

UNIVERSITY OF CALCUTTA

SYLLABUS

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**THREE-YEAR B.Sc. HONOURS
COURSE OF STUDIES**



BIOCHEMISTRY

2015

w.e.f.2015-2016

Overview of the syllabus for B.Sc. (H) in Biochemistry, 2015

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	Organic Chemistry	50
I/Paper 2	M III	I, II, III	Biomolecules	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 their applications to biochemistry	50
II/Paper 3	M VI	I, II, III	Enzymology	50
II/Paper 4	M VII	I, II, III	Cell Biology Microbiology Human Physiology & Nutrition	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	Cell Biology & Clinical Biochemistry	50
III/ Paper 6	M XI	I, II	Immunology	

				50
III/ Paper 6	M XII	I, II	Molecular Biology	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; Microbiology, Seminar/Poster Presentation, Statistical analysis of data	50 + 50
				Theory=200 Practical=200

Syllabi for three-year B.Sc. (H) in Biochemistry (BCMA) 2015

PART-I

PAPER I (F.M. 100)

Module I General and Physical Chemistry

50 marks (60L)

Unit I

1. Atomic Structure

Extra nuclear structure: Bohr's theory of atomic structure and its limitations, Sommerfeld's modification, application of Bohr's theory to hydrogen like atoms and ions, Spectrum of hydrogen atom. Quantum numbers. Preliminary 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 (concept only), Ground state term symbols of atoms and ions (concept only).

2. Intermolecular forces

a. Ionic bonding

Size effects- radius ratio rules and their limitations. Packing of ions in crystals, Lattice energy (concept only), Born- Lande equation (derivation not required) and its applications; Born-Haber cycle (derivation not required) and its application. Preliminary ideas of solvent energy, polarizing power and polarisability, ionic potential and Fajan's rules

b. Covalent bonding

Lewis structures, formal charge, Preliminary idea of 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, Preliminary idea of 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. bonding, non-bonding, antibonding molecular orbitals(concept only) elementary pictorial approach of H₂ and O₂ molecular orbitals , sigma and pi bonds, multiple bonding. Concept of 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,

Reference Books

1. General & Inorganic Chemistry-R.P.Sarkar
2. Inorganic Chemistry-R.L.Dutta
3. New Concise Inorganic Chemistry-J.D.Lee

Unit II:

Biophysical properties

- (a) **Viscosity:** General features of fluid flow (streamlined and turbulent), nature of viscous drag for streamlined motion. Definition of viscosity coefficient. Origin of viscosity of liquids, expression for viscosity coefficient of liquids (with derivation): Poiseuille's equation, temperature dependence of viscosity coefficient of liquids. Stoke's law and terminal velocity. Determination of viscosity coefficient of liquids. Diffusion of solutes in solution, Fick's law.
- (b) **Surface tension:** Definition, angle of contact, interfacial tension, capillary rise, determination of surface tension, temperature effect.
- (c) **Preliminary idea of Chemical equilibrium:** Equilibrium constant, Le Chatelier's principle and its simple applications.

Ionic equilibrium: Standard solution, Molar, Normal, Molal, Formal and percent strengths, Hydrolysis of weak acids and bases. pK_a , pK_b , pH, pOH acid- base neutralization curves, Buffer action definition, Henderson -Hasselbalch equation and preparation of buffers, buffer capacity, Solubility product principle and application.

Unit-III

Electrochemistry:

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. Basic concepts of electrochemical cell and cell reactions. EMF of cell (no derivation), types of electrode, glass electrode, determination of pH of a solution and potentiometric titration, redox reaction.

Chemical Kinetics

- (a) Concepts of rate, rate constant, order and molecularity of a reaction, integrated form of rate expressions; half-life period and its significance.
- (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; Concept of Collision theory and Transition State theory of reaction rate.
- (c) Catalytic reactions: Homogeneous catalysis, acid -base catalysis, primary salt effects, Autocatalysis, Adsorption of gases on solids, Langmuir adsorption isotherm, Heterogeneous catalysis, examples.

Reference Books

1. Physical Chemistry-P.C.Rakshit
2. Lehninger Principles of Biochemistry-Nelson & Cox
3. Text Book of Physical Chemistry-K.L.Kapoor(Vol-II,V)
4. Physical Chemistry-Hrishikesh Chatterjee(Vol-I)

Module II Organic Chemistry

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. dipole moment, 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, measurement
of specific rotation by polarimeter, 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.

Conformation: Conformational nomenclature, eclipse, staggered, gauche and anti forms ;
dihedral angle, torsion angle, energy barrier of rotation; Conformational analysis of
ethane, propane and n-butane; Conformational analysis of cyclohexane (chair and boat
forms), symmetry properties, optical activity and relative stabilities of cyclohexane
systems;

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Unit II: General treatment of reaction mechanisms

Ionic and radical reactions; heterolytic and, homolytic bond cleavage

Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions,
carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic
behaviour, stability, generation and fate. Reaction kinetics: transition state theory, rate
constant and free energy of activation, free energy profiles for one step and two step
reactions.

