

# **TOPICS FOR THE ENTRANCE EXAMINATION AND RECOMMENDED LITERATURE**

## **BIOLOGY**

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### **Topic 01: Cell: Structure**

Chemical constitution of a cell, importance of chemical compounds in cells.

Structure and function of biopolymers: nucleic acids, proteins, polysaccharides.

Phospholipids.

Hierarchy of organisms according to their complexity (viruses, prokaryotes, eukaryotes).

Viruses as non-cellular organisms. Virus structure.

Structure of prokaryotic cell. Structure of eukaryotic cell. Structure and number of chromosomes.

### **Topic 02: Cell: Function**

Cell metabolism. Enzymes, enzymatic catalysis, regulation of enzymatic reactions. Membrane transport: diffusion, endocytosis, exocytosis, osmotic processes, etc. Heterotrophy, autotrophy, mixotrophy. Photosynthesis. Anaerobic glycolysis, oxidative phosphorylation, ATP metabolism.

Synthesis of nucleic acids, synthesis of polysaccharides. Course and regulation of proteosynthesis in prokaryotes and eukaryotes.

Cell cycle. Cell division. Mitosis and meiosis. Regulation of cell cycle.

### **Topic 03: Genetics**

Basic genetic terms. Genes.

Molecular basis of heredity. Nucleic acids, genetic information and genetic code. Gene expression.

Mendelian genetics. Mendel's laws. X-linked inheritance in human.

Cell and heredity. Gene arrangement in chromosomes. Genetics of a prokaryotic cell – prokaryotic chromosome, plasmids. Genetics of a eukaryotic cell – nuclear genome, karyotype. Chromosomes – diploid and haploid number, segregation and combination, sex determination. Extranuclear DNA molecules.

Genetic variability.

Mutations. Classification of mutations. Mutagenic factors in the environment, importance of mutations. Human aneuploidies.

Heredity of a multicellular organism. Sexual and asexual reproduction. Genetic crossing.

Heredity of quantitative traits. Inherited and non-inherited variability, heritability.

Inheritance of human blood group system.

Population genetics. Hardy-Weinberg equilibrium. Genetic structure of a population.

Importance of genetics. Breeding of microorganisms, plants and animals. Medical importance and ethical aspects of genetics. Social perspectives of genetics.

#### **Topic 04: Genetics – examples**

Examples on Mendelian inheritance in human. Examples on blood groups. Calculations using Hardy-Weinberg law: allele frequencies and genotype frequencies.

#### **Topic 05: Genetic manipulations (engineering)**

Genetic manipulation in medicine. Basic methods of gene engineering. DNA cloning. Genetically modified organisms. Animal cloning. Gene therapy.

### **Human body: Structure and function**

#### **Topic 06: Locomotion system in humans**

Locomotor system.

Skeleton of the human body. Structure and function of bones. Axial skeleton. Appendicular skeleton.

Structure and function of skeletal muscles. Smooth muscles. Connective tissue.

#### **Topic 07: Circulatory system, body fluids, blood**

Body fluids. Blood. Blood cells. Haemostasis. Blood groups. Blood transfusion.

Circulatory system. Function of heart. Cardiac muscle. Cardiac cycle. Blood pressure, pulse, capillaries, tissue fluid, blood circulation, vascular diseases, regulation of blood circulation.

Lymph and lymphatic circulation.

Immunity.

#### **Topic 08: Respiratory system**

Respiratory system. Respiration mechanism, lung ventilation, exchange of respiratory gases in lungs and in tissues, regulation of respiratory movements, defensive respiratory reflexes, diseases of the respiratory tract.

Digestive system. Function of the oral cavity and oesophagus, function of stomach, of small and large intestines.

#### **Topic 09: Energy metabolism, Homeostasis**

Energy metabolism. Metabolism of individual nutrients. Importance of the liver for metabolism.

Homeostasis.

Importance of nutrition, composition of food, vitamins. Hypoalimentionation, undernutrition.

Body temperature and its maintenance. Regulation of body temperature.

#### **Topic 10: Excretion system, skin, sensory organs**

Excretion. Structure and function of kidney. Urinary tract.

Structure and function of skin.

Receptors. Structure of sense organs. Function of sense organs.

