaloids and terpenes (no structural elucidation needed).
3. (a) Structure of benzene, preparation and uses of benzene diazonium chloride.
   (c) Latic acid, citric acid.
4. (a) Test of common functional groups.
   (b) Brief idea of polymers, resins, proteins and sulfa drugs.

Chemistry Practical (25 marks)

Group A : 12 marks

1. Qualitative inorganic analysis of mixture containing four radicals.

Basic radicals : Ag^{+}, Hg_2^{+2}, Pb^{+2}, Cu^{+2}, Hg^{+2}, Bi^{+3}, Cd^{+2}, Sb^{+3},Sn^{+4}, Fe^{+2}, Al^{+3},Cr^{+3},Ni^{+2},Co^{+2},Zn^{+2},Mn^{+2}, Ca^{+2}, Ba^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, Na^{+2}, Na^{+}, K^{+}, NH_4.

Acid Radicals : Co_3^{-2}, SO_3^{-2}, S^{-2}, SO_4^{-2}, NO_2^{-}, NO_3^{-} and halides.

Group B : 8 marks

2. Organic Preparation : Preparation of organic compounds by using the following reactions:
   (a) Acetylation of aniline and p-toluidine.
   (b) Nitration of nitrobenzene.
   (c) Oxidation of benzaldehyde
   (d) Hydrolysis of esters like ethyl benzoate and methyl salicylate.
3. Record of Class – Work and Viva – Voce.