

**DETAILED SYLLABUS FOR THE POST OF JUNIOR SCIENTIFIC ASSISTANT  
KERALA STATE POLLUTION CONTROL BOARD**

*(Category Nos: 516/2021)*

(TOTAL MARKS – 100)

**PART I : CHEMISTRY ( 25 Marks)**

**1. Atomic structure and Chemical bonding**

Bohr's atom model , Heisenberg's uncertainty principle, Schrodinger wave equation , Wave function, Shapes of orbitals, various rules for adding electrons to different orbitals, Ionic bond, Covalent bond, Metallic bond, Coordinate bond and Weak chemical forces (2 marks)

**2. Periodic table**

Classification of elements- Periods and groups, Ionisation energy, Electron affinity, Electronegativity - Variation of these properties along a group and a period. (2 marks)

**3. Analytical Chemistry**

Titrametric, gravimetric and colorimetric analysis, Errors- Types of errors, accuracy and precision.

*Spectroscopic methods-* UV-Visible, IR, NMR and Mass spectroscopy.

*Separation techniques-* Solvent extraction, Extraction of metal ions and organic species from aqueous solutions, principle of Chromatography

*Instrumental techniques-* Principle and application of Thermogravimetric analysis and Differential thermal analysis (5 marks)

**4. Colloids and Surface chemistry**

*Colloids-* Classification, Mechanical, Electrical and Electrokinetic properties of colloids, Surfactants, Micelle formation, Emulsification

*Adsorption-* Applications, adsorption isotherms- Freundlich, Langmuir and BET theory. (3 marks)

## 5. Green chemistry

Need of green chemistry, Principles of green chemistry, Green solvents, Microwave assisted reactions and ultrasound assisted reactions

(3 marks)

## 6. Environmental chemistry

Atmospheric structure and composition, Toxic chemicals in environment, Sources and treatment of heavy metal poisoning,

**Air pollution** –Air pollutants, Green house effect, Global warming, Ozone depletion, control of air pollution

**Soil pollution**- Soil formation, soil acidification, liming of soil, Industrial and urban wastes

**Water pollution**- Sources, Eutrophication, BOD, COD, Hardness of water, Domestic water treatment, Sewage treatment.

**Noise and radiation pollution**- Noise - general features, control of noise pollution. Biological effects of radiation, Radioactive waste management

**Chemical toxicology**- Toxic chemicals in the environment, Effects of toxic chemicals, Pesticides and its biochemical effects. (10 marks)

## PART II : MICROBIOLOGY (25 Marks)

### Techniques in Microbiology

(Marks 5)

Microscopy, types of microscopes, advanced techniques in microscopy. Staining techniques- simple, negative, Grams, spore, flagella, acid fast, volutin, capsule and Feulgen staining. Sterilisation and disinfection techniques- Physical and chemical methods- flaming, boiling, autoclaving, inspissation, Heat, Filtration, Radiation. Calorimetry and spectrophotometry, Electrophoretic techniques for proteins and nucleic acids, PCR. Chromatography techniques: adsorption, partition, ion exchange, gel filtration, HPLC, FPLC. Techniques used for identification of microorganisms – biotyping, serotyping, molecular techniques.

### General Microbiology and Microbial Physiology

(5 Marks)

Comparison of eukaryotes and prokaryote. Archaeobacteria and eubacteria. Bacterial forms and arrangement of cells. Actinomycetes, Mold and yeast forms. Viral and bacteriophage forms.

Ultrastructure of bacteria. Effect of antibiotics on microbial cells. Structure, function and chemical composition of cell wall and cell membrane. Endospore: Structure, formation, stages of sporulation. Effect of various parameters and Environmental factors on microbial growth. Bacteria classification based on specific requirements-based on temperature, pH, O<sub>2</sub> and solute concentration. Nutritional requirements of bacteria. Nutritional types of bacteria. Modes of bacterial nutrition. Transport of nutrients by bacteria. Solid and liquid media, use of agar. Different types of culture media. Culturing methods-Streak, spread, pour plate methods, stab culture and lawn culture. Cultivation of aerobic and anaerobic bacteria. Culture preservation strategies. Growth curve and its significance. Viral growth- lytic and lysogenic stage. Viral cultivation methods. Viral and bacteriophage quantitation methods.