### **Human body: Regulation**

#### **Topic 11: Regulation of human metabolism, Hormonal system**

Regulation of human metabolism.

Endocrine glands. Human hormones: their functions and sites of production. Insulin, adrenal hormones, thyroid gland hormones, parathyroids, pituitary, sex hormones.

### **Topic 12: Human nervous system, reflexes**

Structure of human nervous system.

Functions of the nervous system. Function of the spinal cord, hindbrain, midbrain, reticular formation, diencephalon, cortex. Reflexes.

Regulated function of internal organs. Sleep and vigilance. Higher nervous activity.

Conditioned and unconditioned reflexes.

### **Topic 13: Human reproductive system, ontogenesis**

Reproductive system of woman and man. Development of an individual. Human embryogenesis. Intrauterine development, uterus, placenta, pregnancy and mother's body, care of pregnant women and mothers.

Phases of human life.

### **Topic 14: Stem cells**

Features and differentiation of stem cells. Types of stem cells. Source of stem cells. Potential therapeutical use.

### **Topic 15: Human diseases and healthy lifestyle**

Human health.

Infectious diseases.

Civilization diseases. Obesity. Diabetes mellitus.

Healthy nutrition, work and rest regime, drug dependence.

Hereditary diseases and genetic pre-dispositions, genetic counselling.

Human parasitology: main human parasites – protozoa, worms, mites, insects.

### **Topic 16: Ecology**

Basic ecological terms. Relationship between organism and environment. Abiotic components of the environment. Sun, atmosphere, hydrosphere, lithosphere, pedosphere. Biotic components of the environment. Population, interrelations between populations, communities. Ecosystem. Changes of ecosystem. Biosphere.

Man and environment. Human population, present problems associated with the environment - atmosphere, water pollution, pollution of soil. Chemicals in the environment. Increased radioactivity. Noise. Increased amount of waste. Influence of the environment of man, environmental protection.

# CHEMISTRY

## Literature:

Chang R. and Overby J. General Chemistry - the essential concepts. 6th edition, McGraw-Hill, 2011.

Ryan L., Norris R. Cambridge International As and A Level Chemistry. 2<sup>nd</sup> edition, Cambridge University Press, 2012

## Topics:

### GENERAL CHEMISTRY

The structure of the atom, elements, atoms and the periodic table; structure and properties of ionic and covalent compounds; bonds in chemistry; fundamental laws of chemistry, composition, chemical equation and stoichiometry; states of matter - gases, liquids and solids; energy of chemical and biochemical processes, thermochemistry; reaction rates and equilibria, Le Chatelier's principle; solutions; acids and bases, Brønsted-Lowry theory, hydrolysis; oxidation and reduction;

### BASIC CALCULATIONS IN CHEMISTRY

The concentration in mol dm<sup>-3</sup> and in percentage by mass; dilution; calculations based on chemical equations; stoichiometry involving gases; mass fractions; empirical formulae; pH, pOH and concentrations of H<sup>+</sup> and OH<sup>-</sup> of strong acids and bases; balancing of oxidation-reduction reactions.

### INORGANIC CHEMISTRY

Nomenclature of inorganic compounds. Trends across the periodic table. Hydrogen, water; s block metals and their compounds; p block elements and their compounds; transition metals and their compounds.

### ORGANIC CHEMISTRY

Isomerism, functional groups, basic reaction mechanisms in organic chemistry, organic nomenclature.

Nomenclature, properties and reactivity of: alkanes, alkenes, alkynes, aromatic hydrocarbons ; halogenoalkanes and halogenoarenes; alcohols, phenols and ethers; aldehydes and ketones; amines; carboxylic acids and their derivatives - halogenoacids, aminoacids, hydroxyacids; acid halogenides, esters, amides, anhydrides; carbonic acid derivatives. Polymers. Simple five membered and six membered heterocycles.

### BIOCHEMISTRY

Saccharides: structure - linear and cyclic formulae, monosaccharides, disaccharides, polysaccharides, importance in biochemistry. Lipids: classification, composition, properties, importance in biochemistry. Proteins: basic amino acids (formulae), peptide bonds, composition and function of proteins. Nucleic acids: composition, nucleosides, nucleotides, base pairing, structure and function. Enzymes: characteristics, classification, digestive enzymes. Basic metabolic pathway of saccharides, triacylglycerols and proteins. Energy production.

