UNIVERSITY OF CALCUTTA

SYLLABUS

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THREE-YEAR B.Sc. HONOURS
COURSE OF STUDIES

BIOCHEMISTRY

2010

w.e.f.2010-2011

Overview of the syllabus for B.Sc. (H) in Biochemistry,2010

Part/Paper	Module	Units	Broad Subject	Marks
I/Paper 1	M I	I, II, III	General and physical Chemistry (fundamental principles)	50
I/Paper 1	M II	I, II, III	Chemistry of Bio-molecules	50
I/Paper 2	M III	I, II, III	Cell Biology and Enzymology	50
I/Paper 2	M IV (**Practical paper**)	I, II	Physical Chemistry, Organic Chemistry	30+20
				Theory=150 Practical=50
II/Paper 3	M V	I, II, III	Chemical principles and applications to biochemistry	50
II/Paper 3	M VI	I, II, III	Organic chemistry (complex molecules)	50
II/Paper 4	M VII	I, II, III	Enzymes (purification), physiology, cell biology	50
II/Paper 4	M VIII (**Practical paper**)	I	Biochemical Analysis	50
				Theory=150 Practical=50
III/Paper 5	M IX	I, II	Intermediary metabolism	50
III/ Paper 5	M X	I, II	Clinical and nutritional biochemistry	50
III/ Paper 6	M XI	I, II	Immunology and molecular	50

			biology	
III/ Paper 6	M XII	I, II	Biophysical chemistry	50
III/ Paper 7	M XIII, (**Practical Paper)**	I, II	Enzyme assay; Clinical Biochemistry	50 + 50
III/ Paper 8	M XIV (**Practical Paper)**	I, II	Molecular Biology and Immunology; Food analysis, statistical analysis of data	50 + 50
				Theory=200 Practical=200

Syllabi for three-year B.Sc.(H) in Biochemistry 2010

PART-I

PAPER I (F.M. 100)

Module I General and Physical Chemistry
(Fundamental principles) **50 marks (60L)**
Unit I: Principles of thermodynamics

(a) Definition of systems, surroundings and types of systems (isolated, closed and open). Extensive properties and intensive properties, concept of Thermodynamic equilibrium, concept of temperature, concept of heat and work, reversible work, irreversible work and maximum work.

(b) First law of Thermodynamics, internal energy as a state function, properties of a state function, definition of isothermal and adiabatic processes, Joule's experiment and its consequences. Joule-Thompson experiment and enthalpy as a state function, calculation of work done, heat changes for isothermal and adiabatic changes involving ideal gas.

(c) Statement of Second law of Thermodynamics and their equivalence, Carnot's cycle and Carnot's theorem, Absolute scale of temperature, concept of Entropy as a state function, Entropy changes in various Physical processes.

(d) Clausius inequality, condition of reversibility and irreversibility of a process, auxiliary state function-Helmholtz free energy and Gibbs free energy and their simple applications.

(e) Open systems: Partial molar quantities, Chemical potential and its expression for ideal gas; concept of standard states.

Unit II: Atomic Structure and Biophysical properties

a) Extra nuclear structure: Bohr's theory of atomic structure and its limitations, Summerfeld's modification, application of Bohr's theory to hydrogen like atoms and ions, Spectrum of hydrogen atom. Quantum numbers. Idea of de Broglie matter waves, concept of atomic orbital, shapes of s, p and d orbitals, radial and angular probability of s, p and d orbitals (qualitative idea) Many electron atoms, Pauli Exclusion Principle, Hund's rule of maximum multiplicity, exchange energy, Aufbau (building up) principle and its limitations, Electronic energy levels and electronic configurations of hydrogen like and polyelectronic atoms and ions, Ground state term symbols of atoms and ions.

(b) Mass flow: General features of fluid flow (streamlined and turbulent) nature of viscous drag for streamlined motion. Definition of viscosity coefficient. Origin of viscosity of gases and liquids, expression for viscosity coefficient of gases (with derivation), temperature dependence of viscosity coefficient of gases and liquids. Stroke's law and terminal velocity. Determination of viscosity coefficient of liquids, diffusion of gases and solute in solution Fick's law).

(i) Flow of electrical charge: Electrical conductance, cell constant, specific conductance and equivalent conductance. Variation of equivalent conductances of strong and weak electrolytes with dilution, Kohlrausch's law of independent migration of ions, ion conductances and ionic mobility, Equivalent conductances at infinite dilution for weak electrolytes and determination of dissociation constants of weak electrolytes from conductance measurements. Transport numbers, determination of transport numbers by moving boundary method.

(ii) Surface tension: Definition, angle of contact, interfacial tension, capillary rise, determination of surface tension, temperature effect

(iii) Ionic Equilibrium: pH, acid- base neutralization curves, Buffer action definition Henderson's equation and preparation of buffers, buffer capacity, Solubility product principle and application.

Unit III: Chemical Kinetics

(a) Concepts of rate, rate constant, order and molecular of a reaction, integrated form of rate expressions; half-life period and its significance, determination of order of reactions.

(b) Pseudo-unimolecular reactions, multi step reactions, rate determining step, zero and fractional orders, rate expressions for complex reactions, Steady-State approximation. Opposing reaction, parallel reaction and consecutive reaction. Temperature dependence of rate constant, Arrhenius'equation, Energy of Activation, Collision theory and Transition State theory of reaction rate.