### **Environmental Microbiology**

**(5 Mark)**

Soil Microbiology - Types of soil microbes, role of microorganisms in soil fertility; Factors affecting microbial population - moisture, pH, temperature, organic matter, agronomic practices etc. Aquatic Microbiology: Aquatic environment, distribution of microorganisms in aquatic environment. Factors influencing their growth and distribution. Water Purification procedures for public water supplies, Concept of indicator organisms, Microbiological examination of water. BOD, COD, Wastewater treatment steps and methods. Eutrophication and algal bloom. Brief account of water borne diseases and transmission. Aerobiology - atmospheric layers, organisms in air, distribution and sources. Disease forecasting in plants. Indoor and outdoor air. Droplet nuclei, aerosol, infectious dust. Microbiological sampling of air. Air borne transmission of harmful microbes and air borne infections. Biogeochemical cycle- Role of microorganisms in Carbon, Phosphorous, Nitrogen and sulphur cycles. Microbe-Microbe Interactions. Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation.

### **Waste management and Xenobiotic metabolism**

**(5 Marks)**

Solid waste management- Sources and types of solid waste, need for management, Landfills, composting, vermicomposting, anaerobic digesters, and production of biogas. Design and management of biogas plants. Xenobiotic metabolism - Novel pollutants, persistence and biomagnification. Recalcitrant halocarbons- nitroaromatic compounds, PCB, alkyl benzene sulphonates, and petroleum hydrocarbons - their biodegradation. Bioremediation of polluted environment. Oil spills, heavy Metals and other xenobiotics. Microbial leaching and corrosion of metals.

**Food Microbiology****(5 Marks)**

Food as a substrate for microorganisms. Types of microorganisms in food. Source of contamination. Factors influencing microbial growth in foods. Physical and chemical properties of milk. Milk as a substrate for microorganisms. Types of microorganisms in Milk- bacteria, fungi and yeast. Sources of microbial contamination of milk. Microbiological analysis of milk. Food fermentations: Cheese, bread, yoghurt, idli, fermented pickles and fermented vegetables, Ice cream, - methods and organisms used. SCP, Probiotics and prebiotics. General principles underlying spoilage, spoilage of different kinds of foods. Principles of food preservation. Physical and chemical methods of preservation. Food Sanitation, good manufacturing practices, HACCP and personnel hygiene.

**PART III : BIOTECHNOLOGY ( 25 Marks)****Module I- Biophysics and Principle of Instrumentation (3 MARKS)****Principles of thermodynamics:**

Laws of conservation of energy- first and second laws and its relevance in the biological system, entropy and enthalpy, Gibbs free energy, bioenergetics- endothermic and exothermic reactions of biological systems, energy change in the biochemical reactions, sources of heat limits to temperature, heat dissipation and conservation.

**Colorimetry and Spectrophotometry:** Beer-Lambert's law, visible absorption spectrum, molar extinction coefficient, colorimeter, spectrophotometer, fluorescence, phosphorescence.

**Centrifugation:** Principle of sedimentation technique, different types of centrifuge and rotors, principle and procedure and application of differential centrifugation, density gradient centrifugation, ultra centrifugation rate zonal centrifugation, Isopycnic centrifugation

**pH meter:** Principle and working.

Brief account of densitometry, fluorimetry, manometry, polarography, atomic absorption spectroscopy, IR, NMR and X-ray crystallography and Mass spectrometry.

