

**Admission test for PhD Program  
in Biochemical Engineering and Biotechnology at IIT Delhi**

(May 2018)

**Admission Test Pattern**

- 1) The Entrance test shall be based on a single question paper of one-hour duration and will contain only multiple-choice questions.
  - 2) Evaluation will have negative marking: + 2 marks for correct answer and -1 marks for incorrect answer.
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**Syllabus of Admission Test Paper**

BIOCHEMISTRY

Ionization of weak acids and bases, and buffers

Carbohydrates: structure and function (monosaccharides, disaccharides and common polysaccharides – starch and cellulose).

Proteins – primary, secondary, tertiary & quaternary structures

Enzyme: chemical and functional nature of enzymes, Enzyme kinetics

Lipids: membrane and storage lipids

Structure and function of nucleotides, DNA and RNA

Basic metabolic pathways (Glycolysis, TCA cycle, Glyoxalate cycle, Pentose Phosphate pathway).

Biological membrane: structure and function

Membrane transport: Structure and function of biological membranes; transport of nutrients.

Mechanism of enzyme action

Enzyme engineering strategies

Enzyme reaction in non conventional medium

MOLECULAR BIOLOGY

Prokaryotic and eukaryotic genome organization

Basic mechanisms involved in replication, transcription and translation

Mutations: Types of mutations, Isolation of mutants

Regulation of replication, transcription and translation

Gene regulation in prokaryotes: *lac*, *ara* and *trp* operons

Recombination and repair, mutation, inversion, transposition

Enzymes used in molecular cloning and their applications

DNA sequencing: chemical and enzymatic methods

Vectors: types and characteristic features

Directed evolution

## CELL BIOLOGY

Cell signaling  
Cell cycle and regulation  
Cell-cell interactions  
Cytoskeletal  
Intracellular compartments and protein sorting

## MICROBIOLOGY

Structure and function of prokaryotic and eukaryotic cell  
Characteristic features of eubacteria, archaea, molds and yeasts.  
Energy transduction (fermentation, aerobic respiration and anaerobic respiration).  
Nutrition of microorganisms – C, N and S compounds, growth factors.  
Microbial Growth – Measurement techniques; growth kinetics  
Control of microorganisms by Physical and Chemical means  
Genetic recombination; basic features of transformation, transduction and conjugation.  
Bacteriophages  
Pathogenicity of microorganisms  
Antimicrobial chemotherapy

## BIOCHEMICAL ENGINEERING

Stoichiometry and energetics of cell growth and product formation: Elemental material balance.  
Monod growth kinetics; growth cycle phases for batch cultivation; Leudeking and Piret model for product formation kinetics. Concept of maintenance energy.  
Deindoerfer's classification of fermentations .  
Thermal death kinetics of cells and spores.  
Media sterilization: Concept of degree of sterility and decimal reduction time. Batch sterilization and Continuous sterilization.  
Air sterilization.  
Oxygen transfer in fermentations: dynamic gassing-out method for  $k_{La}$  determination.  
Kinetics of enzyme catalyzed reactions: Michaelis-Menten equation; Lineweaver-Burk plots; Eadie-Hofstee plots; substrate inhibition kinetics; competitive, non-competitive and uncompetitive inhibition; effect of pH and temperature.  
Bioreactors: Batch, fed-batch and continuous (CSTR and PFR) reactors; conditions for "wash-out" and maximum cell production in chemostat cultures. Analysis of rate data for batch/continuous flow reactors and development of rate equation; Introduction to the concept of yield and selectivity for multiple reactions;  
Principles of recovery operations: filtrations, centrifugation, solvent extraction, precipitation, adsorption; chromatography, electrophoresis, membrane separations.

Chemical Reaction Engineering -Concepts of rate equations, stoichiometry and rate laws, Unsteady state reactor design, ideal and non-ideal reactors, CSTR and PFR and their use for kinetic interpretation and design, Evaluation of performance properties of the reactors.

Process Systems Analysis and Control- Dynamic behaviour of first order and second order systems, response of first order systems, block diagrams and transfer functions, P, PI, PID controllers, feedback control, feedforward control, cascade control.

Fluid Mechanics- Properties and classification of fluids, normal forces and shear stresses on fluids, pressure-depth relation for fluids, forces on submerged bodies, rigid body motion, pressure and velocity measurement, kinematics of flow, mass, energy and momentum balances (macroscopic).

Mass and Heat Transfer- Diffusion in gases, liquids, and solids. Theories of mass transfer. Different modes of heat transfer, Steady and unsteady heat conduction in solids, Heat exchange equipment, Individual and overall mass and heat transfer coefficients. Simultaneous heat and mass transfer. Mass, heat, and momentum transfer analogies. Dimensionless numbers and their significance.

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Suggested Reading:

- a) Molecular Biology of the Cell, 4<sup>th</sup> Edition, by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, New York: Garland Science; 2002.
  - b) Biochemistry, 5<sup>th</sup> Ed. by J.M. Berg, J.L. Tymoczko and L. Stryer, W.H. Freeman and Company, 2002
  - c) Lehninger Principles of Biochemistry, 5<sup>th</sup> Edition, by David L. Nelson, Michael M. Cox, W. H. Freeman 2008
  - d) Microbiology, 7<sup>th</sup> Ed., by L.M. Prescott, J.P. Harley and D.A. Klein, McGraw-Hill, 2008.
  - e) Lewin's Gene X, by J. E. Krebs, E. S. Goldstein, S. T. Kilpatrick, Jones and Bartlett Learning, 2011.
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- a) "Biochemical Engineering Fundamentals" (second edition), J.E. Bailey and D.F. Ollis, McGraw Hill Book Co, 1986.
  - b) "Bioprocess Engineering: Basic Concepts", M.L. Schuler and F. Kargi, Prentice Hall, 1992
  - c) Bioprocess Engineering Principles, Pauline Doran, Academic Press, 2013
  - d) "Bioseparations – Downstream Processing for Biotechnology" Belter, P.A., Cussler, E.L., and Hu W.S., John Wiley and Sons, New York.
  - e) Chemical Reaction Engineering, (3rd edition), Octave Levenspiel, Wiley, 1998
  - f) Unit Operations of Chemical Engineering (7th edition), Warren McCabe, Julian Smith, Peter Harriott, McGraw Hill Book Co, 2005.
  - g) Mass-Transfer Operations, (3rd edition), R. E. Treybal, McGraw Hill Book Co, 1988.
  - h) Process Heat Transfer, Donald Q. Kern, Tata McGraw Hill Book Co, 2008.
  - i) Process Systems Analysis and Control (3<sup>rd</sup> Edition), Donald R. Coughanowr, Steven E. LeBlanc, McGraw Hill Book Co, 2009.
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