(c) Catalysis: Homogeneous catalysis, acid –base catalysis, primary salt effects, Autocatalysis, Adsorption of gases on solids, Langmuir adsorption isotherm, Heterogeneous catalysis, examples.

Module II Chemistry of Bio-molecules 50 marks (60L)

Unit I: Bonding and Stereochemistry of Carbon Compounds

Concept of hybridisation, resonance (including hyperconjugation), inductive effect Huckel's rules for aromaticity & antiaromaticity. bond distance, bond angles
Tautomerism: keto-enol tautomerism,
Ionization of acids and bases: effect of structure, substituent and solvent on acidity and basicity.(Simple Aliphatic and aromatic Acids, Phenols and amines)
Stereochemistry Optical activity of chiral compounds: specific rotation, racemisation (general principle) resolution of simple acids and bases
Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, Configuration: stereocentres: systems involving 1, 2, 3 centres, stereogenicity, chirotopicity. pseudoasymmetric (D/L and R/S descriptor threo/erythro and syn/anti nomenclatures ii) stereoaxis in C=C & C=N systems, cis/trans, syn/anti, E/Z descriptors.

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Unit II: General treatment of reaction mechanisms

Ionic and radical reactions; heterolytic and, homolytic bond cleavage
Reactive intermediates: carbocations (cabenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behaviour, stability, generation and fate. *Reaction kinetics*: transition state theory, rate const and free energy of activation, free energy profiles for one step and two step reactions,

Nucleophilic substitution reactions- S_N1, S_N2, S_N^i mechanisms. Effect of substrate structure, nucleophiles and medium on reactivity and mechanism; neighboring group participations.

Elimination Reactions- E1, E2, and E1cB mechanisms. Saytzeff and Hofmann rules. Elimination vs substitution reaction.

Electrophilic and Activated Nucleophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions)

Unit III: Bio-molecules (1)

Heterocycles- Introduction- five and six membered heterocycles containing one and two hetero atoms; Aromaticity of heterocyclic compounds; basicity of pyridine and pyrrole. Tautomerism in heterocyclic systems. Structural aspects and reactions of purines and pyrimidines

Amino acids- Classification and structures; essential and non-essential amino acids. Physical properties, zwitterions, isoelectric point, titration of amino acids, separation and analysis of amino acids. Methods of synthesis of amino acids (Gabriel, Strecker, azalactone, acetamide, malonic acid methodologies: brief outline only). Reactions of amino acids- reaction due to amino groups, reaction due to carboxylic acid group, due to the presence of both amino and carboxylic acid groups, ninhydrin reaction.

Lipids- Definition and classification. Fatty acids- properties of saturated and unsaturated fatty acids. Esters of fatty acids-formation and hydrolysis; Essential fatty acids. Triacyl glycerols. Reactions and characterization of fats – hydrolysis, saponification value, iodine number, rancidity of fats, Reichert- Meissel number. Biological significance of fats. Prostaglandins :brief introduction only.

Phospholipids- Introduction and importance. Glycerophospholipids, (lecithins, lysolecithins, cephalins, phosphatidyl serine, phosphatidyl inositol, plasmalogens, sphingomyelines). **Glycolipids**-cerbrosides, gangliosides,

Porphyrins- Porphyrin nucleus and classification. Important metalloporphyrins occurring in nature- hemoglobin, chlorophyll. Bile pigments- chemical nature and their physiological significance.

Steroids and carotenoids- Introduction, and importance, cholesterol (structure), modifications of sterols, bile acids, steroid hormones (structure and brief function), carotenes, lycopene (only structure and brief function)

Paper II (F.M-100)

Module III Cell Biology and Enzymology 50 marks (60L)

Unit I: Cell biology

Evolution of cells- Morphology of cell- cell size, cell shape, comparison of prokaryotic and eukaryotic cell structure, cell types including cellular differentiation, difference in plant and animal cells

Structure and function of cell organelles—Description of eukaryotic cell structure, endoplasmic reticulum, nucleus, mitochondria, lysosomes, peroxisomes, golgi apparatus, ribosome, polysomes, cytoskeletal elements, chloroplasts.

Unit II: Enzymes-1

Introduction
Cofactors – Definition, examples of a) metal ions b) coenzymes c) prosthetic group Definition, examples of holoenzymes, Apoenzyme.
Classification of enzymes, IUPAC system, Name & examples of each class
Mechanism of enzyme activity—standard free energy change in a reaction-transition state, activation energy both in non-enzymatic and enzymatic reaction, reaction rate, rate constant, rate limiting step, rate equation, binding energy, specificity of enzymes- geometric and stereo specificity with example, lock & key hypothesis, induced fit hypothesis, proximity and orientation effect, strain and distortion theory, enzyme catalysis-i) acid- base catalysis, ii)metal ion catalysis iii) covalent catalysis –Examples .

Unit III: Enzyme-2

Enzymes kinetics- concept of steady state kinetics, initial rate, maximum velocity, Michaelis constant, Michaelis- Menten equation, graphical representation, Significance of KM & VMax ,double reciprocal plot, Kcat/K_M, enzyme catalyzed bi substrate reaction, sequential & ping pong reaction-(only example). transaminase & fructose bisphosphate aldolase

Quantitative assay of enzyme activity- Unit of enzyme activity, specific activity, molecular activity/ turnover number, molar activity, katal.

Factors on which enzyme catalyzed reaction depends- substrate concentration, enzyme concentration, pH, temperature, time, cofactors (role of NAD& NADP, FMN & FAD, TPP PALPO, FH4, HSCoA), inhibitors,

Inhibition of enzyme catalyzed reaction- competitive, noncompetitive, uncompetitive, irreversible inhibition, example in each case.