**Electrophoresis:** Principle, procedure and application of zone electrophoresis-, paper electrophoresis, gel electrophoresis (native PAGE, SDS-PAGE).

**Isotopes and radioisotopes:**

Isotopes and radioisotopes, radiations- ionizing radiations, Application of isotopes and radioisotopes in biological research, radioisotope tracer technique and autoradiography.

### **Module II Biochemistry & Enzymology ( 2 MARKS)**

Normality, molality, molarity, percentage solution, mole fraction, parts per million, simple numerical problems from the above, fundamental principles of diffusion, osmosis, osmotic pressure, carbohydrates, lipids, aminoacids, proteins, nucleic acids – their detection methods, Enzymes- Classification and nomenclature, enzyme activation, enzyme inhibition- competitive and non-competitive, allosteric regulation, purification of enzymes, coenzymes.

### **Module III Microbiology (3 MARKS)**

Bacteria, virus, fungi, protozoa, mycoplasma, concept of microbial species, strains; microbial cell surfaces, Gram positive and Gram negative bacteria, Motility in bacteria, kinds of flagella, nutritional classification of bacteria.

Viruses: Viruses, phage culture, Bacteriophage, DNA and RNA phages, T4 phage, Lytic and

lysogenic cycles, host cell adsorption and penetration, synthesis phage nucleic acid.

Microbes in extreme environments

Thermophiles and alkalophiles, pathogenic microorganisms- bacteria, fungi, viruses, protozoans and mycoplasma, defense mechanism against microorganisms, symbiosis and antibiosis among microbial population, nitrogen fixing bacteria in agriculture and forestry, photosynthetic bacteria, Role of bacteria in carbon, nitrogen, sulphur and phosphorous cycle in nature.

### **Bacterial nutrition**

Culture media – requirements of bacterial culture media, types and uses, Bacterial growth curve, microbial metabolism, fermentation, different types of fermentation, methanogenic bacteria.

Isolation of pure culture: Spread plate, streak plate, pour plate etc., synthetic media, simple and complex media. Isolation of anaerobes and its culture techniques, slant culture and stab culture.

### **Industrial microbes and their uses**

Production of food (dairy and SCP) and drugs (antibiotics such as penicillin & streptomycin), products of fermentation, Strain improvement by enrichment mutation and recombinant DNA technique, production of heterologous proteins of interest in microorganisms.

### **Control of microorganisms**

Physical agents, chemical agents, antibiotics and other therapeutic agents

Bacterial cell structure and Growth – Eukaryotic cells and prokaryotic cells, Glycocalyx, bacterial cell membranes, bacterial cell wall, cytoplasm, spores, organs of locomotion, chemotaxis in bacteria, ribosomes in bacteria, bacterial nucleus and chromosomes, bacterial nucleoid. Bacterial Growth curve, Measurement of growth, factors affecting growth of bacteria.

Nutrition in bacteria-classification based on nutrition- autotrophic and heterotrophic organisms, Photosynthetic and chemosynthetic organisms- purple sulfur bacteria, Saprophytes and parasites-pathogenic parasites.

**Nitrogen Metabolism-** Biological nitrogen fixation, symbiotic nitrogen fixation, components involved in the process of nitrogen fixation, Inorganic nitrogen metabolism, assimilation of inorganic nitrogen, Nitrogen cycle.

Energy production in bacteria- Energy and ATP, aerobic respiration, Glycolysis and tricarboxylic acid cycle, Electron transport and oxidative phosphorylation in Bacteria, catabolism of other carbohydrates.Photosynthesis in bacteria

Anaerobic respiration- Fermentation, alcohol fermentation by yeasts and bacteria, lactic acid fermentation, Methnogenic bacteria, Acetobacter and acetic acid fermentation.

Application of bacterial metabolism in industry and agriculture, economically important bacteria – lactic acid bacteria, nitrogen fixing bacteria etc.

Lichens, mycorrhizae, pollution indicators etc.

