JSPM UNIVERSITY
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JSPM UNIVERSITY PUNE

SYLLABUS

RPET 2023

Research Program Entrance Test

Subject Concerned Syllabus

Chemistry

Physical Chemistry

1) **Chemical Kinetics** : order, molecularity, differential and integral rate laws, first- second- and third-order reactions, zero order reactions, reactions of half integral order, complexities in reaction kinetics reversible reactions, consecutive reactions, steady state approximation- elucidating reaction mechanisms, parallel (or side) reactions, autocatalysis, Arrhenius equation, unimolecular reactions, Collision theory, theory of absolute reaction rates, Eyring equation, enthalpy, entropy and free energy of activation, potential energy surface accompanying simple reactions, dependence of rate constants of ionic reactions on pressure or dielectric constant, primary and secondary salt effects, Enzyme catalysis, Michaelis-Menten mechanism, K_M and r_{max} from the Lineweaver-Burk and Eadie-Hoftsee methods, fast reactions, relaxation and flow techniques, oscillatory reactions.
2) **Thermodynamics** : Carnot cycle, first and second laws of thermodynamics, dependence of enthalpy, entropy and free energy on pressure or temperature, absolute entropy, third law of thermodynamics, Partial molar quantities, statistical thermodynamics, Maxwell-Boltzmann/ Fermi -Dirac/Bose-Einstein statistics, partition function, Thermodynamic parameters from partition functions, residual entropy, nonequilibriumthermodynamics, entropy production, Onsager's Reciprocal relationships.
3) **Surface-, Electro- chemistry and Materials Chemistry** : Adsorption, Freundlich and Langmuir adsorption isotherms, multilayer adsorption and BET theory, surface area determination , Temkin isotherm, adsorption in solution, surface excess,Gibbs adsorption equation, 2D gas law, phase rule and its applications, Electrochemical cells, half-cell reactions, Nernst equation, overvoltage, liquid junction potential, strong and weak electrolytes, Debye Huckel theory, principles underlying polymer chemistry, chain and branched polymers, determination of molecular weight (number and mass average) of polymers, introductory nanoscience, synthesis and characterization of nanomaterials.
4) **Elementary Quantum Chemistry and Chemical Bonding:** Bohr theory, quantization, uncertainty principle and wave particle duality, postulates of quantum mechanics, Schrodinger equation, Exactly solvable systems Particle in

1D, 2D and 3D box, degeneracy, quantum mechanical harmonic oscillator, Hydrogen atoms , radial function and spherical harmonics, shapes and representation of hydrogenic atomic orbitals, many electron atoms, SCF theory, Slater rules and periodicity, R-S coupling, Valence bond and Molecular orbital theory , H_2 molecule, equivalence of VBT and MOT, Homonuclear and Hetronuclear diatomic molecules, correlation diagrams, hybrid orbitals (sp, sp^2 and sp^3 hybridization), variational method, Huckel molecular orbital theory, approximations therein, mobile bond order, charge densities and free valence index , delocalization energy, aromaticity, Applications of Huckel theory.

5) **Nuclear and Radiation Chemistry**: nuclear dimensions, stability of nucleus, isotopes, isotones and isobars, nuclear forces, nuclear models(shell, liquid drop and Fermi gas models) , artificial radioactivity and nuclear reactions (spallation, fission, fusion etc.), alpha, beta and gamma decay, measurements of radiation, GM-, proportional- and scintillation- counters, isotopic dilution analysis, applications of radioisotopes, neutron activation analysis, hot atom chemistry, recoil energy, Szilard Chalmers reaction, radiation chemistry- dose and dose rate, Fricke and ceric sulfate dosimeters, biological effects of radiation, specific ionization, E_{max}, radiation absorption coefficient and interrelation therein,

   radiolysis of water

6) **Molecular Spectroscopy General principles**: FTIR, spectral line widths and spectral line intensities, selection rules in microwave and infrared spectroscopy , classification of molecules, determination of bond distances in diatomic and linear triatomic molecules, intensity profile in microwave spectra, infrared spectra, Morse potential, overtonesand combination and hot bands, polyatomic molecules, skeletal and normal vibrations, effect of isotopic substitution on microwave and infrared spectra, Classical and quantum theory of Raman effect, polarizability ellipsoid, Raman activity, Stokes and antistokes lines, vibrational Raman spectra, Combining IR and Raman data to elucidate structure/shape of molecules, effect of nuclear spin, Electronic spectra, Potential Energy curve, Born Oppenheimer Approximation, sequence and progression, Franck Condon principle, predissocation, dissociation energies from IR and electronic spectra, Fortrat parabolae, Solvent effects , bathochromic and hypsochromic shifts, oscillator strength, LASER, magnetic resonance spectroscopy, principles underlying NMR and ESRspectroscopy.

7) **Solid state Chemistry** :crystalline and amorphous solids, crystal structure types, unitcell, Miller indices, Bragg equation, Bravis lattices, defects in crystals, Frenkel and Schottky defects, Band theory of solids, molecular solids, phosphorescence and fluorescence.

8) **Symmetry and Group theory** :definition of group, multiplication tables, symmetry elements and symmetry operations, point groups, determination of point group, representations, reducible and irreducible representations, character tables, Use of character tables, SALC, Applications to chemical bonding and spectroscopy.

