

## Himachal Pradesh Public Service Commission

No. 3-53/2023-PSC (R-I)

Dated 22-04-2025

Syllabus for the descriptive Subject Aptitude Test (SAT) for the recruitment to post of Assistant Professor (Biochemistry), Class-I (on regular basis) in the Department of Medical Education & Research, H.P. The SAT shall be of 03 hours duration having 120 Marks. The SAT paper shall have two parts i.e. Part-I and Part-II and cover the following topics of M.D. (Bio-Chemistry)/ MBBS with M.Sc (Medical Bio-Chemistry)/ M.Sc (Medical Bio-Chemistry) with Ph.D (Medical Bio-Chemistry)/ M.Sc (Medical Bio-Chemistry) with D.Sc. (Medical Bio-Chemistry) level.

### PART-I (60 Marks)

#### 1. Biomolecules, Cell biology, Biochemical Techniques, Biostatistics and Research Methodology, Basics of Medical Education and Assessment of Biochemistry:-

##### i. Biomolecules:

- Properties of water,
- Concept of an acid, a base, pH, pK, buffer and buffering capacity.
- Classification, structure and functions of amino acids and peptides.
- Structural organization of proteins and relationship with their functions
  - primary, secondary, tertiary and quaternary structure of proteins,
  - protein folding and denaturation,
- Structure-function relationship of proteins
  - Structure and functions of hemoglobin and myoglobin,
  - Structure and function of collagen,
  - Structure and function of immunoglobulins
- Classification, functions, properties and reactions of carbohydrates,
- Classification, properties and importance of lipids
  - Fatty acids - nomenclature, classification, properties, reactions,
  - Mono, di- and triacylglycerols,
  - Trans fats,
  - Cholesterol - structure, properties and functions,
  - Phospholipids - definition, types, properties, s and importance,
  - Glycolipids - definition, types, functions, examples,
  - Lipoproteins - definition, structure, types, functions, role of apoproteins, importance in health and disease,
  - Biological membranes - structure, function, properties and importance,
  - Micelles and liposomes.
- Nucleotides and nucleic acids
  - purine and pyrimidine bases in DNA and RNA,
  - nucleosides and nucleotides,
  - physiologically important nucleotides,

- synthetic analogues of purine/pyrimidine bases and nucleosides used as therapeutic agents (anti-cancer drugs, anti-viral drugs),
- Watson and Crick model of DNA structure,
- Structure and functions of different types of RNA.

**ii. *Cell biology***

- Structure of the cell and different subcellular organelles,
- Structure and functions of cell membrane, solute transport across biological membranes,
- Intracellular traffic and sorting of proteins,
- Intracellular signaling pathways, membrane receptors and second messengers  
Extracellular matrix: composition, importance and biomedical importance, cellular adhesion molecules and intercellular communication,
- Cytoskeleton, muscle contraction and cell motility,
- Cell cycle, mitosis, meiosis and mechanisms of cell death,
- Red and white blood cells.

**iii. *Analytical techniques in biochemistry***

- Spectrophotometry (UV and visible spectrophotometry),
- atomic absorption spectrophotometry,
- Flame photometry,
- Fluorometry,
- Turbidimetry and nephelometry,
- Gravimetry,
- Electrochemistry (pH electrodes, ion-selective electrodes, gas-sensing electrodes),
- Chemiluminescence,
- Water testing,
- Electrophoresis (principle, types, applications; isoelectric focusing capillary electrophoresis; 2-D electrophoresis),
- Chromatography (principle, types [including high performance liquid chromatography and gas chromatography]),
- Techniques in molecular biology: Blotting techniques, polymerase chain reaction (PCR), DNA and protein sequencing, microarrays and DNA chip technology, cloning techniques, genomics, proteomics and metabolomics.