Regulatory enzyme- allosteric enzyme, definition & example, allosteric modulators, feedback inhibition, kinetic properties of allosteric enzyme, K enzymes, M enzymes, sequential model & symmetry model, examples, regulation by covalent modification (like phosphorylation), example, regulation by proteolytic cleavage of protein, zymogens, example

Isozymes-Definition and basis of difference, example-lactate dehydrogenase.

Module IV Practical Paper (Physical Chemistry and Organic Chemistry):

Unit I: Physical Chemistry 30M

(One experiment 20+ Lab note book 5+ Viva 5)

1. Determination of viscosity coefficient of a given liquid/solution with Ostwald viscometer.
2. Determination of rate constant of decomposition of hydrogen peroxide by acidified KI solution using Clock reaction.
3. Determination of solubility and solubility product of a sparingly soluble salt by titrimetric method.
4. Determination of specific rotation of a given optically active compound and %composition of its aqueous solution using Polarimeter.
5. To study the kinetics of saponification of ester by conductometric method.
6. Conductometric titration (i) weak acid versus.strong base (ii) Mixed acids versus strong base
7. Potentiometric titration (Mohr vs. dichromate).
8. To verify Lambert-Beer's law for K2Cr2O7 solution and to determine the concentration of the given solution of the substance by Colorimetric method.
9. Determination of pKin value of a weak acid - base indicator by Colorimetric method.
10. pH metric titration (i) weak monobaic and (weak dibasic acid) by strong base.

Unit II: Organic Chemistry 20M

(One experiment 15+ Lab note book 5+ Viva 5)

1. Physical characteristics (colour, odour, texture) [1M]
2. Preliminary Tests: [2M]
   (Ignition Test, litmus Test, Beilstein test for halogen, Br_2 in AcOH/water or $KMnO_4$ in water test)
3. Detection of special elements (N, Cl, S) by Lassaigne's tests. [2+2+1=5 M]
4. Solubility and classification [2+1=3M]
   (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)
5. Detection of the following functional groups by systematic chemical tests:
   (aromatic amino ($–NH_2$), Amido ($–CONH_2$, including imide), aromatic nitro ($–NO_2$), Phenolic –OH, Carboxylic acid (–COOH), Carbonyl (>C= O); only one test for each functional group is to be reported) [6×1½=9M]
6. *Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown organic compounds. Each student, during laboratory session, is required

to analyze at least SIX (6) unknown organic samples. In practical examination, one unknown solid organic compound containing not more than two of the above functional groups (IV) shall be assigned to a candidate through a single draw lottery.

B. **LABORATORY RECORDS** [5 M]

7. Candidates at the practical examinations are required to submit the day to day record of all types of laboratory works prescribed in the syllabus performed by them and duly signed by their teachers. Marks of the laboratory records shall be awarded by the examiner at the practical examination. Candidates failing to submit their laboratory note books may be debarred from the examination.

PART-II

Paper-III (F,M.-100)

Module V Chemical principle and their applications in biochemistry 50M (60L)

Unit I: Thermodynamic principles

(a) Laws of Thermo chemistry and their applications, Born Haber Cycle, Standard Enthalpy changes in various transformations, Kirchoff's relation.

(b) Maxwell's relation, C_p-C_v relation, Joule- Thompson coefficient for Van der Waal gases, Thermodynamic Equation of state.

(c) Gibbs- Helmholtz relation, Coupling reactions, concept of orders of phase transition, Clausius- Clapeyron relation and phase transition.

(d) State of equilibrium and thermodynamic condition of equilibrium (condition of Minimum Gibbs' potential), Van't Hoff's reaction isotherm (deduction using chemical potential), Temperature dependence of Equilibrium constant.

(i) Homogeneous equilibrium : Use of different standard states to define K_p, K_c, K_x and their interrelations, examples of homogenous equilibrium in gas phase and ionic equilibrium in solution.

(ii) Heterogeneous equilibrium: Chemical equilibrium in different phases, solubility product, Distribution/ partition constant, Langmuir's adsorption isotherm.

Unit II: Intermolecular forces

(a) Ionic bonding

Size effects- radius ratio rules and their limitations. Packing of ions in crystals, Lattice energy, Born- Lande equation and its applications. Born- Haber cycle and its application. Solvent energy, polarizing power and polarisibility, ionic potential, Fajan's rules.

(b) **Covalent bonding**

Lewis structures, formal charge, Valence Shell Electron Pair Repulsion (VSEPR)Theory, shapes of molecules and ions containing lone pairs and bond pairs. Partial ionic character of covalent bonds, bond moment and dipole moment, Partial ionic character from dipole moment values and electro negativity differences, Valence Bond Theory (Heitler- London approach). Directional character of covalent bonds, hybridization, equivalent and non equivalent hybrid orbital, Bent's rule. Concept of resonance, resonance energy, resonance structures

Molecular Orbital (MO) theory (elementary pictorial approach H_2, O_2 and water), sigma and pi bonds, multiple bonding. Bond order, bond length, bond strength, bond energy.

(c) Weak Chemical Forces

Van der Waal's forces, ion- dipole, dipole –dipole interactions, London forces, Hydrogen bonding. Effect of chemical forces on physical properties.