Nucleophilic substitution reactions- S_N1 , S_N2 , S_Ni 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: Specific Reactions and Heterocycles

Addition reactions to Carbon-carbon multiple bonds- Electrophilic additions-mechanisms of halogenations, hydrohalogenation, hydration, hydroboration, epoxidation, hydroxylation, ozonolysis.

Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. Formation of acetal, LiAlH_4 and NaBH_4 reductions, Grignard reactions, Cannizzaro, aldol condensation.

Heterocycles- Structural aspects of five and six membered heterocycles containing hetero atoms (furan, pyran, pyridine, pyrrole, furanose, pyranose, purines, pyrimidines). Aromaticity of heterocyclic compounds; basicity of pyridine and pyrrole. Tautomerism in heterocyclic systems.

Reference Books

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

Paper II (F.M-100)

Module III: Biomolecules

50 marks (60L)

Unit I:

1. Amino acids

Definition, classification & structures. Physico-chemical properties of amino acids (amphoteric molecules, ionisation, zwitterions, pK values, isoelectric point, Lambert-Beer's law, optical density, absorption spectra), titration of amino acids (glycine, glutamic acid, lysine, histidine), Formol titration of glycine (only reaction and principle), reaction of amino acids: reaction due to amino groups (reaction with mineral acids, alkyl halides, acetyl chloride, acetic anhydride in presence of base, nitrous acid, ninhydrin and fluorescamine), reaction due to carboxylic acid group (reaction with base, alcohol, LiAlH_4 , metal oxide), separation and analysis of amino acids by paper & thin layer chromatography and HPLC.

2. Peptides & Proteins

Peptide bond: Definition, structure and geometry of peptide bond, example of biologically important peptide and its functions in brief (glutathione-peptide of non protein origin), Merrifield solid-phase peptide synthesis using protection/ deprotection protocol (brief outline). N-terminal amino acid determination (Edman degradation, dansyl chloride reagent, Sanger's reagent) and C-terminal amino acid determination (carboxypeptidase and using hydrazine)

Proteins : Definition & structure, primary, secondary, tertiary and quaternary structure (definition and example), structure of globular protein (albumin, globulin, haemoglobin & myoglobin – Structure, function and occurrence in brief) and fibrous

protein (keratin, collagen -role of Vitamin C in hydroxylation, elastin- Structure, function and occurrence in brief), Forces that stabilise structure of proteins, behaviour of proteins in solutions, salting in and salting out, Denaturation and renaturation of proteins (example -RNase), absorbance of proteins, example of metalloprotein, lipoprotein. Biuret and Folin-Lowry test for protein.

Unit II:

1. Carbohydrates

Definition, classification, structure, occurrence and biological importance of monosaccharides (aldohexose-glucose, mannose, galactose; epimers; ketohexose-fructose; ; aldopentose-ribose; deoxysugars-deoxyribose; fucose; rhamnose), Molish's test for carbohydrate, reaction of monosaccharides with nitric acid, bromine water, periodic acid and phenylhydrazine, osazone formation, reaction of deoxyribose with DPA and reaction of ribose with orcinol reagent; glycosidic linkage, disaccharides (sucrose-invert sugar, inversion of sucrose, maltose and lactose) reducing and non-reducing sugar (tests for reducing sugars, reaction with Benedict's reagent, Fehling's solution, Tollen's reagent, Seliwanoff test for ketose sugar,), Configuration of D-glucose and D-fructose, anomers (α & β - D-glucopyranose), anomeric effect, differences between anomers and isomers, mutarotation and its mechanism; polysaccharides (cellulose, glycogen, starch, chitin, agar), blood group polysaccharides, Glycoprotein, proteoglycan, glycosaminoglycan, muramic acid, sialic acid.

2. Lipids

Definition and classification (simple, complex and derived lipids with examples). Fatty acids- definition, structure, properties, examples of saturated and unsaturated fatty acids, essential, non-essential fatty acids, Geometric isomerism of fatty acids, Triacyl glycerols. Reactions and characterization of fats – hydrolysis, saponification, saponification value, iodine number, rancidity of fats, Reichert- Meissel number. Phospholipids- Definition, general structure (Glycerophospholipids, lecithins-phosphatidyl choline, lysolecithins, cephalins-phosphatidyl ethanolamine, phosphatidyl serine, phosphatidyl inositol, plasmalogens, sphingomyelins – structure, occurrence and brief function). Glycolipids- cerebroside, gangliosides (structure, occurrence and brief function), cholesterol (structure, occurrence and brief function). test for cholesterol.