Inorganic Chemistry

1. **Structure and Bonding** : Atomic orbitals, electronic configuration of atoms (L-S coupling) and the periodic properties of elements, ionic radii, ionization potential, electron affinity, electronegativity, concept of hybridization. Molecular orbitals and electronic configuration of homonuclear and heteronuclear diatomic molecules. Shapes of polyatomic molecules. VSEPR theory. Symmetry elements and point groups for simple molecules. Bond lengths, bond angles, bond order and bond energies. Resonance. Types of chemical bond (weak and strong). Intermolecular forces. Types of solids, lattice energy.
2. **Acids and Bases** : Bronsted and Lewis acids and bases. pH and pKa, acid-base conceptin non-aqueous media, SHAB concept, Buffer solutions.
3. **Redox Reactions** : Oxidation numbers, Redox potentials, Electrochemical series, Redox indicators.
4. **Introductory Energetics and Dynamics of Chemical Reactions** : Law of conservation of energy. Energy and enthalpy of reactions. Entropy, free energy, relationship between free energy change and equilibrium. Rates of chemical reactions (first-and second- order reactions). Arrhenius equation and Concept of transition state. Mechanisms, including S_N1 and S_N2 reactions, electron transfer reactions, catalysis Colligative properties of solutions.
5. **Aspects of s, p, d, f Block Elements** : General characteristics of each block. Chemical principles involved in extraction and purification of common metals. Coordination chemistry, Structural aspects, isomerism, octahedral and tetrahedral crystal-field spliting of d-orbitals. CFSE, magnetism and colour of transition metal ions. Sandwich compounds metal carbonyls and metal clusters. Rare gas compounds, non- stoichiometric oxides. Radioactivity and transmutation of elements.
6. **Chemistry of Non-transition Elements** : General discussion on the properties of the non-transition elements, special features of individual elements, synthesis, properties and structure of their halides and oxides, polymorphism of carbon, phosphorus and sulphur. Synthesis, properties and structure of boranes, carboranes, borazines, silicates, carbides, silicones, phosphazenes,

sulphur, oxyacids of nitrogen, phophorus, sulphur and halogens. Interhalogens, pseudohalides and noble gas compounds.

7. **Chemistry of Transition Elements** : Coordination chemistry of transition metalions. Stability constants of complexes and their determination, stabilization of unusual oxidation states. Stereochemistry of coordination compounds. Ligand field theory, spliting of d-orbitals in low symmetry environments. Jahn-Teller effect, interpretation of electronic spectra including charge transfer spectra, spectrochemical series, nephelauxetic series. Dia-para-ferro and antiferromagentism, quenching of orbital angular moments, spin orbit coupling. Inorganic reaction mechanisms, substitution reactions, trans-effect and electron transfer reactions, photochemical reactions of chromium and ruthenium complexes. Fluxional molecules. Iso and heteropolyacids, metal clusters. Spin crossover in coordination compounds.
8. **Chemistry of Lanthanides and Acitindes** : Spectral and magnetic properties, use of lanthanide compounds as shift reagents.
9. **Organometallic Chemistry of Transition Elements** : Synthesis, structure and bonding,organometallic reagents in organic synthesis and in homogeneous catalytic reactions (hydrogenation, hydroformylationn, isomerisation and polymerisation), pi- metal complexes, activation of small molecules by coordination.
10. **Topics in Analytical Chemistry:** Adsorption, partition, exclusion, electrochromatography. Solvent extraction and ion exchange methods. Application of atomic and molecular absorption and emmision spectroscopy in quantitative analysis. Light scattering techniques including nephelometry and Raman spectroscopy. Electroanalytical techniques, voltametry, cyclic voltametry, polarography, amperometry, coulometry and conductometry. Ion-selective electrodes. Anodic stripping voltametry, TGA, DTA, DSC and on-line analysers.
11. **Bioiorganic Chemistry** : Molecular mechanism of ion transport across membranes, ionophores. Photosynthesis-PS-I, PS-II, nitrogen fixation, oxygen uptake proteins, cytochromes and ferrodoxions.

Organic Chemistry

1. IUPAC Nomenclature of Simple Organic and Inorganic Compounds.
2. **Concept of Chirality** : Recognition of symmetry elements and chiral structures, R-S nomenclature, diastereoisomerism in acyclic and cyclic-systems, E-Z isomerism. Conformational analysis of simple cyclic (chair and boat cyclohexanes) and acyclic systems, Interconverison of Fischer, Newman and Sawhorse projections.
3. **Common Organic Reactions and Mechanisms** : Reactive intermediates. Formation and stability of carbonium ions, carbenes, nitrenes, radicals and arynes. Nucleophilic, electrophilic, radical substitution, addition and elimination reactions. Familiar name reactions : Aldol, Perkin, Stobbe, Dieckmann condensations ; Hofmann, Schmidt, Lossen, Curtius, Beckmann and Fries rearrangements, Reimer-Tiemann, Reformatsky and Grignard reactions. Diels-Alder reaction, Claisen rearrangement, Friedel-Crafts reaction, Witting reaction. Routine functional group transformations and inter- convertions of simple functionalities. Hydroboration, Oppenauer oxidation, Clemmensen, Wolf-Kishner, Meerwein-Ponndorf Verley and Birch reductions.
4. Elementary principles and applications of electronic, vibrational, NMR, EPR, Mossbauerand mass spectral techniques to simple structural problems.
5. **Bioiorganic Chemistry** : Molecular mechanism of ion transport across membranes, ionophores.Photosynthesis-PS-I, PS-II, nitrogen fixation, oxygen uptake proteins, cytochromes and ferrodoxions.
6. **Aromaticity** : Huckel's rule and concept of aromaticity : annulenes and heteroannulenes,fullerenes. (C_{60})
7. **Stereochemistry and Conformational Analysis** : Newer methods of assymetric synthesis (including enzymatic and catalytic nexus), enantio-and diastereo selective synthesis. Effects of conformation on reactivity in acylic compounds and cyclohexanes.
8. **Selective Organic Name Reactions** : Favorskii reaction, Strok enamine reaction, Michael addition, Mannich reaction, Sharpless asymmetric expoxidation, ene reaction, Barton reaction, Hofmann Loffler-Freytag reaction, Shapiro reaction, Baeyer-Villiger reaction, Chichibabin reaction.
9. **Mechanisms of Organic Reactions** : Labelling and kinetic isotope effects, Hamett equation,(sigma-rho) relationship, non-classical carbonium ions, neighbouring group participation.
10. **Pericyclic Reactions** : Selection rules and stereochemistry of electrocyclic reactions, cycloaddition and sigmatrophic shifts, Sommelet-Hauser, Cope and

Claisen rearrangements.