(d) Co-ordination compounds

Double salts and complex salts, Werner's theory, ambidentate and polydentate ligands, chelate complexes, Naming of co-ordination compounds (up to two metal centres). Isomerism of co-ordination compounds: Constitutional, geometrical and optical isomerism in respect co-ordination numbers 4 and 6. Determination of configuration of cis-, trans-, isomers by chemical methods,

Unit III: Applications of chemical principles to biochemical analysis

a) *Radioactivity* Radioactive decay, average life of radio elements and its relation with half life, radioactive equilibrium,.

b) *Atomic Nucleus* Fundamental particles of atomic nucleus, atomic number and its significance, Nuclear stability, neutron-proton ratio and different modes of decay, nuclear binding energy. Nuclear forces, Meson field theory. Nuclear models (elementary idea), magic numbers.

c) *Nuclear reactions:* Artificial radioactivity, Transmutation of elements, fusion, fission and spallation, Nuclear energy.

(iii) Application of radionuclides in biomedical chemistry (principles):

(a) Application of gamma radiation
(b) Effect of radiation on biological cells and the chemical basis of radiation damage
(c) Radioisotopes in medicine

e.g. diagnosis of thyroid tumor, magnetic resonance imaging of diseased organs (thyroid, brain, kidney), diagnosis of heart disorders, treatment of thyroid cancer and blood cancer, radiation therapy in cancer etc.

(iv) Applications of the principles of physical chemistry in separation of bio-molecules, column chromatography, GLC and HPLC, Application of electrophoresis – Principles of techniques of separation processes namely, dialysis, ultrafiltration, ultracentrifgation and chromatography.

Module VI: Organic Chemistry 50M(6)

Unit 1 Specific reactions

Addition reactions to Carbon–carbon multiple bonds- Electrophilic additions- mechanisms of halogenations, hydrohalogenation, hydration, hydroboration, epoxidation, hydroxylation, ozonolysis. Carbenes- addition to double bonds.
Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. Formation of acetal, $LiAlH_4$ and $NaBH_4$ reductions, Grignard reactions, Cannizzaro, aldol condensation, addition to α, β- unsaturated carbonyl compounds.
Rearrangements to electron-deficient carbon, nitrogen and oxygen- general features; Wagner rearrangements; pinacol-pinacolone rearrangement; Wolff rearrangements; Schmidt, Curtius, Lossen and Hofmann rearrangements, Beckmann rearrangement. Baeyer-Villiger reaction.

Unit II: Biomolecules (2)

Carbohydrates- Monosaccharides- classification and structure. Stepping up and stepping down of aldoses. Interconversion of aldoses and ketoses, osazone formation, epimerization. Configuration of D-glucose and L-fructose, anomeric effect, mutarotation. Ribose and deoxyribose. Structure and biological importantance of disaccharides (sucrose, maltose and lactose)
Peptides- Structure and geometry of peptide bond. Synthesis of peptides using protection/ deprotection protocol (brief outline). Merrifield solid-phase peptide synthesis. Structure elucidation of peptides. N-terminal and C-terminal amino acid determination. Conformation of peptides.

UnitIII:Complex biomolecules

Proteins- Introduction and classification. Protein structure- primary, secondary, tertiary and quaternary structure, Denaturation and renaturation of proteins. Behavior of proteins in solutions, salting- in and salting -out of proteins. Structure and biological function of fibrous proteins (keratins, collagen and elastin), globular proteins (hemoglobin, myoglobin), lipoproteins, metalloproteins, glycoprotein and nucleoproteins.
Nucleic acids- Nucleosides and nucleotides. Nature of genetic material. Composition of RNA and DNA, generalized structural plan of nucleic acids, nomenclature used in writing structure of nucleic acids, complementary base- pairings, features of DNA double helix (Watson-Crick model). Denaturation and annealing of DNA, structure and role of different types of RNA. Size of DNA of prokaryotic and eukaryotic cells.
Complex carbohydrates: Oligosaccharides and polysaccharides- (cellulose, glycogen, starch, chitin, agar, proteoglycans). Sialic acids, blood group polysaccharides.

Paper-IV (F.M.-100)

Module-VII-Enzymes (purification),physiology, cell biolog 50 M(60L)

Unit I: Enzymes-3

1. **Methods of Enzyme Purification & Characterization** - dialysis, Ultra filtration, ultracentrifugation, molecular exclusion chromatography, iso-electric precipitation, salting in, salting out, solvent fractionation, electrophoresis-Paper and SDS-PAGE, ion exchange chromatography, adsorption chromatography, affinity chromatography.

2. Trypsin, Ribonuclease, Amylase, Acid alkaline phosphatases: properties and catalytic mechanisms.

3. **Industrial & clinical applications of enzymes** – Enzymes involved in the production of glucose from starch & cellulose, use of proteases in food, detergent & leather industry, Asparaginase, lactate dehydrogenase, creatine kinase, serum glutamate oxaloacetate transaminase Serum glutamate pyruvate transaminase, Strepto kinase, glucose oxidase (sources and applications only)

Unit- II: Human Physiology

1. **Water and fluid:** Composition and balance: Buffering against pH changes in physiological system, Numerical and qualitative Problems.

2. **Cell Membrane Biophysical Phenomenon of Membrane**: Structure and membrane potentials, Excitable tissues, Neurons, Muscles, Biochemical mechanism of muscle movements, NM Junctions, receptors etc.
3. **Respiratory Physiology:** Structure and functional organization, Major principles of gas exchanges, Acid base balance, Bohr's effect, acidosis and alkalosis, qualitative and/or quantitative problems.