Unit III:

Nucleic acids

Definition, generalized structural plan of nucleic acids, phosphodiester bond, structure of purine and pyrimidine bases, composition of DNA and RNA, Nucleosides and nucleotides (definition, structure and example), nomenclature used in writing structure of nucleic acids, complementary base-pairings, Chargaff's rule, features of DNA double helix (Watson-Crick model). different forms of DNA structure (A, B & Z DNA), major and minor

groove, three major types of RNA, secondary and tertiary structure of tRNA, chemical properties: hydrolysis (acid & alkali), absorbance of DNA & RNA, Denaturation and annealing of DNA, melting temperature, factors affecting melting temperature, hyperchromic effect, electrophoresis and staining of DNA (with EtBr), Central dogma (outline only).

Porphyrins

Porphyrin nucleus and classification. Important metalloporphyrins occurring in nature - haemoglobin, leghemoglobin (plant hemoglobin), chlorophyll, cyanocobalamin and their brief functions (it is important to know the metal centers but memorizing the structures are not required).

Reference Books

1. Biochemistry – Voet & Voet
2. Biochemistry – Lubert Stryer
3. Lehninger Principles of Biochemistry – Nelson & Cox

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

Unit I: Physical Chemistry 30M (One experiment 20+ Lab note book 5+ Lab Quiz 5)

- a. Preparation of buffer of a given pH (for example acetate buffer of pH=4, phosphate buffer of pH=7, glycine-NaOH buffer of pH 9.0)
b. Preparation of a primary standard solution (oxalic acid, dichromate) of known strength.
- Determination of pK_{in} value of a weak acid - base indicator by Colorimetric method.
- pH metric titration: weak monobasic acid by strong base.
- Conductometric titration of: Mixed acids vs strong base.
- Potentiometric titration (Mohr vs. dichromate).
- Determination of solubility and solubility product of a sparingly soluble salt by titrimetric method.
- Determination of specific rotation of a given optically active compound and % composition of its aqueous solution using Polarimeter.
- Determination of viscosity coefficient of a given liquid/solution with Ostwald viscometer.
- To study the kinetics of saponification of ester by conductometric method.
- Estimation of protein by biuret method: application of Lambert - Beer's law.

Unit II: Organic Chemistry

20M

(One experiment 15+ Lab note book 2.5+Lab Quiz 2.5)

- Physical characteristics (colour, odour, texture) [1M]
- Preliminary Tests: [2M]
(Ignition Test, litmus Test, Beilstein test for halogen, Br_2 in AcOH/water or $KMnO_4$ in water test)
- Detection of special elements (N, Cl, S) by Lassaigne's tests. [2+2+1=5 M]
- Solubility and classification [2+1=3M]
(Solvents: H_2O , 5% HCl, 5% $NaHCO_3$, 5% NaOH)
- 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]

*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.

Practical Reference Books

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

PART-II

Paper-III (F.M.-100)

Module V

50M (60L)

Unit I:

1. 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-Thomson 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) Laws of Thermo chemistry and their applications, Born Haber Cycle, Standard Enthalpy changes in various transformations, Kirchoff's relation.
- f) Maxwell's relation, C_p - C_v relation, Joule- Thompson coefficient for Van der Waal gases, Thermodynamic Equation of state.

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

Unit-II

1. Chemical Equilibrium: 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, Distribution/ partition constant.

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

3. 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.

Unit III:

1. Radioactivity

Laws of radioactivity, Radioactive decay, decay constant, average life of radio elements and its relation with half life, radioactive equilibrium, properties of α, β, γ radiations, radiation damage, radiation protection and safety aspects, units of radioactivity, radioactive carbon dating,

Atomic Nucleus

Fundamental particles of atomic nucleus, atomic number and its significance, nucleus stability, neutron proton ratio and different modes of decay, nuclear binding energy, nuclear forces.

Applications of radioactive isotopes

Examples of radio isotopes (^{14}C , ^3H , ^{32}P , ^{35}S , ^2H) and their uses in biological systems.

Basic principles of liquid scintillation counter. Radiation absorption, Radiation therapy in cancer (examples only)

2. Spectroscopy

Concept of electromagnetic radiation: UV, visible, IR. Infrared Spectroscopy-rotational and vibrational coupled (concept only). Light Scattering, Raman scattering (concept only), UV and visible Spectrophotometry (examples of absorption spectra of amino acids, protein, purine, pyrimidine bases and nucleic acids); Concept of chromophore, Lambert-Beer's law-derivation & deviation; absorptivity, fluorescence spectroscopy, concept of fluorescence energy transfer (FRET), examples of autofluorescence in biological samples, fluorescence from tryptophan present in proteins and chlorophyll, green fluorescence protein (GFP), concept CD spectroscopy and its application in determining secondary structure of polypeptides.