11. **Heterocycles:** Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline,isoquinoline and indole. Skraup synthesis, Fischer indole synthesis.
12. **Reagents in Organic Synthesis** : Use of following reagents in organic synthesis and fuctinal group transformations-Complex metal hydride. Gilman's reagent, lithium, dimethylcuprate, lithim, disopropylamide (LDA) dicyclohexylcarbodimide, 1, 3-dithiane (reactivity umpolung). Trimethy, silyl iodide, tri-n-butyltin hydride, Woodward and Prevost hydroxylation, osmium tetraoxide, DDQ, selenium dioxide, phase transfer catalysts, crown ethers and Merrifield resin. Peterson's synthesis, Wilkinson' catalyst, Baker's yeast.
13. **Chemistry of Natural Products** : Familiarity with methods of structure elucidation and biosynthesis of alkaloids, terpenoids, steroids, carbohydrates and proteins, Conformations of proteins and nucleic acids.
14. **Bioorganic Chemistry** : Elementary structure and function of biopolymers such as proteins and nucleic acids, Genetic code, Mechanism of enzyme action.
15. **Photochemistry** : Principles of energy transfer, cis-trans isomerization, Paterno-Buchi reaction,Norrish Type I and II reactions, photoreduction of ketones, di-pi-methane rearrangement, photochemistry of arenes.
16. **Spectroscopy:** Combined applications of mass, UV-VIS, IR and NMR spectroscopy for structural elucidation of compounds.

Biomolecules I: Ca0bohydrates and Lipids

1. **The molecular logic of life**: The chemical unity of diverse living organisms, compositionof living matter. Macromolecules and their monomeric subunits.
2. **Properties of water**: With interactions in aqueous systems. Ionization of water, weakacid weak bases.
3. **Carbohydrates**: Classification, basic chemical structure, general reactions and properties, biological significance, Sugar derivatives, deoxy sugars, amino sugars, andsugar acids.
4. **Lipids**: Classification, structure and function of major lipid subclasses-acylglycerols, Lipoproteins, chylomicrons, LDL, HDL and VLDL, rancidity. Formation of micelles, monolayers, bilayer, liposomes.
5. **Vitamins and Co-enzymes**: Classification, watersoluble and fatsoluble vitamins. Structure, dietary requirements, deficiency conditions, coenzyme forms and theirmechanism.

Biomolecules II: Proteins

1. **Amino acids**: Classification, Properties, reactions, rare amino acids.
2. **Protein classification**: Reactions, functions, properties and Solid phase synthesis,
3. **Structural levels of protein:**
   a. Primary Structure: Peptide bond, importance of primary structure.
   b. Secondary structure: X ray diffraction, alpha-helix, β - structure, β-helix, supersecondary structure.
   c. Tertiary Structure: Forces stabilizing, unfolding/ refolding expt. Prediction of tertiaryStructure
   d. Quaternary structure – hemoglobin.
4. End group analysis, sequencing and peptide synthesis
5. Ramachandran plot.

Enzymology

1. Historical aspect: Remarkable properties, cofactors, nomenclature, classification, isoenzymes and multienzymes.
2. **Enzymes kinetics**: One-substrate reactions, effect of pH, temperature, inhibitions, two substrate reactions: theory, order analysis, pre-steady state kinetics, stopped flow technique, relaxation methods.
3. **Mechanism of enzymes action**: Theoretical background, factors leading to rate enhancement of enzyme catalyzed reactions, acid-base catalysis, proximity and orientation effects, covalent catalysis, strain or distortion and change in environment. Experimental approaches of determination of enzymes mechanism: Kinetics studies, detection of intermediates, X-ray crystallographic studies, chemical modification of amino acid side chain and affinity labeling. Examples of chymotrypsin, triose phosphate isomerases, Lysozymes and Ribonuclease.
4. **Regulation of Enzyme activity**: Control of activities of single enzyme: Inhibitor molecules, availability of substrate or cofactor and changes in covalent structure of enzymes. Zymogen activation and phosphorylation, dephosphorylation, ligand binding and induced changes, allosteric enzymes, theoretical models, Hill equation, Adair equation, M.W.C. and K.N.F. Models, usefulness of the models. Significance of allosteric and cooperative behavior in enzymes.
5. **Enzyme turnover**: Kinetics of enzyme turnover, measurement of enzyme turnover, Ks and Kd, correlation between the rates of enzyme turnover and structure and function of enzymes, mechanism of enzyme degradation, significance of enzyme turnover

Reference Books:

1. Fundamentals of Enzymology by Price and Stevens
2. Enzymology by Dixon and Webb
3. Enzymes by Palmer

Biophysical Techniques (Principle, methodology and biological applications)

1. UV and visible Spectophotometry.
2. Membrane filtration and dialysis: Nitrocellulose, fibre glass, Polycarbonate filters, dialysis and Concentration, reverse dialysis, freeze drying and lyophilization.
3. Chromatography techniques: Partition and adsorption Chromatography- paper, TLC, GLC, gel filtration, ion exchange chromatography: properties of ion exchangers, choice, HPLC, HPTLC, affinity chromatography, hydrophobic interaction chromatography, metal chelate chromatography, covalent chromatography. Special chromatographic

   techniques for nucleic acids: DNA cellulose chromatography, MAK hydroxyl-apatite chromatography, separation of DNA fragments according to their base composition.
4. Electrophoretic techniques: Types of electrophoresis: moving boundary electrophoresis and zone electrophoresis (paper, celluse-acetate electrophoresis, gel Electrophoresis (starch gel, native PAGE, disc PAGE, gradient PAGE, SDS-PAGE, agarose gel electrophoresis, Isoelectric focusing, 2D gel electrophorosis)
5. Isolation, purification and criteria of purity of proteins and enzymes & other biomolecules.