4. **Digestive mechanism:** Structure and functional organization, Biochemical mechanisms of carbohydrate, lipid, Protein or nucleic acid digestion, absorption and metabolic processes. Qualitative and/or quantitative problems.

5. .**Excretory mechanism:** Kidney structure & its organization, selective re-absorption & secretion, active and passive transport of various substances (sugar, amino acid, urea & creatinine); qualitative and/or quantitative problems.

Unit—III: Cell biology

1 .**Cell division**—Cell cycle: stages and characteristics of each stage, cell and tissue culture (preliminary idea only).

2. **Biological membranes—**Types, subcellular localization, chemical composition of biomembranes, model lipid membrane, different models of cell membrane, functions of biomembranes including transduction, signal recognition etc., membrane transport - active transport and passive transport, proton and Na^{+}- K^{+} pumps, simple and facilitated diffusion, porter molecules, symport, antiport, and uniport, anion porter and glucose porter, Red cell membrane proteins, membrane receptor structure and function (only preliminary idea).

3. **Bacterial and plant cell walls** - Structure, composition.

Module VIII (Practical) 50M

Unit-I

BIOCHEMICAL ANALYSIS

Two sets of experiments 2X15=30
Laboratory Note Book 10
Viva voce 10

Laboratory Work Recommended for Classes:-

1) Identification of biomolecules - Amino acids, proteins, carbohydrates, lipids, RNA & DNA

2) Estimation of the strength of amino acid using formol titration

3) Separation of amino acids using paper chromatography

4) Separation of amino acids and lipids using thin layer chromatography (TLC)

5) Separation of two proteins using column chromatography

6) Estimation of proteins using Biuret method

7) Estimation of proteins using Folin Method- application of Lambert-Beer's law for experiments 6 & 7

8) Estimation of DNA and RNA using DPA and Orcinol reagent respectively

Part III

Paper – V (F,M.-100)

Module IX : Intermediary Metabolism 50M

Unit I Carbohydrate and Energy metabolism

1 Introduction: Concept of metabolism, catabolism, and anabolism, experimental approach to study of metabolism using intact animals, bacterial mutants, and radioactive isotopes.

2. Carbohydrate metabolism: Intracellular metabolism of glucose - glycolysis, reaction and energetic of TCA cycle, gluconeogenesis, glycogenesis, glycogenolysis, reactions and physiological significance of pentose phosphate pathway, regulation of glycolysis, TCA cycle, and glycogen metabolism. Photosynthesis- light and dark reaction.

3. Oxidative phosphorylation and electron transport chain: Structure of mitochondria, sequence of electron carriers, ATP synthesis, inhibitors of ETC, basic concept of oxidative phosphorylation, inhibitors and uncouplers of oxidative phosphorylation, photophosphorylation .

Unit II: Metabolism of non-carbohydrates

4. Lipid metabolism: Metabolism (anabolism and catabolism) of triglyceride, Transport of fatty acid into mitochondria, Beta-oxidation of fatty acids, reactions and energetic of beta oxidation, biosynthesis of saturated and unsaturated fatty acids, metabolism of ketone bodies, biosynthesis of phospholipids and cholesterol.

5.Amino acid metabolism: general reactions of amino acid metabolism (oxidative deamination, transamination, decarboxylation etc), glucogenic and ketogenic amino acids, urea cycle, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid), inborn errors of amino acid metabolism.

6.Nucleotide metabolism: Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine)

7. Porphyrin metabolism: Biosynthesis and degradation of porphyrins, biosynthesis of bile pigments.

Modul:X Clinical and nutritional biochemistry 50M (60L)

Unit I: Clinical biochemistry

1. Introduction: Basic concept of clinical biochemistry - Definition and scope of clinical biochemistry in diagnosis, , collection and preservation of biological fluids (blood, serum, plasma, urine & CSF), normal values of important constituents of blood, CSF, urine etc,.

Biochemical principles of water and electrolyte imbalance, acid base homeostasis, preliminary concept of cardiovascular, liver and kidney disorders including laboratory test for respective markers.

2. Clinical Enzymology: Functional plasma enzymes, isozymes and diagnostic tests. Enzyme pattern in health and diseases as is special reference to plasma lipase, amylase, alkaline and acid phosphatase, cholinesterase, LDH, CPK, SGOT & SGPT,

3. Metabolism and diseases: Hypo and hyperglycemia, diabetes, glycogen storage disease, lipid malabsorption, abnormal lipid metabolism and disease, lipoprotein and diseases, inborn errors of amino acid metabolism (alkaptonurea, phenyl ketonuria, albinism, gout, hyper uricemia etc), disorder in heme synthesis, abnormal hemoglobin.

Unit II: Nutritional Biochemistry

(a) Introduction and definition of foods and nutrition - requirement, balance studies, uses and & limitation of balance technique, energy requirement, total energy expenditure, factors contributing to total energy requirement, basal metabolism, factors affecting basal metabolism, principles of calorimetry, calorigenic effect of food, respiratory quotient, nitrogen balance, factors affecting nitrogen balance, protein efficiency ratio, biological value, net protein utilization, net dietary protein calories per cent, calcium and iron balance

(b) Vitamins - Water soluble vitamins: chemistry & biochemical functions of – thiamin, riboflavin, nicotinic acid, pyridoxine, pantothenic acid, pteroylglutamic acid, vitamin B_{12}, Biotin, ascorbic acid.