NMR spectroscopy: Elementary principles of NMR, ^1H -NMR, NMR signals, their numbers, positions areas and spin-spin splitting; its application in structure determination of simple organic molecules and proteins (representative of simple spectra of two organic molecule and a standard protein (BSA) should be shown).

4. **Mass spectrometry: Basic principles of MS-MS and its applications.**

Reference Books

1. Physical Chemistry-P.C.Rakshit
2. Text Book of Physical Chemistry-K. L. Kapoor (Vol-II,III,V)
3. Physical Chemistry-Hrishikesh Chatterjee(Vol-I,II)
4. Lehninger Principles of Biochemistry-Nelson &Cox

5. Molecular Spectroscopy-C. N. Banwell& McCash
6. Organic Spectroscopy-William Kemp
7. Techniques and Methods in Biology-K. L. Ghatak

PAPER III

50M

MODULE VI

UNIT-I

Enzymology

Enzymes

Definition of enzymes, differences between biocatalysts and chemical catalysts, holoenzymes and apoenzymes, cofactors: metal ions (Zn^{+2} , Mg^{+2} , Fe^{2+}), coenzymes (NAD^+ , $NADP^+$, HSCoA, FH_4 , cobalamin), prosthetic groups (FAD^+ , TPP, PALPO, biotin), co-substrate (NAD^+)- one reaction of each. Classification of enzymes, IUPAC system, Name & examples of each class

Precursor of coenzymes: Water soluble vitamins B & C and fat soluble vitamins A, D, E & K (It is important to know the precursor vitamins of both categories and the corresponding coenzymes and the examples of associated enzyme catalyzed reactions.)

Basic thermodynamic principles of enzymatic reactions:

Standard free energy, entropy and enthalpy change in a reaction. Transition state, activation energy of both in non-enzymatic and enzymatic reaction, reaction rate, rate constant, rate limiting step, rate equation, binding energy, association and dissociation constants, lock & key hypothesis, induced fit hypothesis, proximity and orientation effect, strain and distortion theory (**FROM LEHNINGER**). **Numerical problems on each section**

Enzymes kinetics

Concept of pre steady state and steady state kinetics, initial rate, maximum velocity, Michaelis constant, Michaelis- Menten equation(derivation), graphical representation, double reciprocal plot, Significance of K_M & V_{max} , K_{cat}/K_M , turnover number, enzyme catalyzed bi substrate reaction, sequential & ping pong reaction-(only example of each).

Factors on which enzyme catalyzed reactions depend: Substrate concentration, enzyme concentration, pH, temperature, time. **Numerical problems on each section**

UNIT-II

2. Inhibition of enzyme catalyzed reaction

Competitive, noncompetitive (mixed), uncompetitive, irreversible inhibition, one example in each case.

Effect of metal ions (Zn^{2+} , Cu^{2+} , As^{3+} , Hg^{2+}) on enzyme activity (with examples)

Mechanism of enzyme catalysis (basic concepts)

- i) acid- base catalysis (example- RNase A)
- ii) metal ion catalysis (example- Carbonic anhydrase)
- iii) covalent catalysis (example- trypsin)

Regulatory enzyme

Allosteric enzyme, definition & example (ATCase, T& R states), examples of positive and negative modulators, feedback inhibition, kinetic properties of allosteric enzyme, K enzymes, M enzymes (examples), sequential model & symmetry model, examples; regulation by covalent modification (phosphorylation), regulation by proteolytic cleavage of protein (zymogens-trypsinogen, chymotrypsinogen) Isozymes: Definition and basis of difference, example-lactate dehydrogenase.

UNIT-III

1. Enzyme activity

Unit activity, specific activity, molecular activity / molar activity, Katal, turn-over number; numerical problems

2. Methods of Enzyme Purification

Dialysis, Ultra filtration, ultracentrifugation, molecular exclusion chromatography, column chromatography, GLC and HPLC, FPLC, iso-electric precipitation, salting in, salting out, solvent fractionation, electrophoresis-Paper and SDS-PAGE, ion exchange chromatography, adsorption chromatography, affinity chromatography.

3. **Industrial applications of enzymes** – Enzymes involved in the production of glucose from starch & cellulose, use of proteases in food, detergent & leather industry.