Microbiology

1. Cell structure and components, characterization and classification of microorganisms.
2. Microscopy: Theory, phase contrast microscopy, fluorescence microscopy and electron microscopy: Theory, specimen preparation, freeze etching, freeze fracture, shadow casting, electron microscopy of nucleic acids, TEM, SEM.
3. Cultivation of Bacteria, nutrition, physiology and growth of microbial cells, reproduction and growth, synchronous growth, continuous culture of microorganisms.
4. Pure cultures and their characteristics.

5. Fundamentals of control of microbial growth control by physical agents and controlbiochemical agents.
6. Production of mutants by chemical and physical agents and their characterizations.

7. Host microbe interactions, endotoxins, exotoxins, capsular material. Enzymatic andother factors, tissue affinity, resistance and immunity.

8. Viruses of bacteria, plant and animal cells: Structure, classification and life cycle,mycoplasma and viriods, diseases.
9. Nitrogen fixation: Historical background, nitrogen cycle in nature, symbiotic nitrogenfixation, nitrogenase system, nitrate reductase.

Reference Books :

1. Microbiology, M.S. Pelczar, R.D. Reid, E.C.S. Chan, Mc Graw Hill, New York (1986).
2. General Microbiology (Vth Edition), R.Y. Stanier, Prentice Hall (1986)
3. Biology of Microorganisms by Brocks
4. Introductory Microbiology, F.C. Ross, Charles Merril Publication (1983).

Cell Biology

1. Cell classification, cell variability, size, shape and complexity, function
2. Animal cell : Structure, sub cellular components: Nucleus, chromosomes, plasma membrane, endoplasmic reticulum, lysosomes, peroxisomes, Golgi apparatus, mitochondria, cytoskeleton, sub-cellular fractionation: Differential and density gradient centrifugation, specific staining of organelles and marker enzymes.
3. Cell division: mitosis, meiosis and cell cycle
4. Plant cells: Cell wall and its function, chloroplast, xylem, phloem and epidermal cells. The interaction and communication between the cells, cell-cell reorganization in plants, role of Golgi vesicles in plasma membrane, cell growth and division.
5. Fungi: Cell structure, classification and biological importance.
6. Cell-cell adhesion and the extracellular matrix, intercellular recognization, specific cell aggregation in sponges, cell junctions, extracellular matrix and role of collagen, elastinand fibronectin.

7. Germ cells and fertilization, stem cells, cell differentiation, organogenesis, functional andbiochemical maturation of tissues.

Bioenergetics and Metabolism-I

1. Introduction of metabolism and overview.
2. Bioenergetics: Basic low of thermodynamic, internal energy, enthalpy, entropy, concept of free energy, standard free energy change of a chemical reaction, redox potentials, high energy compounds, structure and significance of ATP
3. Glycolysis: Detailed study, energetics, regulation and significance.
4. Citric acid cycle: Detailed study, energetics, regulation and significance.
5. Electron transport and oxidative phosphorylation ,AIP synthase and mechanism
6. Alternate pathways of carbohydrate metabolism: Pentose phosphate pathway, glyoxalate cycle, glucuronic acid pathway, inter conversion of hexoses, Pasteur effect.
7. Polysaccharide metabolism: Biosynthesis, degradation and regulation of glycogen,metabolism starch and cellulose, inborn error of carbohydrate metabolism.
8. Gluconeogenesis
9. Lipid metabolism: Beta oxidation of even and odd number carbon atoms fatty acids, energetics and regulation. Formation of ketone bodies, other types of fatty acid oxidation.
10. Biosynthesis of lipids: Requirements of carbon dioxide and citrate for biosynthesis, fatty acid synthase complex, regulation of biosynthesis. Biosynthesis of triglycerides, cholesterol and phospholipids.

Bioenergetics and Metabolism-II

1. Oxidative degradation of amino acids: Proteolysis, transamination, oxidative deamination, acetyl CoA, alpha ketoglutarate, acetoacetyl CoA, succinate, fumarate and oxaloacetate pathway. Decarboxylation, urea cycle, ammonia excretion.
2. Biosynthesis of amino acids: Amino acid biosynthesis, precursor functions of amino acids, biosynthesis of aromatic amino acids, Histidine, one carbon atom transfer by folic acid (Biosynthesis of glycine, serine, cysteine, methionine, threonine.)
3. Inborn errors of amino acid metabolism
4. Peptides, polyamines, porphyrins, gamma glutamyl cycle, glutathione

biosynthesis,nonribosomal protein biosynthesis.

5. Purine and pyrimidine degradation.
6. Biosynthesis of purine and pyrimidine nucleotides, regulation and biosynthesis ofnucleotide coenzymes.

Biophysical Methods

1. Sedimentation: Theory, Preparatory and analytical ultracentrifuges, factors affectingsedimentation velocity, sedimentation coefficient, measurement of S, Zonal centrifugation, DNA analysis, Determination of molecular weight by sedimentation, diffusion and sedimentation equilibrium methods. Specific example of application.
2. Partial specific volume and the diffusion coefficient, Measurement of partial specificvolume and diffusion coefficients.
3. Viscosity: Theory, effect of macromolecules on the viscosity of a solution, measurement,molecular weight determination.

4. Isotope Tracer Technique: Types of radiations, measurement scintillation and gamma counters. Background noise quenching, free radicals and raidiolysis of Water and its applications. Interaction of radiation with matter, passage of neutrons through, matter, interaction of gamma rays with matter, units of measuring radiationabsorption,Radiation dosimetry.