Fat soluble vitamins: chemistry and biochemical functions of vitamin A, D, E, K. Vitamin like compounds - ubiquinone, lipoic acid, choline, meso inositol.

(c) Minerals and Water - biological functions, deficiency syndrome, food sources, dietary requirement of Calcium, Phosphorus, Magnesium, Sodium, Chlorine, Potassium, Sulfur, Iron, other trace elements - copper, iodine, manganese, molybdenum, fluorine, selenium, zinc, chromium

(d) Toxicity of common contaminants – lead,mercury, arsenic, organophosphorus pesticides (biochemical effects and underlying causes only)

Paper-VI (F.M.-100)

Module : XI – Immunology and molecular biology 50M

Unit-I Immunology

1. Introduction: overview of the Immune system.

2. Cells and organs of Immune system: Hematopoietic stem cells, stromal cells, hematopoietic growth factors, Lymphoid organs (primary and secondary) and cells, Mononuclear cells, Granulocytic cells, Mast cells, Dendritic cells- characteristics and functions.

3. Types of Immunity: (i) Innate immunity - mechanism of immune response (anatomic, physiological, phagocytic and inflammatory barriers).

(ii) Adaptive immunity: Humoral and Cell-mediated immunity - mechanism of immune response---antigen processing and presentation, types and structures of Major histocompatibility complex molecules (MHC) and their role in antigen presentation, clonal selection of lymphocytes, definition of cytokine, generation of humoral and cell mediated response by cellular interactions (general concept only).

4. Antigens: chemical nature, antigenicity, immunogenicity, hapten, epitopes, mitogens (definition, properties, examples); Adjuvant (definition, examples, function).

5. Immunoglobulins: Isotypes- definition, basic and fine structures, general characteristics and functions. Monoclonal and polyclonal antibody (definition and characteristics).

6.Antigen - Antibody interactions: Precipitation reactions-Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition.

8.Complement : The complement components, function, complement activation-(i) Classical, (ii) Alternate and (iii) lectin pathways (characteristics & functions).

9. Hypersensitivity: definition, types, examples.

10. Vaccines : Active and passive immunization (definition, characteristics, examples and functions). Attenuated and inactivated viral or bacterial vaccines (definition, characteristic, functions, examples).

Unit II: Molecular biology

1. Basic concept of genetic information: DNA: the genetic material, experimental proofs; the structures of DNA, Genome organization- from nucleotide to chromatin; the versatility of RNA.

2. Molecular Synthesis:

(a) DNA replication:
Basic features of DNA replication in vivo: semiconservative replication, bidirectional replication-visualization of replication forks by autoradiography, unique origins of replication, DNA polymerases and DNA synthesis in vitro: Discovery of DNA polymerases, multiple DNA polymerases; the complex replication apparatus: semidiscontinuous synthesis, replication initiation, elongation and termination-Enzymology, outline of DNA replication in eukaryotes, different types of DA polymerases

(b) Gene expression:

(i) Transcription: Transfer of genetic information: the central dogma, evidence for an RNA intermediary, RNA polymerases, transcription: initiation, elongation and termination; regulation of gene expression in prokaryotes: positive and negative control using lac operon as an example, attenuation: trp operon, role of sigma factor; differences in gene structures between prokaryotes and eukaryotes, different types of RNA polymerases, post transcriptional processing: capping, splicing and polyadenylation.

(ii) Translation: Genetic code: properties of genetic code, deciphering the code-experimental basis; translation: overview, components of protein synthesis: ribosomes and tRNAs, mechanism of synthesis of polypeptides using mRNA templates, outline of transcription in eukaryotes

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(**c) Mutation and DNA repair:** Molecular basis of mutation: spontaneous and induced mutations (chemicals, radiation and transposable genetic element), types of mutation, reversion and suppression, DNA repair mechanisms.

(e) Recombinant DNA technology; Restriction modification system- construction of restriction map, methods of creating recombinant DNA molecule in vitro: vectors-plasmids, cosmids, phagemids, construction of genomic DNA library and cDNA library, screening of libraries for gene of interest- southern blot, northern blot and western blot techniques , polymerase chain reaction.

Module XII Biophysical Chemistry 50M (60L)

Unit I: Quantum Chemistry

Approaching Quantum Mechanics: Black-Body Radiation, Photo- electric effect, wave particle duality: de Broglie hypothesis and Compton effect, Heisenberg's uncertainty principle.
The tools in quantum mechanics: elementary concept of operator, eigen function and eigen value. Schrodinger's equation (time independent); Well behaved wavefunction. Setting up of Schrodinger's equation, expressions (without derivation) for quantized energy and eigen states for the systems: Particle in one dimension box, its extension to 3 D box, SHO and rigid rotor.
Towards its Application: Analysis of the quantum features with reference to both energy and wavefunctions for the above systems. A few model application of the above results.

(a) **NMR spectroscopy:** Elementary principles including the basic quantum machinery for NMR, ^{1}H NMR signals: their number, positions, areas and spin-spin splitting, with examples of simple organic molecules.

(b) **Molecular Spectroscopy, Electronic Spectroscopy and photochemistry:**
EMR, its interaction with nuclear motion, range of frequency for different spectroscopy, transition moment integral and selection rule, Spectroscopy for **diatomic** molecules: rotational using rigid rotor and vibrational using SHO model, modification over RR and SHO model involving non-rigidity and anharmonicity. Molecular (linear and non linear AB_2 type) information obtained from microwave and IR with examples. Rotational and vibrational coupled.
Raman scattering, its semi classical analysis, rotational and vibrational Raman.
Born-Oppenheimer approximation, Potential energy curve for electronic states, electronic and vibronic absorption spectra, Franck Condon principle.
Relaxation of excited states by radiative and non radiative paths. Laws of Photochemistry, quantum yield, its measurement, Actinometry.