Reference Books

1. Biochemistry – Voet & Voet
2. Biochemistry – Lubert Stryer
3. Lehninger Principles of Biochemistry – Nelson & Cox
4. Industrial Microbiology- Prescott & Dunn's

Paper-IV (F.M.-100)

Module-VII –Cell Biology, Microbiology, Human Physiology & Nutrition 50M (60L)

UNIT-I: Cell Biology I

1. Cell

Definition, Morphology - cell size, cell shape, comparison of prokaryotic and eukaryotic cell (with respect to cell wall & membrane composition, cell organelles, genome size), endosymbiotic theory, cell types (epithelial, endothelial)

2. Structure and brief function of cell organelles

Schematic diagram & brief functions of eukaryotic cell structure, cell membrane (membrane composition, fluid mosaic model & its validity, artificial membrane-liposome), structure (with diagram) and brief functions of endoplasmic reticulum (differences between SER & RER; simple overview of secretory and membrane bound protein synthesis), nucleus, mitochondria, lysosomes, peroxisomes, Golgi apparatus, ribosome, polysomes, cytoskeletal elements (actin, tubulin), chloroplasts (difference between mitochondria and chloroplast).

UNIT-II: Microbiology

1. **Different types of microbes-** bacteria, virus, fungi (mention only names with pictures)

2. Bacterial morphology

Size and shape of bacteria (examples of Bacillus, Coccus, Spirillum, flagellated and ciliated bacteria, gram positive and gram negative bacteria, concept of ribotyping, spore forming bacteria(Only example with purpose and significance; no mechanism or pathway needed).

3. Cultivation of Bacteria

Basic concepts of nutritional requirements, bacteriological media: nutrient broth (liquid media) and nutrient agar (solid media), complex media and synthetic media (mention only). Physical conditions required for optimum growth (temperature, oxygen, osmotic pressure), effect of pH and salt concentration on bacterial growth, cfu, growth curve of bacteria (using cell no, turbidity), different phases of growth, generation time. Basic principles of storage of bacteria: idea of slant, stab cultures, freeze-drying (lyophilization). **(for this Section detailing must be avoided)**

4. Control of Growth

Basic concepts of sterilization, disinfection; Basic concept with examples of physical method of disinfection and sterilization- high temperature: dry heat, moist heat, steam under pressure(autoclave), pasteurization, filtration, radiation, lyophilization, osmotic pressure, UV (mode of action & application); Basic concept with examples of Chemical control- antiseptic, sanitizer, germicide, antimicrobial agent (definition,

application, examples) alcohol, acid, alkali, phenol, ethylene oxide, detergents (mode of action, applications). Antibiotic-mode of action of penicillin; Resistance to antibiotics (definition and significance). Basic concept of probiotic therapy. **(for this Section detailing must be avoided)**

UNIT- III: Human Physiology & Nutrition

1. HORMONE: Endocrine systems: Pituitary hormones functions and targets (tabular form)

2. Digestive mechanism

Structure and functional organization, Biochemical mechanisms of carbohydrate, lipid, Protein or nucleic acid digestion, absorption

3. Excretory mechanism

Kidney: functional organization, GFR, selective re-absorption & secretion, buffering system, Acid base balance, acidosis and alkalosis, biochemical principles of water and electrolyte imbalance, polyuric states, nephrogenic Diabetes insipidus (antidiuretic hormone-vasopressin).

4. Nutrition

Energy requirement, basal metabolism, factors affecting basal metabolism, calorific 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, balanced diet, diseases due to malnutrition (Kwashiorkor, Marasmus)

5. Toxic effects of toxic substances and elements: Lead, Mercury, Arsenic, Cadmium; Organophosphorous pesticides and polycyclic aromatic hydrocarbons

6. Minerals

Biological functions, deficiency syndrome, food sources, dietary requirement of Calcium, Phosphorus, Sodium, Chlorine, Potassium, Iron, other trace elements - iodine, manganese, molybdenum, fluorine, zinc, chromium.

1. Cell Biology

- (i) Molecular Cell Biology – Lodish and Albert's Cell Biology
- (ii) Molecular Cell Biology – Karp
- (iii) Cell Biology – C.B. Power
- (iv) Cell Biology – P.K. Gupta
- (v) Cell Biology – Devsena

2. Microbiology

- (i) Microbiology- Pelczar, Chan, Krieg
- (ii) Fundamental principles of bacteriology- Salle

3. Physiology

- i) Human Physiology – CC Chatterje
- ii) Text Book of Medical Physiology-Mahapatra
- iii) Medical Physiology-Guyton & Hall
- iv) Harper's Physiology

4. Nutritional Biochemistry

- i) Text Book of Biochemistry for Medical Students-D.M.Basudevan
- ii) Nutritional Biochemistry-M.S.Swaminathan
- iii) Nutrition –An Integrated Approach, Ruth L.Pike &Brown

Module VIII (Practical)

50M

Unit-I

BIOCHEMICAL ANALYSIS

Three sets of experiments 40

Laboratory Note Book 5

Viva voce 5

Laboratory Work Recommended for Classes:-

- 1) Identification of biomolecules - Amino acids, proteins, carbohydrates, lipids.
- 2) Estimation of the strength of amino acid using formol titration
- 3) Separation of amino acids using paper chromatography
- 4) Separation of amino acids using thin layer chromatography (TLC)
- 5) Estimation of proteins using Folin Ciocalteu (Lowry) method.
- 6) Estimation of Vitamin-C using 2,6-dichlorophenol indophenol.
- 7) Estimation of soluble calcium in milk using EDTA.
- 8) Estimation of total phenolic content in Black Tea.