5. Autoradiography
6. Atomic Absorption Spectroscopy
7. X-Ray diffraction studies

Biostatistics

Principles and practice of statistical methods in biological research, samples and populations, Basic statistics-average, statistics of dispersion, coefficient of variation, confidence limits, Probability distribution, normal, binomial and Poisson distribution. Mean variants, standard deviations and standard error, correlation and regression, test of statistical significance, and analysis of variance, latest software, introduction of softwares, exercise on biochemical problems.

Computers:

Theoretical background of Computer programming

Introduction to hardware and software, binary and decimal numbers, constants and variables, assignment statement, flow chart and their use, IF and GO TO statements,

Do loops. Input, output and format statements, Subroutines and function subprograms.

Introduction to programming in BASIC/Fortran/C

Membrane Biochemistry

1. Biological membrane, structure, and assembly: Constituents, asymmetry, flip flop, protein lipid interaction, factors affecting physical properties of membranes. Membrane models: biological and physical model, membrane associated diseases
2. Membrane transport: Diffusion, passive, active and facilitated, transport role of proteins in the process, exocytosis, receptor mediated endocytosis, osmoregulation and ATP-ADPexchanger.
3. Na, H dependent processes and phosphotransferase synthesis, specialized mechanism for transport of macromolecules, gap junctions, nuclear pores, toxins, control of transport processes and binding proteins.
4. Role of Na, K ATPase and passive permeability of the plasma membrane to Na, K and Cl,voltage and ligand gated ion channels.
5. Molecular mechanisms, ionophores, ion translocating antibiotics, valinomycin,gramicidin, , group translocation.

6. Drug transport: How antimicrobial agents and lipozomes reach their targets, cellular permeability, barrier to drug penetration, some examples of modes of penetration ofantimicrobial agents.
7. Assembly of virus membrane receptor

Genetics

1. Molecules of Heredity: Structure of DNA and RNA, DNA as genetic material, double helix, semi conservative mechanism of replication, nearest neighbor analysis, denaturation and renaturation, A, B, and Z forms of DNA.
2. Laws of Heredity: Genotype, Phenotype and Mendelian Laws of inheritance.
3. Basis of Biochemical genetics: Concept of gene by Benzer, One gene one cistron,complementation tests and Co-linearity.

4. Auxotroph, prototroph, conditional mutants, mutant isolation and selection.Transformation, conjugation and transduction.
5. Sex factors and Plasmids: Fertility factor, Hfr, mapping of E. coli chromosome, Cloningvectors: Plasmids, phases, cosmids. Introduction to Operon.
6. Genetic Code: Biochemical and genetic analysis of the genetic code.
7. Genetic disorders: Chromosomal origin, gene origin –mutation, human teratogenesis.
8. Specialized genetic systems of fungi: Tetrad Analysis.

Reference Books:

1. Biochemistry of antimicrobial action- 4th edition, Chapman and Hall , TJ Franklin and GAShow
2. Biochemistry-G Zubay , Addison Wesley, 1983
3. Biochemistry, L Stryer, 3rd/4th/5th ed, 1989 , Freeman and Co. NY
4. Principles of Biochemistry –Lehninger
5. Biochemistry with clinical correlation- Thomas Devlin, 2nd ed, John Wiley and sons
6. Membranes and their cellular functions- IB Filnean, R.Coleman and RH Michell, 1984,Blackwell scientific publishers, Oxford, 3rd ed.
7. Genetics – Strickberger M.W., Macmillan Pub;. Inc. (1976).
8. 36 Lectures in Biology – S.E. Luria, M.I.T. Press, Cambridge (1975).
9. The Genetics of Bacterial viruses – William Hayes, PBS Publ. (1984).
10. Molecular Biology of the Gene- Watson Benjamin / Cummings Publ. Company (1987).
11. Genetics Analysis and Principles: R.J. Brooker Addison-Wesley.

BCH 167 ANALYTICAL BIOCHEMISTRY I AND II

1. Separation of amino acid mixture by Paper chromatography
2. Estimation of amino acid by Ninhydrin method
3. Estimation of protein by Biuret method
4. Estimation of protein by Lowry et.al method.
5. Estimation of protein by Bradford method
6. Specific reactions for Carbohydrate
7. Estimation of sugar by Folin-wu method
8. Estimation of sugar by Ferricyanide method
9. Estimation of sugar by DNSA method
10. Identification of carbohydrate mixture with suitable tests.
11. Isolation of amino acid cystine from hair hydrolysate.

12. Isolation of Egg albumin and globulin.
13. Isolation of milk casein by IpH precipitation.
14. Isolation of Starch and characterization.
15. Alpha and Beta amylolysis.
16. Isolation of Cholesterol and lecithin from egg.
17. Estimation of Vitamin C from lemon fruits.
18. Isolation of Lipid and estimations.
19. Determination on alpha amino nitrogen of amino acid.
20. Estimation of inorganic phosphorus by Fiske-Subbarow method.

Biophysical Techniques

1. Concept of pH, preparation of buffer of desired pH and molarity and measurement ofpH.
2. pH metry: Acid base titration curves. Measurement of pKa of amino acids.
3. Ion exchange chromatography: Nature of ion exchanger, capacity of column, Separationof amino acids.
4. Gel filtration: Determination of void volume, Determination of partition coefficient, and Separation of two components in a sample.
5. Viscosity: Viscosity of hydrolyzed, partially hydrolyzed and unhydrolyzed starch. Determination of relative viscosity, Specific viscosity and intrinsic viscosity.
6. Electrophoresis: Separation of serum proteins by paper or agarose gel electrophoresis/Polyacrylamide Gel electrophoresis (PAGE).
7. UV and Visible Spectrophotometry: Absorption spectra, Varification of Lamberts-Beer's Law, absorption spectrum of proteins and amino acids, Absorption spectra of hemoglobin derivatives — oxyhemoglobin, carboxyhemoglobin and methemoglobin.
8. Dialysis, reverse dialysis and membrane filtration.
9. RBC membrane fragility.