**iv. *Nanotechnology and microfabrication.***

**v. *Techniques to study in vivo metabolism - NMR, SPECT, PET scans, etc.***

**vi. *Radioisotope-based techniques and its applications.***

**vii. *Biostatistics and research methodology***

- Basic concepts of biostatistics as applied to health science,
- Statistical tests: t-test, analysis of variance, chi-square test, non-parametric tests, correlation and regression,

- Statistical methods of validation of diagnostic tests,
- Basics of epidemiological study designs and sampling methodologies,
- Meta-analysis and systematic reviews.

viii. ***Basics of medical education in teaching and assessment of biochemistry***

- Principles of adult learning, taxonomy of learning, educational objectives, principles of assessment and question paper setting, methods of assessing knowledge, appropriate use of media, microteaching, small group teaching,
- Environmental Biochemistry,
- Health and pollution.

2. **Enzymes, Bioenergetics, Biological Oxidation, Intermediary Metabolism and Regulation, Inborn errors of Metabolism and Nutrition:-**

i. ***Enzymes:***

- Properties, classification, mechanism of action, coenzymes and cofactors, kinetics of enzyme activity, regulation of enzyme activity, isoenzymes, diagnostic and therapeutic enzymes, principles of assays of enzymes, enzymes as therapeutic targets of drugs.

ii. ***Biological oxidation***

- Basic concepts of thermodynamics and its laws, as applied to living systems,
- Exergonic and endergonic reactions and coupled reactions, redox potential
- High energy compounds
- Classification and role of oxidoreductases
- Cytochromes; cytochrome P450 system.

iii. ***Respiratory chain and oxidative phosphorylation***

- Components, complexes and functioning of the respiratory chain,
- Process of oxidative phosphorylation,
- Mechanisms of ATP synthesis and regulation,
- Mitochondrial transport systems and shuttles,
- Inhibitors, uncouplers and ionophores,
- OXPHOS diseases.

iv. ***Overview of metabolism and intermediary metabolism***

- ***Metabolism of carbohydrates***
  - Digestion and absorption,
  - Glycolysis and TCA cycle, including regulation,
  - Glycogen metabolism and its regulation,
  - Cori cycle, gluconeogenesis and control of blood glucose,
  - Metabolism of fructose and Galactose,
  - Pentose phosphate and uronic acid pathways and their significance,
  - Polyol pathway,
  - Regulation of blood glucose levels,

- Diabetes mellitus (including gestational diabetes mellitus) – classification, pathogenesis, metabolic abnormalities, diagnostic criteria, principles of treatment, pathogenesis of complications, laboratory tests,
- Metabolism of ethanol.
- ***Metabolism of lipids***
  - Digestion and absorption, including role of bile salts,
  - Biosynthesis and oxidation of fatty acids,
  - Ketone bodies – formation, utilisation and regulation,
  - Metabolism of unsaturated fatty acids and eicosanoids,
  - Metabolism of triacylglycerol; storage and mobilisation of fats,
  - Metabolism of cholesterol,
  - Metabolism of lipoproteins,
  - Metabolism in adipose tissue,
  - Role of liver in lipid metabolism,
  - Role of lipids in atherogenesis,
  - Metabolism of phospholipids and associated disorders.
- ***Metabolism of amino acids and proteins***
  - Digestion and absorption,
  - Pathways of amino acid degradation - transamination, oxidative Deamination,
  - Transport and metabolism of ammonia
  - Metabolism of individual amino acids,
  - Plasma proteins.
- ***Metabolism of nucleotides***
  - De novo synthesis of purine nucleotides,
  - Salvage pathway for purines,
  - Degradation of purines,
  - De novo synthesis of pyrimidine nucleotides,
  - Degradation of pyrimidines,
  - Synthetic analogues of purine/pyrimidine bases and nucleosides used as therapeutic agents.
- ***Metabolism of haem***
  - Biosynthesis of heme and associated disorders,
  - Degradation of heme and associated disorders.
- ***Metabolism in individual tissues and in the fed and fasting states***
  - Liver, adipose tissue, brain, RBCs.
- ***Nutrition***
  - Principal food components,
  - General nutritional requirements,
  - Energy requirements,
  - Biological value of proteins,
  - Thermogenic effect of food,
  - Balanced diet, diet formulations in health and disease, mixed diet,