Reference Books for Practical:

- i) An Introduction to Practical Biochemistry – David T Plummer
- ii) Introductory Practical Biochemistry – Sawhney & Singh
- iii) Biochemical Methods –S.Sadasivam and A.Manickam
- iv) Experimental Biochemistry-Rao & Deshpande

Part III

Paper – V (F.M.-100)

Module IX : Intermediary Metabolism

50M

Unit I Carbohydrate and Energy metabolism

Introduction

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

Carbohydrate metabolism

Intracellular metabolism of glucose - glycolysis, energetics of glycolysis, regulation of glycolysis, gluconeogenesis and its regulation, entry of galactose and fructose in glycolysis, fates of pyruvate, formation of acetyl coenzyme A, PDH complex and its regulation, reaction and energetics of TCA cycle, regulation of TCA cycle, malate aspartate and glycerol-3-phosphate shuttle, ATP yield from complete oxidation of glucose, Cori cycle, glyoxylate cycle, glycogen metabolism and its regulation (glycogenesis, glycogenolysis), reactions and physiological significance of pentose phosphate pathway, Photosynthesis- light and dark reaction, photophosphorylation, Calvin Cycle, photorespiration, C₄ pathway (tropical plants).

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, .

Unit II: Metabolism of non-carbohydrates

Lipid metabolism

Metabolism (anabolism and catabolism) of triglyceride, Transport of fatty acid into mitochondria, Beta-oxidation of fatty acids (satd, unsatd, odd no & even no) reactions and energetic of beta oxidation, essential and non essential fatty acids, biosynthesis of saturated and unsaturated fatty acids (precursors and site of synthesis, pathway not required) metabolism of ketone bodies, biosynthesis of cholesterol.

Amino acid metabolism

General reactions of amino acid metabolism (oxidative deamination, transamination, decarboxylation etc), glucogenic and ketogenic amino acids, urea cycle, essential and non essential amino acids, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid), inborn errors of amino acid metabolism (alkaptonuria, phenylketonuria, albinism), NIH shift, amino acids (serine, tyrosine, tryptophan, glycine) as precursors of many biomolecules.

Nucleotide metabolism

Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine), preliminary idea of de novo synthesis and salvage pathway (complete pathway is not required), precursor molecules, regulation, diseases due to defect in nucleotide metabolism.

Porphyrin Metabolism

Biosynthesis of porphyrin, biosynthesis and degradation of bile pigments (detail pathway not required but precursors for biosynthesis and end products for degradation with regulation need to be known), bile acids and their significance.

Reference Books

1. Biochemistry – Voet & Voet
2. Biochemistry – Lubert Stryer
3. Lehninger Principles of Biochemistry – Nelson & Cox

Unit—I: Cell biology, Signal Transduction. Membrane Transport

1 .**Cell division**—Cell cycle: conceptual ideas of G1, S, G2 & M stages and brief characteristics of each stage, Mitotic cell division (brief description of each phases with diagram), cell culture (preliminary idea only)- media, synthetic media, complex media, aseptic conditions, requirement of CO₂ (5%) incubator.

2. **Signal transduction**-Preliminary conceptual ideas on receptor-ligand interaction, activation of cellular enzymes (such as Adenylate cyclase, Phospholipase C, Tyrosine Kinase, Ras), Concept of transmembrane proteins as membrane receptor and channels with a couple of examples and their functions for each. Endocrine signaling: preliminary ideas for autocrine, paracrine and endocrine signaling; Difference from exocrine system (also mention local hormones), Flow diagram/tables illustrating an overview of hormonal (non-steroid and steroid) (endocrine) network in human body (showing source glands, target organs/tissues, functions, one or two examples of hyper and hypo activity of hormones).

3.Transport across membranes—Membrane transport - active transport and passive transport, proton and Na⁺- K⁺ pumps, simple and facilitated diffusion, preliminary ideas with examples of porter molecules, symport, antiport, and uniport, anion porter (RBC membrane protein) and glucose porter, Ca²⁺-pump, Membrane potential (concept of hyper- & depolarization), Voltage gated channel, ion gated channel, ligand gated channel, Ca²⁺-channel inhibitors, Na⁺-K⁺ ATPase inhibitors (one example of each)- (their brief clinical significance as cardiovascular and other medicines).