Reference Books:

1. An introduction to practical Biochemistry – David T. Plummer, Tata Mc Graw HillCo. Ltd.,Bombay.
2. Introductory Practical Biochemistry (2001). Ed. S.K. Sawhney and Randhir Singh.
3. Practical Biochemistry Sadasivam and Manickam.
4. Practical Biochemistry, Principles and Techniques (1995). Ed. Keith Wilson and JohnWalker.

Computer Programming

The student is expected to write and execute at least six of the following or similar computer programs in BASIC/Fortran/C

1. Linear regression
2. Quadratic equation
3. Simulation of pH titration
4. Michaelis Menten enzyme kinetics
5. Analysis of amino acid sequences
6. Analysis of DNA sequences, Complementary sequences, repeat frequencies, etc
7. Handling of atomic co-ordinates, files and distance statistics in large molecules
8. Determination of number of covalent or weak bonds from the given atomic co-ordinate files of a protein molecule. These programs are only indicative. The instructor may choose other programs to illustrate the use of computers in chemistry.

1. DNA Replication: Enzymes involved in DNA synthesis e.g. topoisomerase, helicase, ligase and others. DNA polymerase I, II, III , origin of locus, Okazaki fragments, replication fork.Mechanism in Prokaryotes and Eukaryotes.
2. DNA Repair: DNA damages , detection and repair systems. Pyrimidine dimer formation and its repair. Defective repair system and diseases, Ames test.
3. Gene rearrangements: Recombination pathways, Holliday structures, rec A,B,C,D. SOS response, mobile genetic elements.
4. Transcription and splicing: RNA polymerases, promoters, sigma and Rho factors, initiation, elongation and termination of transcription (Prokaryotes), Inhibitors of transcription. Transcription in Eukaryotes, RNA pol I,II,III, enhancers. Post transcriptional modifications of t,r and m-RNA , 5' capping, 3' poly A tailing, RNA editing.
5. Splicing: Splicing phenomenon. Mechanism, spliceosomes, alternative splicing, self splicing, ribozyme (catalytic RNA).
6. Translation: Role of t-RNA and Ribosome in protein synthesis. Mechanism in Prokaryotes and Eukaryotes. Inhibitors of protein synthesis.
7. Protein targeting: Intracellular protein targeting. Signal hypothesis, signal sequences,
8. glycosylation, Targeting of protein to mitochondria, lysosomes, ER, plasma membrane,Peroxisomes, chloroplast, protein degradation.
9. Eukaryotic chromosome and gene expression: Chromatin structure, transcription

factors, chromatin remodeling, control of gene expression at post transcription level.

10. Molecular virology: Information of adenoviruses, retroviruses (HIV and H1N1).

Medical Biochemistry:

1. Mechanism of action at molecular level of selected antibiotics: inhibitors of cell wall, plasma membrane, nucleic acids and protein synthesis. Mechanism of action of anti metabolites, analgesics, hallucinogens, antiviral, antifungal, antiprotozoal and mechanism of resistance to antibiotics and other drugs.
2. Lysosomes and their physiological role: Structure and function of lysosomes, role in animal and plant cells. Physiological role in various types of digestive phenomenon disturbances to lysosomes, (lysosomal pathology); lysosomal storage disease.
3. Molecular basis of hemoglobinopathies: concept of hemoglobinopathies,β and α thalassemias, sickle cell anemia, pathophysiology, biochemistry, types of mutations.
4. Ischemic heart disease/CHD: myocardial infarction and coronary heart diseases (pathophysiology); laboratory findings, enzymes involved.
5. Cancer: carcinogenesis, microevolution process, molecular genetics of cancer, causative agents, role of viruses, control of cancer –basic approaches by WHO.
6. Biochemistry of diseases: Influenza: life cycle, transmission, biochemical mechanism, Malaria: epidemiology, life cycle, biochemical mechanism; Alzheimer: dementia, biochemical mechanism, formation and tangles and plaques.
7. Apoptosis: extrinsic and intrinsic mechanism, role in diseases and physiology.

Immunology:

1. Cellular basis of immunity: immunological memory, specificity, diversity, discriminationbetween self and non self, primary and secondary lymphoid organs, cell mediated andhumoral immuneresponses, T and B lymphocytes, autoimmunereactions.
2. Clonal selection theory of antibody production, monoclonal and polyclonal antibodies,catalytic antibodies (abzymes).
3. Antigen and antibody: antigen, antigenic determinant, immunopotency, structure ofantibody, constant and variable regions, Fab, F(ab2) and Fc fragments, different classes ofantibodies and their functions, fine structures of antibodies, X ray diffraction studies,isotypes, allotypes and idiotypes.
4. Multigene Organization of Ig Genes: variable gene rearrangement, generation of

antibody diversity and class switching among constant region genes.