- Nutritional supplements,
- Food toxins and additives,
- Parenteral nutrition,
- Disorders of nutrition, obesity, protein and protein energy malnutrition, dietary fibers, under-nutrition, laboratory diagnosis of nutritional disorders,
- National Nutrition Programme.
- ***Vitamins***
  - Classification, biochemical role, sources, RDA and deficiency state of each vitamin (including diagnostic tests for deficiency and treatment).
- ***Minerals***
  - Classification, biochemical role, sources, requirement and deficiency state of each mineral (including diagnostic tests for deficiency and treatment).
- ***Metabolism of xenobiotics.***
- ***Free radicals and anti-oxidant defence systems in the body and associations with disease processes.***

### **PAPER-II (60 Marks)**

#### **1. Molecular Biology, Molecular and Genetic Aspects of Cancer, Immunology and Effects of Environmental Pollutants on the body:-**

- i. ***Structure and organization of chromosomes and chromatin re-modelling***
  - ***DNA replication***
    - DNA replication in prokaryotes and eukaryotes (including important differences between the two),
    - Roles of DNA polymerase, helicase, primase, topoisomerase and DNA ligase,
    - Replication fork,
    - Okazaki fragments and its importance in replication,
    - Overview of role of major DNA repair mechanisms – mismatch repair, base excision repair, nucleotide excision repair and double strand break repair,
    - Diseases associated with abnormalities of DNA repair systems,
    - DNA recombination.
  - ***Transcription***
    - Structure of a gene - exons and introns, promoter, enhancers/repressors and response elements,
    - Process of transcription in prokaryotes and eukaryotes – initiation, elongation and termination (including important differences),
    - Post-transcriptional processing – capping, tailing and splicing.
  - ***Genetic code and mutations***
    - Characteristics of the genetic code,
    - Molecular basis of degeneracy of the genetic code (Wobble hypothesis),
    - Mutagens- examples of physical, chemical and biological mutagens,

- Types of mutations – point mutations and chromosomal mutations,
- Relationship of mutations with specific diseases.

- ***Translation***

- Basic structure of prokaryotic and eukaryotic ribosomes,
- Structure of tRNA (diagram of clover leaf model of tRNA structure) and its function in protein synthesis,
- Function of aminoacyl tRNA synthase,
- Process of protein synthesis (translation) – initiation, elongation and termination (including important differences between prokaryotic and eukaryotic translation),
- Inhibition of prokaryotic translation by antibiotics,
- Post-translational modifications

- ***Regulation of gene expression in prokaryotes and eukaryotes***

- The operon concept in prokaryotes,
- Role of general and gene specific transcription factors,
- Small interference RNA (siRNA) and micro RNA (miRNA),
- Other modes of regulation of gene expression: alternative splicing, alternative promoter usage, DNA methylation, Histone acetylation / deacetylation, RNA editing, alterations of RNA stability.

- ***Recombinant DNA technology and its applications in modern medicine***

- Concepts of recombinant DNA, genetic engineering, biotechnology and cloning,
- Restriction endonucleases,
- Vectors for cloning – plasmids and phages,
- Genomic and cDNA libraries,
- Applications of recombinant DNA technology in medicine,
- Gene therapy,
- Diagnosis of genetic diseases and genetic counselling,
- DNA fingerprinting,
- DNA sequencing,
- Microarrayz,
- Fluorescent in situ hybridization (FISH),
- DNA vaccines,
- Transgenic animals,
- Application of molecular techniques in forensic investigation and medicolegal cases.

**ii. *Overview of Human Genome Project.***

**iii. *Basics of bioinformatics.***

**iv. *Principles of human genetics.***

- Alleles, genotypes and phenotypes,
- Patterns of inheritance: monogenic and polygenic inheritance,
- Population genetics,

- Genetic factors in causation of diseases,
- Types of genetic diseases: Chromosomal, monogenic and polygenic disorders, mitochondrial disorders, nucleotide repeat expansion disorders, imprinting disorders,
- Screening for genetic diseases and prenatal testing,
- Ethical and legal issues related to medical genetics.