Unit II: Clinical biochemistry

1. Clinical Analysis

Blood: Ingredients-Plasma, serum, cells; Blood group analysis, Rh factor, blood transfusion-precautions; brief description of clotting (clinical significance with reference to snake venoms)

Collection and preservation of biological fluids (blood, serum, plasma, urine), Factors affecting levels of important constituents of blood, urine (**see also Section 3 below**) (blood levels of sugar, glycated haemoglobin, lipid profile, cholesterol, total protein, albumin, urea, creatinine, uric acid, Na⁺, K⁺). **Definition of NORMAL LEVELS (concept of variations in different race, age, gender, food habits etc)**

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; Preliminary concept of biomarkers for cardiovascular, liver and kidney disorders including their laboratory tests.

3. Metabolism & Diseases

Hypo and hyperglycemia, diabetes mellitus, glycogen storage disease, lipid malabsorption, abnormal lipid metabolism and disease, lipoprotein and diseases, disorder in heme synthesis (anemia, thalassemia, sickle-cell anemia), abnormal hemoglobin (diabetic)

Reference Books

Cell Biology

- (i) Molecular Cell Biology – Lodish
- (ii) Molecular Cell Biology – Karp
- (iii) Cell Biology –C. B. Power
- (iv) Cell Biology –P. K. Gupta
- (v) Cell Biology –Devsena

Clinical Biochemistry

- i) Teitz Clinical Biochemistry
- ii) Medical Biochemistry- N.V. Bhagavan (Academic Press)

Paper-VI (F.M.-100)

Module : XI – Immunology

50M

Unit-I

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- brief characteristics and functions.

Types of Immunity

- (i) Innate immunity – Preliminary conceptual ideas on the mechanism of immune response (anatomic, physiological, phagocytic and inflammatory barriers).
- (ii) Adaptive immunity: Humoral and Cell-mediated immunity - Preliminary conceptual ideas on the mechanism of immune response---antigen processing and presentation, Brief introduction of Major histocompatibility complex molecules (MHC I & II) and their role in antigen presentation (concept only); Preliminary conceptual ideas on clonal selection of lymphocytes, definition of cytokine, generation of humoral and cell mediated response by cellular interactions (**general concept only**).

Antigens

Chemical nature, antigenicity, immunogenicity, hapten, epitopes, Adjuvant (definition, examples, function).

Immunoglobulins

Isotypes- definition, basic and fine structures, general characteristics and functions; Monoclonal (basic procedure of synthesis) and polyclonal antibody (definition and characteristics)

Unit - II

Antigen Antibody interactions

Precipitation reactions-Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition

Complement

The complement components, function, complement activation-

(i) Classical, (ii) Alternate and (iii) lectin pathways (characteristics & functions), ELISA, RIA

Hypersensitivity

Definition, types, examples

Vaccines

Active and passive immunization (definition, brief characteristics, examples and functions); Attenuated and inactivated viral or bacterial vaccines (definition, brief characteristics, functions, examples)

Immunological diagnosis

Tumor, Cancer (example-prostate cancer, PSA-prostate specific antigen), ELISA for detection of flu antigens, malaria antigen, dengue antigen, HIV, HBsAg, HCV, Typhoid (details not required)

Reference Books:

- i) Immunology – Kuby
- ii) Immunology-Roitt, Roitt

Module : XII Molecular biology

Unit I:

Basic concept of genetic information

Central dogma, DNA: the genetic material, Griffith's experiment, Hershey-Chase experiment, experimental proof by Avery, McLeod, McCarty; Preliminary conceptual ideas of Genome organization- from nucleotide to chromatin; the versatility of RNA (different types of RNA and their brief functions)

DNA replication:

Basic features of DNA replication in vivo: semiconservative replication (Meselson-Stahl's Expt), unidirectional & bidirectional replication (theta and rolling circle models), leading and lagging (okazaki) strands, visualization of replication forks by autoradiography, unique origins of replication, Brief description of DNA polymerases (prokaryotic and eukaryotic); brief introduction of other replication machineries, basic concept of replication initiation, elongation and termination (**outline only**) ; Preliminary idea of DNA replication in eukaryotes (**outline**); Major salient differences between prokaryotic and eukaryotic replication; Examples for inhibitors of replication in prokaryotes and eukaryotes and corresponding targets.

Mutation and DNA repair

Preliminary idea of molecular basis of mutation: examples of spontaneous and induced mutations (chemicals, radiation), types of mutation, reversion and suppression, Basic rudimentary concepts of DNA repair mechanisms (Photoreactivation, Mismatch repair, Excision repair, SOS repair system); Examples of Recombination repair and Transposable genetic element.