5. Measurement of antigen- antibody interaction: immunodiffusion,immuno-electrophoresis, radioimmunoassay, immunoflorescence, ELISA, Westernblotting
6. Complement system: classical, alternate and lectin pathway pathway
7. T lymphocytes and cell mediated immunity, T cell sub populations, immune responsegenes, MHC gene complex, polymorphism, graft rejection, graft versus host response
8. Hypersensitivity and allergy, immunodeficiency diseases (AIDS)
9. Vaccines
10. Blood antigens: blood group substances and Rh factor

Neurochemistry:

1. Brain and behavior, Nerve cells and behavior
2. **Anotomical organization**: Central nervous system, spinal cord, different regions of the brain, peripheral and autonomic nervous system afferent and efferent pathways.
3. **Neurotransmitters:** Synthesis, storage**,** uptake degradation and action of neurotransmitters. Acetyl choline, GABA, Serotonin, Dopamine, Glutamate Aspartate,Nitrous Oxide etc., Neuropeptides.
4. **Receptors:** Types of receptors, properties of receptors, sensory modalities and sensorycircuits. Sensory perception, Cerebrospinal fluid, blood- brain barrier
5. **Learning and memory :** Mechanism of short term memory and long term potentiation. NMDA and AMPA glutamate receptors. Retrograde messengers in synaptic transmission. Role of CAM kinase II, Calcium, Protein kinase, CAMP, No, Calpain and other proteins in memory and learning process.
6. Circadian rhythms

Biochemistry of specialized tissues:

1. Muscle contraction and cell motility: skeletal muscle structure of muscle cell, ultra structural organization, protein components of myofibrils, molecular organization of thick and thin filaments, mechanism of muscle contraction, metabolism of muscle, cardiac muscle contraction, regulation of contraction, contractile proteins in cells other than muscle filaments, microfilaments, microtubules, cilia and flagella of eukaryoticcells, chemotaxis.
2. Nerve Conduction: Structure aned composition of nervous tissue,creation and propogation of nerve impulse , action potential,Na= and K+

channels,transmission of nerve impulse , cholinergic receptors,electroplaxes as a source of acetyl choline receptor

,acetyl choline esterase, nerve poisons.

3. Biochemistry of vision: Structure of eye,lens, and retina, perception of light ,rods and cones,rhodopsin, primary events in visual excitation, cyclic GMP,,transducin in generation of nerve impulse, colour vision.
4. Biochemistry of sense of taste and smell.
5. Biochemistry of sense of touch and hearing.

Toxicology

1. **Principles of toxicology**

   Different areas of toxicology, spectrum of toxic dose, risk and safety. Classification of toxic agents, characteristics of exposure, route and site of exposure. Duration of frequency of exposure. Spectrum of undesired effects: Allergic reactions, Idiosyncratic reactions, Immediate verses delayed toxicity, Reversible verses irreversible toxicity, Local verses systemic toxicity. Interaction of chemicals, Tolerance, Dose response. Selective toxicity.

2. **Evaluation of Toxicity**

   Descriptive Animal toxicity tests: Acute lethality, Sub acute, sub chronic and chronic toxicity testing. Teratology and reproduction, Mutagenecity.

3. **Biotransformation of toxicants**

   Phase I and II biotransformation reactions, Detoxication and toxication. Components of Cytochrome P-450 monooxygenase system, Mechanism of phase I and II reactions. Bioactvation, Toxicity of insecticides i.e.organophosphorous, carbamates and chlorinated insecticides metals, animal and plant toxins, industrial solvents and vapors.

4. Applications of toxicology: forensic, clinical and occupational health and industrialhygeine

Plant Biochemistry

1. Mineral nutrition: micro and macro elements, requirement, role, excess and deficiencydisorders.
2. Photosynthesis: chloroplasts, photosystem, mechanism CO2 fixation,C3 and C4pathways
3. Nitrogen and Sulfur metabolism: Nitrogen cycle, nitrogen fixation, assimilation of nitrate and ammonium ions, nitrogen transformation during development, assimilation of sulfate.
4. Plant hormones: types and role in plant growth and development, Auxins

gibberellins, cytokinins, ethylenes, abscisic acid, hormones in senescence and abscission.

5. Secondary metabolites: definition types, phenolics, flavanoids, lignins, terpenoids alkaloids, Gum Pectins Rubber: chemistry examples and applications
6. Biochemistry and physiology of seed germinationand dormancy, seed storage proteins.
7. Plant diseases: Pest types, symptoms, treatment, pesticides.

Physiological biochemistry

1. Liver: anatomy, physiological functions, Liver function tests, Liver disorders:- hepatitis,cirrhosis, Jaundice: etiology and symptoms
2. Kidney: anatomy, physiological functions, diseases/disorder, diagnostic tests
3. Respiration: Principles of gaseous exchange during respiration, Bohr effect, transport ofoxygen and carbon dioxide in the blood, regulation of respiration.
4. Digestion and Absorption of food: Generalized structure of digestive tract and associated digestive gland. Function of different parts- peristalsis, regulation of saliva, gastric, pancreatic, Intestinal and bile secretion (i.e. digestion), Absorption — (carbohydrate, protein, lipid, minerals and vitamin) transport and excretion ofnutrients.
5. Biochemistry of blood clotting ,clotting factors, intrinsic and extrinsic pathways, mechanism of formation of thrombin, fibrin, fibrin clot, role of vitamin K clotting process, lysis of fibrin clot. Conditions that cause excessive bleeding in humans.
6. Regulation of acid-base balance, types and functions of acid-base buffers, clinical abnormalities associated with acid-base imbalance.
7. Water and Mineral metabolism.