### **Microbial Diseases of Humans**

Airborne bacterial diseases – streptococcal; diseases, tuberculosis, Pneumococcal Pneumonia, Klebsiella Pneumonia,

Foodborne and waterborne bacterial diseases- Foodborne and waterborne intoxications-Botulism, Staphylococcal food poisoning;

Foodborne and waterborne infections- Typhoid fever, salmonellosis, Cholera, Shigellosis, E.coli Diarrheas, Brucellosis

Soilborne bacterial diseases- Anthrax, Tetanus, Leptospirosis,

Viral diseases of Humans- Pneumotropic viral diseases-Influenza, Adenoviral infections,

Rhinoviral infections,

Dermatoviral diseases- Herpes simplex, chickenpox, Measles, Rubella,

Viscerotropic Viral diseases- yellow fever, Dengue fever,

Neurotropic viral diseases- rabies, Polio

#### **Module IV Molecular Biology ( 2 Marks)**

##### **Introduction**

DNA, replication of DNA, RNA, Types of RNA. Transcription, translation, transcriptional and translational modifications, ORF, Eukaryotic and prokaryotic differences in the genetic makeup and processing, genes, transposons, mutations and repair of nucleic acids,

Transfer of genetic information in bacteria, Bacterial chromosomes- DNA, Plasmids, different types of plasmids- non-conjugative, mobilizable plasmids, resistance plasmids

Bacterial recombination:Conjugation- Fertility factors, F<sup>+</sup> and F<sup>-</sup> cells, F pili, High frequency recombination, Transformation- Griffith's effect, evidence of DNA as genetic material, , Transduction- general characteristics of bacteriophages, Lambda phage-general structure, general multiplication in bacteria- lytic phase and lysogenic phase, bacterial recombination through transduction, Phages and plasmids as vectors for genetic engineering, Bacterial recombination and transferable drug resistance

#### **Module V Immunology & Immunotechnology ( 2 Marks)**

The Human Immune System: Organs and cells of immune system

Immune system and immunity, innate and specific or acquired immunity,

Immune system- organs, tissues and cells involved in immunity, Humoral immunity and cell mediated immunity, antigens, antibodies, immunogens,



haptens. Immunoglobulins, structure and functions, Antibody-antigen interaction, antigen-antibody reactions, agglutination, immuno-diffusion, immuno-electrophoresis, ELISA, RIE, production of polyclonal and monoclonal antibodies, hybridoma technology, Immunity to infections of diseases: vaccines - attenuated and recombinant vaccines, vaccination. therapeutic antibodies

Autoimmunity and autoimmune diseases: Hashimoto's thyroiditis; Myasthenia gravis; Rheumatoid Arthritis, Pernicious anemia, Asthma.

### **Module VI Recombinant DNA Technology ( 3 Marks)**

#### **Tools of recombinant DNA technology-**

Restriction endonucleases, classification and general characteristics of endonucleases; Other enzymes used in the recombinant DNA technique- DNA ligase, alkaline phosphatase;

Vectors, the vehicle for cloning: special features needed for a vector, Various types of cloning vectors- plasmid cloning vectors- pBR322, Expression vectors, the pUC series, Bacteriophage cloning vectors -phage  $\phi$  cloning vectors, M13 based vectors, Phagemids and Cosmid vectors, Artificial Chromosomes: Yeast Artificial vectors (YACs), Bacterial artificial Vectors (BACs), Application for YAC and BAC,- genome sequencing

Shuttle vectors for animals and plants, mammalian vectors; Gene Therapy- Vectors for gene therapy.

Construction of recombinant DNA, host cells, competent cells, bacterial transformation, screening methods of transformed cells, Various methods of genetic transformation in eukaryotes- Direct gene transfer and vector mediated gene transfer, Screening methods of transformed cells and organisms.