## **PHYSICS**

### **Literature:**

Miriam Lazar. Let's Review Physics. Publisher: Barron's Educational Series, 2009.

Greg Curran. Homework Helpers: Physics. Publisher: Career Press, 2012.

Jonathan Orsay. Examcrackers: 1001 Questions in MCAT in Physics. Publisher: Osote Publishing, 2001.

### **Topics:**

#### **PHYSICAL QUANTITIES AND THEIR UNITS**

SI - basic units, complementary, derived. Formation of parts and multiples. Conversions of units, determination of unit dimensions.

#### **MECHANICS**

Types of motions and their classification. Uniformly rectilinear motion. Uniformly accelerated and decelerated motion. Uniform circle motion.

Newton's law of motion. Mass and weight of a body. Quantity of motion of a body. Effect of force - work, impulse of force, moment of force with regard to the axis, pressure, mechanical stress.

Energy and work. Power and efficiency.

Gravitational field, Newton's gravitational law.

Mechanics of liquids, the term "ideal liquid".

Pressure in the liquid induced by external force. Pascal's law and its application. Hydrostatic pressure. Archimedes' law. Flow of liquids. Equation of continuity and Bernouille's equation.

#### **MOLECULAR PHYSICS AND THERMODYNAMICS**

Quantity of compounds.

Interactions inside molecules, intermolecular interactions.

Heat and temperature and their measurement.

Molecular properties of gases. Events in gases. Equation of state of an ideal gas. Dalton's and Avogadro's laws.

Molecular properties of liquids. Surface tension and its biological importance.

Diffusion, osmosis. Viscosity of liquids and its importance.

Molecular properties of solids. Changes of state.

#### **MECHANICAL WAVE MOTION AND ACOUSTICS**

Harmonic motion.

Types of wave motion and their properties.

Sound properties with regard to sound source and propagation.

Sound pitch, timbre, intensity. Ear as a biological detector of sound. Sound field. Intensity level and loudness level of sound.

## ELECTRICITY AND MAGNETISM

Electric charge and electric field. Classification of atmosphere from the electrical point of view. Potential of electric field. Voltage.

Capacity, capacitor, arrangement of capacitors.

Metal conductivity. Electric current, simple circuit.

Operation and output of electric current.

Electric resistance. Ohm's law. Branched electric circuit.

Kirchhoff's laws. Assembly of resistors.

Semiconductors and their application.

Electric current in electrolytes. Faraday's law.

Electric current conduction in gases and in vacuum.

Magnetic field.

Alternating current. Electromagnetic induction.

Induction coil.

Transformers.

Electric oscillating circuit.

## OPTICS

Electromagnetic spectrum - survey and properties.

Light as an electromagnetic wave motion.

Wave properties of light, interference, light polarization. Quantum properties of light , photoelectric phenomenon.

Geometric optics, Fermat's principle. Reflection, refraction.

Picture formation by mirrors and lenses.

Optical instruments, magnifying glass, microscope. Eye as an optical system.

Eye as a biological detector of light. Eye defects. Photometric quantities and their units.

X-ray radiation and its biological importance.

## ATOMICS

Structure of atom, atom and its characteristics.

Electron shell.

Atomic nucleus. Natural and artificial radioactivity.

Nuclear reactions and their power utilization.

## PHYSICAL MEASUREMENT METHODS

Balances and weighing. Density and its measurement. Temperature and thermometers.

Measurement of electrical quantities - current, voltage, resistance.

Optical measurement - refractometry, polarimetry, photolorimetry.

## GENERAL REQUIREMENTS

- ability to perform simple numerical calculations related to solution of a given problem (percentage, conversion of units, conversion of angles),

- knowledge of basic mathematical functions and their physical applications (linear, quadratic, refracted, exponential, logarithmic, goniometric functions),

- knowledge of basic geometrical formulas,

- knowledge of basic physical constants.

## **MATHEMATICS**

Literature:

**J. K. Backhouse and S. P. T. Houldsworth - PURE MATHEMATICS 1 and 2**

**For all subjects:**

General knowledge such as basic mathematical operations, unit conversions etc. is required.