Endocrinology

1. General characteristics of hormones: chemistry, structure, synthesis, secretion, transport, metabolism & mechanism of action of hormones of the thyroid, hypothalamus, pituitary, pancreas, adrenals, glands, prostaglandins and gastro intestinal hormones, secondary messengers and their mode of action, calcium signaling, zinc fingers
2. Disorders related to hormones.
3. Cell membranes and intracellular receptors for hormones
4. Hormonal inter relationship
5. Biosynthesis of steroid hormones, cholera toxin, adenylate cyclase and TP, hormoneoverproduction and target cell insensitivity
6. EGF, NGF, PDGF, Enkephalin

Fermentation Technology

1. Characteristics of industrial microorganisms
2. Strain improvement, use of auxotrophic mutants
3. Methods and parameters of cultivation of microorganisms , media for industrial fermentation
4. Fermenters, design of fermenters, fermentation process, and maintenance of asepticconditions, aeration and agitation.
5. Downstream processing, recovery and purification of fermentation products, effluenttreatment
6. Applications of fermentation technology
7. Manufacturing by fermentative process: beer, Citric acid, Glutamic acid, lipase, Penicillin,L-asparginase

Tissue culture

Plant tissue culture

1. Media requirements: Sterilization and role of growth regulators, Requirements of aplanttissue culture laboratory,
2. PTC Techniques: Callus and cell suspension culture,Micropropogation, Conditioning of tissue culture plants (weaning and hardening),Somatic cell hybridization, Haploid (anther) culture, Embryo culture, Protoplast fusion, Somatic embryogenesis,Somaclonalvariations, Cybrids and Allopheny, Agrobacteriummediatedhairy root culture
3. Active principles in medicinal plants and phytochemistry of the metabolites ofmedicinalimportance.

Animal tissue culture

1. Media requirements: preparation of medium and sterilization techniques, Advantagesand disadvantages of natural and synthetic media
2. Cell culture methods: Hanging drop,suspension and monolayer culture, Behaviour and characteristics of cells in culture, Primaryand established cell lines, characteristics of transformed cells, Methods of cell preservation.
3. ATC techniques: Primary cultures and secondary cultures, cloning, heterocaryons, variant cells, contact inhibitions, Organ culture and cell and tissue banking

Genetic Engineering Section I:

1. Genetic engineering concepts: early development in genetics, concept of gene

cloning and its importance.

2. Manipulation of DNA: Enzymes in genetic engineering, Restriction endonucleases, restriction map, Ligase, polymerase modifying enzymes, ligation; putting sticky ends to blunt ended molecules.
3. Cloning vectors: Vectors for E Coli: Plasmids, M 13 bacteriophage vectors, λ bacteriophage, Cosmid. Eukaryotic cloning vectors: Cloning vectors for yeast, other fungi, YAC, cloning vectors for higher plants, Ti plasmid, Ri plasmid, plant viruses for cloning, cloning vectors for insects, viruses as cloning vectors for mammals.
4. Introduction of DNA in living cells: Transformation, identification of recombinants, introduction of phage DNA into bacterial cells (transfection), identification of recombinant phage.
5. Selection of recombinant DNA clones: construction of genomic and c DNA library, colonyand plaque hybridization probing, Southern blotting,
6. Sequencing genes and genomes: chain termination using ddNTPs, pyrosequencing, shotgun and clone contig approaches, chromosome walking, and genetic maps.
7. Characterization of recombinant gene: studying RNA transcript of a gene S1 nuclease mapping, studying regulation of gene expression, foot printing using DNase 1, reportergenes.

Section II:

1. Polymerase chain reaction: concept, types, methods and applications.
2. Expression of foreign gene: gene expression in E coli, production of recombinant proteins in Eukaryotes, fungi, yeast, mammalian and insect cells systems.
3. Genetic engineering of plants: Gene transfer methods, vectors; Transgenic plants: Pest resistant, herbicide resistant, antisense RNA and other applications.
4. Transgenic animals: Gene transfer strategies, production of recombinant proteins andother applications.
5. Recombinant DNA technology applications in medicine and industry: Recombinant hormones, recombinant vaccines. Human proteins (antibodies, clotting factors, antibodyengineering) RFLP and application in forensic science.
6. Protein Engineering: In vitro mutagenesis, Oligonucleotide directed, PCR based,applications of protein engineering
7. Study of genomes: genome annotations, study of transcriptome, proteome.

8. RNA interference and its applications

BCH: 473 DEVELOPMENTAL BIOLOGY AND MOLECULAR EVOLUTION

1. Theories of Evolution.-the time scale and some evolutionary principles. Chemicalevolution and origin of life. Prototypes of metabolic pathways.
2. Genesis of oxygen generating photosynthesis and aerobic respiration. Methanogens-evolution of prokaryotes
3. Evolution of protists
4. Origin of eukaryotes
5. Theories regarding origin of mitochondria and chloroplast, the five kingdom classification of living organisms, outline of eukaryote evolution- evolution of primates.
6. Construction of phylogenetic trees- molecular data set based on sequences
7. Evolution of proteins and nucleic acid – elastic analysis.
8. Evolution of introns
9. Evolutionary view of exon domain relationships
10. Developmental Biology—Cell differentiation, hierarchy of genes, measurement of time during development, nature of differentiation, DNA rearrangements& amplification, genetic control of morphogenesis, plant molecular genetics.

Clinical Nutrition:

1. Diet and nutrition in India: Assessment of nutritional status
2. Factors affecting digestion and absorption of food
3. Effects of irradiation, cooking, refining, sprouting and fermentation on nutritional qualityof food
4. Food toxins, adverse effects of alcohol, tobacco, tea
5. Interrelationship between dietary lipids and cholesterol metabolism
6. Malnutrition and infection
7. Malnutrition and mental development
8. Infant and geriatric nutrition
9. Nutritional basis of behavior, neutral tranquilizers
10. Amino acid therapy
11. Acidic and alkaline foods
12. Dietary fiber- chemical composition and importance
13. Physiological effects and metabolic adaptation during exercise
14. Nutritional management of inborn errors of metabolism

Food Technology:

1. Foods of animal and plant origin
2. Monitoring food quality
3. Primary feedstock
4. Proteins from unconventional sources- OCP, SCP etc
5. Starch production, manufacture of natural and synthetic sweeteners and syrups
6. Enzymes in food analysis, toxins, alcohol, amino acids, glucose
7. Enzymes in food processing, meat tenderization and fruit juice technology
8. Biochemistry of food spoilage, principles of food preservations
9. Food additives, starches, sugars, syrups and sweeteners, flavoring agents, colors
10. Genetically modified foods