**v. *Stem cells in clinical medicine***

- Basic concepts regarding stem cells,
- Types of stem cells: embryonic and induced pluripotent stem cells (iPSC),
- Potential applications in the clinical medicine,
- Ethical and legal issues related to use of stem cells in medicine.

**vi. *Cancer***

- Carcinogens: physical, chemical and biological,
- Clonal origin of cancers,
- Genetic basis of carcinogenesis,
- Role of oncogenes and tumour suppressor genes,
- Familial cancer syndromes,
- Cancer stem cells,
- Epigenetic regulation in cancer,
- Gene expression profiling in cancer,
- Cancer cell biology: cell cycle abnormalities, telomerase activity, proliferative capacity and decreased apoptosis,
- Metastasis,
- Tumor markers,
- Biochemical basis of cancer chemotherapy and drug resistance,
- New methods of anti-cancer therapy: targeted cancer therapy, cancer immunotherapy.

**vii. *Immunology***

- Innate and acquired immunity,
- Humoral and cell-mediated immunity,
- Cells and organs of the immune system - T and B cells, macrophages, dendritic cells, NK cells, granulocytes,
- Antigens, epitopes and haptens,
- Immunoglobulin classes, isotypes, allotypes, idiotypes, monoclonal antibodies, organization and expression of immunoglobulin genes, immunoglobulin gene rearrangement, class switching,
- Antigen-antibody interaction - immunochemical techniques,
- Major histocompatibility complex, antigen processing and presentation,
- T cell and B cell receptor, toll like receptors,
- T cell maturation/activation/differentiation,
- B cell generation/activation/differentiation,
- Cytokines,

- Complement system, cell,
- Immune response to infections,
- Hypersensitivity reactions,
- Vaccines,
- Immuno-deficiency syndromes,
- Autoimmunity,
- Transplantation immunology,
- Cancer and immune system,
- Immunodiagnosics,
- Immunotherapy.

## **2. Clinical Biochemistry and Molecular Diagnosis related to different Body Systems/Organs, Endocrinology and Recent Advances in Biochemistry:-**

### ***i. Basic principles and practice of clinical biochemistry***

- Units of measure, reagents, clinical laboratory supplies, basic separation techniques, laboratory calculations, specimen collection and processing, safety in the laboratory, clinical utility of laboratory tests (including sensitivity, specificity, ROC curves, etc), analysis in the laboratory, selection and evaluation of methods (including statistical techniques), evidence based laboratory medicine, establishment and use of reference values, pre-analytical variables and biological variations, quality management, clinical laboratory informatics.

### ***ii. Analytical techniques and instrumentation***

- Principles of basic techniques used in a clinical biochemistry laboratory (spectrophotometry, electrochemistry, electrophoresis, osmometry, chromatography, mass spectrometry, immunochemical techniques, molecular techniques, automation, point of care testing.

### ***iii. Clinical correlates and analytical procedures***

- Amino acids, peptides and proteins; non-protein nitrogenous compounds
- enzymes
- carbohydrates
- lipids, lipoproteins and apolipoproteins and other cardiovascular risk factors
- electrolytes
- blood gases and pH
- hormones and associated disorders
- catecholamines and serotonin
- vitamins; trace and toxic elements
- hemoglobin, and bilirubin
- porphyrins and associated disorders
- bone and mineral metabolism
- tumour markers

- assessment of organ functions (hypothalamus and pituitary, adrenal glands, gonads, thyroid, parathyroid, liver, kidney, heart, stomach, pancreas, intestine, etc) and associated disorders
- pregnancy and maternal and fetal health
- reproduction related disorders – infertility
- newborn screening
- inborn errors of metabolism
- hemostasis
- therapeutic drug monitoring
- clinical toxicology
- molecular diagnostics
- body fluid analyses.