Molecular hybridization techniques for genome analysis Genome analysis: RFLP, AFLP, RAPD, Southern hybridization PCR: Principle and applications, Nucleic acid sequencing: Principle and applications, Genome sequencing methods, Human genome project– a brief account. Gene expression analysis – Northern hybridization and microarrays. Transgenic organisms and its impact in agriculture, Medicine and Environment, Biosafety and Ethics in Genetic Engineering.

### **Module VII Industrial and Food Biotechnology ( 3 Marks)**

#### **Industrial Microbiology**

Microbes in industry- Industrially important microorganisms, screening and isolation, industrially important enzymes and chemicals, Industrial production of enzymes and chemicals, Microbial production of antibiotics, vitamins, amino acids and other organic acids

#### **Fermentation**

The biological process of fermentation- various types of fermentation, alcohol fermentation, Respiration vs Fermentation – Important products of fermentation. Fermentation as an industry, selection of industrial microorganisms for specific products and reactions,

Laboratory scale biological process- scale up of biological reactions in to bioprocess;

Bioreactors-types of bioreactors / Fermentors, Bioreactors for bacteria and yeast cells, Fermentors for plant cell cultures and animal cell cultures,

Microbes of food and fermented food- Curd, wheat and rice flour, Meat and fish, Poultry and Eggs, Breads and bakery products, Grains, Microorganism in food spoilage, types of spoilage, canning, microbes in the spoilage of canned foods, principles of preservation of foods, Hazardous effect of food spoilage, mycotoxins;

Industrial production of antibiotics (penicillin & streptomycin) and organic acids (acetic acid & Citric acids)

Microorganisms as food and food supplements – fermented food, microalgae- Single cell protein, Edible mushrooms. Microbes in dairy industry, dairy products; microbial processing of foods- enzymes in food processing.

Agricultural waste and food industry wastes as the substrate for fermentation, solid state fermentation; production of single cell proteins, microbial production of enzymes;

### **Module VIII Environmental Biotechnology ( 3 Marks)**

Ecosystem, Biodiversity, Types of ecosystem and biosphere;

**Pollution:** sources of pollution, Greenhouse effect, general characteristics of domestic wastes, community wastes, agricultural wastes, effect of solid waste in the environment

Types of pollution, Organic load in aquatic systems, BOD and COD, microbial quality of water, drinks and food Use of biotechnology in the treatment of municipal wastes and hazardous industrial effluents

**Bioremediation:** Microbial degradation of pesticides, herbicides and other toxic chemicals in the environment, Biological control of pests and insects, Biopesticides- *Bacillus thuringiensis*, bioherbicides; Plants used in metal remediation, plants and algae used in phytoremediation and their mechanisms

Application of biotechnology in the production of biofertilizers and nitrogen fixation – nitrogen fixing microorganisms, mycorrhiza

Renewable and non-renewable energy resources: conventional fuels and their environmental impacts (fire wood, animal oils, coal, petroleum)

## **Non-conventionnel Energy Sources**

**Biomass:** utilization of biomass as energy source– application of microbes in production of fuels from biomass- biogas and methanogenic bacteria, microbial hydrogen production, production of methanol, ethanol and other types of chemicals from biomass and agricultural wastes, the gasohol experiment

Solar energy converter, hopes from photosynthetic pigments, vegetable oils as engine fuels, energy crops-jojoba;

Possibility of plant-based petroleum industry and cellulose degradation for combustible fuels

## **Bioleaching**

Enrichment of ores by microorganisms (bioaccumulation and biomineralization);

Bio-assessment of environmental quality.

## **Module IX Plant and Animal Biotechnology (3 Marks)**

### **Plant tissue culture**

Fundamental principles of in vitro plant cultures: use of plant growth regulators, composition of tissue culture media- media components and its functions. Types of in vitro cultures

Callus cultures, cell suspension cultures, organ cultures- root cultures, hairy root cultures, embryo cultures, anther culture ; their applications,

Genetic engineering of plants

Methods of gene transfer in plants –Physical, chemical and biological methods

*Agrobacterium tumefaciens*, tumor formation in plants by *A. tumefaciens*, application of *A. tumefaciens* in plant genetic engineering, Virus mediated gene transfer in plants.