Transcription

Transfer of genetic information, RNA polymerases, Preliminary idea of transcription initiation (role of sigma factor), elongation and termination; basic concept of regulation of gene expression in prokaryotes: positive and negative control using lac operon as an example, attenuation, basic concept of post transcriptional processing: examples of capping, splicing and polyadenylation, outline of transcription in eukaryotes (only mention the differences with prokaryotes [e.g. at the level of 5'-untranscribed region (promoter and enhancer sequences) and RNA polymerase complexity], idea of transcription factors only. Inhibitors of transcription in prokaryotes and eukaryotes.

Unit II

Translation

Genetic code: properties of genetic code, deciphering the code-experimental basis (Khorana's expt); translation: overview, components of protein synthesis: ribosomes and

tRNAs, schematic description of synthesis of polypeptides using mRNA templates, concept of post-translational modifications. Mention of differences in translational machinery of prokaryotes and eukaryotes (Initiation factors only); Inhibitors of translation in prokaryotes and eukaryotes

Genetics

Basic principles of Mendelian genetics (monohybrid and dihybrid, test and back crosses); Bacterial genetics-transformation, transduction, conjugation (mention of F^+ / F^- , Hfr strain, function of pillus)

Recombinant DNA technology

Restriction modification system- construction of restriction map of *E. coli*, vectors-plasmids, cosmids, phagemids, definition of genomic DNA library and cDNA library, Basic concept of expression of eukaryotic gene in prokaryotic system (example-insulin, growth hormone) Southern blot, northern blot and western blot techniques.

Preliminary ideas for application of RDT in agriculture (examples of genetically modified crop, herbicide and pest resistance) and pharmaceuticals (recombinant vaccine); Polymerase Chain reaction –DNA synthesis and amplification in vitro, Steps and enzymes of PCR, **PCR based analysis & diagnosis (a few examples of forensic and clinical).**

Reference Books

- i) GENE VIII- Lewin
- ii) Biochemistry-Voet & Voet
- iii) Molecular Biology of the gene-Watson
- iv) Biochemistry-Lubert Stryer
- v) Molecular Biology by Weaver
- vi) Principles of Gene Manipulations by Old and Primrose

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
- 3) Determination of pH optima & temperature optima of alkaline phosphatase
- 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 GOD-POD method.
2. Lipid Profile in blood by enzymatic method.
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. Blood group determination.

Paper VIII (Practical) (F.M.-100)

Module XIV

Unit I Molecular Biology and Immunology

Two sets of experiments: Molecular Biology, one set (20) +

Immunology, one set (15)

Laboratory Note Book

Viva-voce

Laboratory works recommended for classes:

- 1) Isolation of DNA (bacterial genomic and plasmid)
- 2) Estimation of DNA
- 3) Determination of purity of DNA
- 4) Gel electrophoresis of bacterial genomic and plasmid DNA
- 5) Transformation with plasmid DNA
- 6) ImmunoDiffusion assay (radial-immuno diffusion)
- 7) Immunoelectrophoresis

Unit II Microbiology, Statistical Analysis of data and Poster Presentation/ Seminar Full Marks-50

Microbiology:

One set of experiment 15

Laboratory Note Book

Viva-Voce

- 1) Preparation of bacterial culture media (nutrient broth, nutrient agar) and sterilization (autoclave) (Only for practice in the class)
- 2) Streaking and single colony isolation (Only for practice in the class)
- 3) Isolation of bacteria from natural sources: soil/water and determination of cfu/ml by serial dilution method (**to be set in the examination**)
- 4) Assay of antibiotics-antibiotic sensitivity test by paper disc/cup plate method (**to be set in the examination**)
- 5) Gram-staining-Gram positive, Gram-negative (Only for practice in the class).

Statistical analysis of data:

Laboratory Note Book 5

Viva-Voce 5

- 1) Sampling Techniques
- 2) Statistical evaluation of results-mean, mode, median calculation ,standard deviation calculation
- 3) Distribution of student t, correlation coefficient

4) Poster Presentation/Seminar

1) Presentation & question answer session	8+2
2) Abstract	5

Reference Books for 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)

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 ($10 \times 2 = 20$). The subject of such questions shall be from all the units. The total number of questions shall be 15.
- ii. One question (10 marks) should be answered from each unit. Each unit will comprise of two questions of 10 marks each.
- iii. Each question of ten marks should further be divided into part questions such that the marks for these parts do not exceed 4 and are not less than 1. **For example but not restricted to 4+3+3 or 4+4+2.**
- iv. The paper setter shall set five short questions from each Unit 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 ($10 \times 2 = 20$). 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 ($2 \times 15 = 30$) to be answered taking one from each unit.
- vii. Each question of fifteen marks should further be divided into part questions with 4 marks maximum and 1 mark minimum. **For example but not restricted to 4+4+3+2+2 or 3+3+3+3+3.**
- viii. The paper setter shall set five short questions from each Unit 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