**iv. *Regulation of fluid and electrolyte balance and associated disorders***

**v. *Regulation of acid-base balance and associated disorders***

**vi. *Biochemistry of the endocrine system***

- Classification and general mechanism of action of hormones
- Biosynthesis, secretion, regulation, transport and mode of action of hypothalamic peptides, adenohipophyseal and neurohipophyseal hormones, thyroid and parathyroid hormones, calcitonin, pancreatic hormones, adrenocortical and medullary hormones, gonadal hormones, gastrointestinal hormones, opioid peptides, parahormones.
- Biochemistry of conception, reproduction and contraception
- Endocrine interrelationship and their involvement in metabolic regulation
- Neuro-modulators and their mechanism of action and physiological significance
- Biochemical aspects of diagnosis and treatment of endocrinal disorders

**vii. *Hematopoietic disorders***

- Iron deficiency and other hypoproliferative anaemias - iron metabolism, laboratory tests of iron status, iron therapy
- Anaemia of chronic disease, anaemia of renal disease
- Hemoglobinopathies - sickle cell anaemia, methaemoglobinemias, thalassemia syndromes, Megaloblastic anaemia
- RBC membrane and metabolism
- Hemolytic anaemia - inherited defects in RBC membrane and enzymes (G6PD deficiency), immunologic causes of hemolysis
- ABO blood group system - biochemical basis, transfusion biology.
- Plasma cell disorders - multiple myeloma.

**viii. *Hemostasis and thrombosis***

- Biochemical mechanisms, related laboratory tests, antiplatelet/anticoagulant/fibrinolytic therapy.

**ix. *Cardiovascular system***

- Atherosclerosis - pathogenesis, risk factors, prevention and treatment
- Cardiac failure, acute coronary syndrome, cardiac biomarkers.

**x. *Respiratory system***

- Gaseous exchange in lungs - physiological features and disturbances, arterial blood gases
- Pathogenesis of cystic emphysema, alpha-1 anti-trypsin deficiency.

**xi. *Kidney***

- Kidney function tests; pathophysiology, biochemistry, laboratory findings and management in acute kidney injury and chronic kidney disease; estimation of GFR; glomerular diseases -pathogenesis and mechanisms of glomerular injury, nephrotic syndrome, diabetic nephropathy; tubular disorders - renal tubular acidosis, proteinuria, nephrolithiasis, kidney transplant; biochemical aspects of renal stones.

**xii. *Gastrointestinal system***

- Gastric physiology
- Pathophysiology of peptic ulcer disease, including role of *H. pylori*; gastric function tests; Zollinger-Ellison syndrome
- Digestion and absorption of nutrients; evaluation of malabsorption (steatorrhea, lactose intolerance)
- Celiac disease
- Inflammatory bowel disease
- Protein losing enteropathy
- Regulatory peptides in the gut
- Neuroendocrine tumours.

**xiii. *Liver***

- Liver function tests
- Hyperbilirubinemias
- Viral hepatitis
- Serologic/virologic markers
- Alcoholic liver disease, fatty liver, chronic liver disease, cirrhosis and its complications
- Pathogenesis of ascites
- Hepatic encephalopathy
- Metabolic diseases affecting liver
- Reye's syndrome
- Diseases of gall bladder/bile ducts - pathogenesis of gallstones
- Pancreas - acute and chronic pancreatitis, cystic fibrosis, pancreatic function tests.

**xiv. *Bone and mineral metabolism***

- Bone structure and metabolism; metabolism of calcium, phosphate and magnesium; regulation and abnormalities of bone metabolism; vitamin D; parathyroid hormone; calcitonin; parathyroid hormone-related (PTHrP); osteoporosis – pathophysiology; markers of bone turnover.

**xv. *Nervous system***

- Neurotransmitters and their receptors
- Ion channels and channelopathies
- Neurotrophic factors
- Protein aggregation and neurodegeneration
- Alzheimer's disease, Parkinson's disease, Huntington's disease, multiple sclerosis
- Prions and prion diseases
- Guillain-Barre syndrome – immunopathogenesis
- Myasthenia gravis – pathophysiology
- Hereditary myopathies - Duchenne muscular dystrophy
- Inherited disorders of muscle energy metabolism
- Mitochondrial myopathies
- Pathophysiology of psychiatric disorders such as anxiety, depression and schizophrenia.