Unit II: Crystallography and Colloidal State

Solid state: Types of cubic Lattice, indexing system (Weiss and Miller), separation of lattice planes, Bragg's law and x-ray crystallography, Debye powder technique and its simple applications. .

Colloidal State: Electrokinetic phenomena- concept of Zeta potential, stability of colloids, mechanism of coagulation, Brownian motion,. Electrical property of membrane, Donann membrane equilibrium. Gibbs adsorption isotherm-statement and significance, Surfactant, Micelle formation.

1. Ideal and non- ideal Solutions and Thermodynamics of EMF of Cells

Ideal solutions: Raoult's law of relative lowering of vapour pressure. Thermodynamic derivation of colligative properties of solution (using chemical potential) and their inter relationships.
Non-ideal solutions: Concept of activity and activity coefficient with special reference to electrolyte solutions, statement of Debye-Huckel limiting law and its applications. Thermodynamic derivation of EMF, its use in measuring thermodynamic properties.

Paper –VII – (Practical) (F.M. –100)

Module XIII

Unit I : Enzyme assay 50 Marks

Two sets of experiments, 20 each		40
	Laboratory Note Book	5
	Viva –Voce	5

1) Standard curve of Para nitrophenol and glucose.
2) Determination of specific activities of Amylase, Alkaline phosphatase & Trypsin.
3) Determination of pH optima & temperature optima of alkaline phosphatase & Amylase.
4) Determination of optimum substrate concentration of alkaline phosphatase & Amylase.
5) Determination of K_M & V_{MAX} of Alkaline phosphatase & Amylase using both Michaelis- Menten hyperbolic curve & Line Weaver Burk plot.
6) Determination of K_M and V_{MAX} of Alkaline phosphatase in presence of competitive inhibitor, arsenate.
7) Activation of Alkaline phosphatase by Mg^{2+}, inhibition of Alkaline phosphatase by F^- .

Unit II : Clinical biochemistry 50 Marks

Two sets of experiments, 20 each		40
	Laboratory Note Book	5
	Viva- Voce	5

1. Estimation of reducing sugar in blood by Nelson-Somogyi Method & GOD-POD method.
2. Estimation of cholesterol in blood using Ferric Chloride in acetic acid & sulphuric acid
3. Estimation of bilirubin in blood by Malloy Evelyn method.
4. Estimation of urea by diacetyl monoxime & creatinine by Jaffe end point method in blood.
5. Determination of SGPT, SGOT and alkaline phosphatase by colorimetric end point method in blood.
6. Gel electrophoresis for detection of abnormal hemoglobin.

Paper VIII (Practical) (F.M.-100)
Module XIV
Unit I Molecular Biology and Immunology 50 Marks

Two sets of experiments: Molecular Biology, one set (20) + Immunology, one set (15)	= 35
Laboratory Note Book	5
Viva-voce	10

Laboratory works recommended for classes:

1) Isolation of DNA
2) Estimation of DNA
3) Determination of purity of DNA
4) Gel electrophoresis of DNA
5) Transformation with plasmid DNA
6) Immunodiffusion assay
7) Immunoelectrophoresis

Unit II Food Analysis and Statistical Analysis of data
Full Marks-25

One experiment	15
Laboratory Note Book	5
Viva-Voce	5

Laboratory works recommended for classes on **food analysis**:-

(a) Estimation of Vitamin C in fruit juice using 2, 6-dichlorophenol indophenol
(b) Total phenolic content in black tea
(c) Determination of Iodine Number in fats
(d) Estimation of soluble Calcium in milk using EDTA
(e) Estimation of soluble phosphorous in milk by colorimetric method
(f) Determination of total Carbohydrate content in cereal by anthrone method

Full Marls -25

One experiment	15
Laboratory Note Book	5
Viva-Voce	5

Laboratory works recommended for classes on **statistical analysis of data**:

1) Sampling Techniques
2) Statistical evaluation of results-mean, mode, median calculation-standard deviation calculation
3) Distribution of student t, chi- square, correlation coefficient
4) Use of Excel for graphical representation of data

Question pattern for Part I and Part II (Theory)

For each module (of 50 marks and three units)

i. There shall be one compulsory question comprising of ten short (objective) questions of two marks each (10X2= 20). The subject of such questions shall be from all the units. The total number of questions shall be 15.
ii. Three questions of ten marks each (3X10= 30) to be answered taking one from each unit.
iii. Each question of ten marks should further be divided into part questions such that the marks for these parts do not exceed 5 and are not less than 2. For example 5+5 or 4+4+2.
iv. The paper setter for each Unit shall set five short questions for the compulsory question (of two marks each) and two questions (of ten marks) each. The moderator shall compile the questions for the compulsory part.

Question pattern for Part III (Theory)

For each module (of 50 marks and two units)

v. There shall be one compulsory question comprising of 10 short (objective) questions of two marks each (10X2= 20). The subject of such questions shall be from all the units. The total number of questions shall be 15.
vi. Two questions of fifteen marks each (2X15= 30) to be answered taking one from each unit.
vii. Each question of fifteen marks should further be divided into part questions of 5 marks and above. E.g. 5+5+5 or 10+5.

viii. The paper setter for each Unit shall set ten short questions for the compulsory question (of two marks each) and two questions (of fifteen marks) each. The moderator shall compile the questions for the compulsory part.

Reference books for Part I, II and III

Part I

1. Physical Chemistry

(i) Physical Chemistry- G.W Castellan
(ii) Physical Chemistry- P.W.Atkins
(iii) Physical Chemistry- S. Glasstone
(iv) Physical Chemistry- P.C. Rakshit
(v) Text Book of Physical Chemistry – KL Kapoor (vol II, V)
(vi) Physical Chemistry – Hrishikesh Chatterjee (vol I)
(vii) Chemical kinetics- K. J. Laidler

2. Inorganic Chemistry

(i) Inorganic Chemistry- A. G. Sharpe
(ii) General and Inorganic Chemistry- R.P.Sarkar
(iii) Inorganic Chemistry – RL Dutta
(iv) Inorganic Chemistry- J.E. Huheey, E. A. Keitar and R. L. Keitar &O.K. Medhi
(v) New Concise Inorganic Chemistry- J.D. Lee
(vi) Basic Inorganic Chemistry- F. A. Cotton, G. Willkinson & P.L Gous
(vii) Inorganic Chemistry- D.F Shriver, R.W. Atkins and C. H. Langford

3. Organic Chemistry

(i) Organic Chemistry (vol.1&2) – I.L.Finar
(ii) A Guide to Organic Reaction Mechanism- P. Sykes
(iii) Stereochemistry of Carbon Compounds- D. Nasipuri
(iv) Basic Stereochemistry of Organic Compounds- S. Sengupta

4. Biochemistry

(i) Biochemistry – Voet & Voet
(ii) Biochemistry – Lubert Stryer
(iii) Lehninger Principles of Biochemistry – Nelson & Cox
(iv) Biochemistry – Campbell & Farrell

5. Cell Biology

(i) Molecular Cell Biology – Lodish
(ii) Cell and Molecular Biology – PK Gupta
(iii) Cell Biology – CB Power

6. Practical

(i) Advanced Practical Chemistry – Subhas Ch. Das
(ii) Handbook of Practical Chemistry – University of Calcutta

Part II

1. Physical Chemistry

(i) Physical Chemistry- G.W. Castellan
(ii) Physical Chemistry- P.W.Atkins
(iii) Physical Chemistry- S. Glasstone
(iv) Physical Chemistry- P.C. Rakshit
(v) Text Book of Physical Chemistry – KL Kapoor (vol II & III)
(vi) Physical Chemistry – Hrishikesh Chatterjee (vol I & II)
(vii) Physical Chemistry – Puri, Pathania & Sharma

Inorganic Chemistry

Same as Part I

2. Organic Chemistry

Same as Part I

3. Biochemistry

Same as Part I

4. **Cell Biology**
(i) Molecular Cell Biology – Lodish
(ii) Molecular Cell Biology - Karp
5. Physiology

(i) Human Physiology – CC Chatterjee
6. **Practical**

(i) An Introduction to Practical Biochemistry – David T Plummer
(ii) Introductory Practical Biochemistry – Sawhney & Singh

Part III

1. Biochemistry

(i) Same as Part I
(ii) Harper's Illustrated Biochemistry – Murray
(iii) Outlines of Biochemistry – Conn & Stumpf

2. Molecular Biology

(i) Molecular Biology of The Cell – Alberts
(ii) Gene IX
(iii) Molecular Biology - Freifelder

3. Immunology

(i) Immunology – Kuby

4. Clinical Biochemistry

(i) Teitz Clinical Biochemistry
(ii) Clinical Biochemistry- Metabolic And Clinical Aspects.
William J. Marshall and S.K. Bangert.
(iii) Medical Biochemistry, 4th Edition. N.V. Bhagavan (Academic Press)

5. Nutritional Biochemistry

(i) Nutritional Biochemistry – MS Swaminathan
(ii) Nutritional Biochemistry, 2nd edition, Tom Brody, Academic Press
(iii) Nutrition- An integrated approach, 3rd edition, Ruth L. Pike and Myrtle L. Brown

6. Physical Chemistry

(i) Molecular spectroscopy – C. N. Banwell and McCash
(ii) Organic spectroscopy- William Kemp
(iii) Physical Chemistry – Puri, Pathania & Sharma
(iv) Physical Chemistry – I. Levine
Physical Chemistry- G.W. Castellan
Physical Chemistry- P.C. Rakshit
(v) Physical Chemistry – Hrishikesh Chatterjee (vol II)

7. Practical

(i) An Introduction to Practical Biochemistry – David T Plummer
(ii) Introductory Practical Biochemistry – Sawhney & Singh
(iii) Biochemical Methods- For Agricultural Sciences.
S. Sadasivam and A. Manikam. (Wiley Eastern Limited)
(iv) Practical Biochemistry in Clinical Biochemistry. R. L. Nath
.Academic Press, Calcutta.
(v) Practical Clinical Biochemistry, 5th Edition. Varley & Gowenlock
William Heinemann Medical Books Ltd.
(vi) Experimental Biochemistry: A Student Companion Textbook. Rao and Deshpande (IK International Pvt.Ltd)

(vii) Molecular cloning: A Laboratory Manual Sambrook (Vol 1)

Existing General in Bio- Chemistry effective from the academic session 2009-2010 (vide University Notification No. CSR/ 28/ 09 Dt. 05.06.09 will remain unchanged)