## **Transgenic plants**

Transgenic crops, Impact of transgenic plants in agriculture and Horticulture, Non-Agricultural applications of transgenic plants- Biopharming- production of therapeutic proteins in transgenic plants, edible vaccines, disease resistant, salt tolerant, pest resistant and stress tolerant crop and medicinal plants, Metabolic engineering of plants for enhanced and controlled production of plant products.

## **Application of Animal Cell Cultures**

Uses of animal cell cultures, Products of animal cell cultures- hormones (insulin, growth hormones), interferon, t-plasminogen activator, factor VIII, Factor IX and virus cultivation;

Expression of cloned proteins in animal cells, production of vaccines in animal cells, production of polyclonal and monoclonal antibodies-hybridoma technology

Transgenic animals and its practical uses

## **Module X Bioinformatics (1 Mark)**

Databases-various types of databases, Biological Databases- Importance of databases in biotechnology, NCBI, Gene bank, PubMed. Etc.

Genomics and Proteomics-Definitions, Application of Proteomics and genomics in Biotechnology.

## **PART IV : Environmental Science (25 Marks)**

### **Module 1 (5 marks)**

Dissociation of water, ionic product of water, concept of pH and pOH, types of acids, bases, buffers and electrolytes. Dissociation of weak acids and electrolytes. Meaning pKa values, buffers and mechanism of action. Handerson Hassel's baach equation. Molecular interactions. Non covalent interactions and covalent interactions with examples. Meaning of normality,

molality and molarity. Percentage solutions and mole fractions. Simple numerical values from the above. Principles of diffusion and osmosis, definition of osmotic pressure. Influence of ionization and molecular size on osmotic pressure. Isotonic, hypertonic and hypotonic solutions- definition and examples. Meaning of true solutions, colloidal solution and coarse suspension. The distinction between lyophilic and lyophobic salts with examples. Elementary study of charge on colloids, Tyndall effect. Emulsions and emulsifying agents and examples. Reverse osmosis and its applications.

### **Module 2 (5 marks)**

Biomolecules-carbohydrates, lipids, proteins, nucleic acids, aminoacids, fatty acids, nucleotides classification with examples. Basic structure of proteins, carbohydrates and nucleic acids. Enzymes-properties, factors affecting its action, basic mechanism of action. Name of methods for the detection of carbohydrates, amino acids and proteins in a solution. Denaturation of proteins and DNA. Precipitation reactions of proteins.

Polymers. Natural polymers, semisynthetic polymers, synthetic polymers, definition and examples. Examples for addition polymers, condensation polymers, elastomers, thermoplastic polymers, thermo setting polymers. Difference between natural and synthetic rubber. Biodegradable polymers.

### **Module 3 (5 marks)**

Methods of microbial control. Physical and chemical methods with examples and their mechanism of action. Preparation of different culture media. Preparation of slants, butts and plates. Inoculation techniques and study of growth. Use of differential and selective media with examples. Identification of gram positive and negative bacteria. Microbiological analysis of water purity, indicator organisms, ground water quality and home treatment systems. Distribution and sources of air borne organisms. Droplet and droplet nuclei. Examples of water borne and food borne microbial diseases. Food adulterants,

artificial sweeteners, artificial colours, artificial flavours. Common microbial toxins and fungal toxins in stale food.

#### **Module 4 (5 marks)**

Air pollutants. Gaseous air pollutants, oxides of sulphur, oxides of nitrogen, hydrocarbons, oxides of carbon, carbon monoxide, carbon dioxide, their sources and health effects. Particulate air pollutants. Smoke, dust, mist, fumes and their sources. Smog, classical and photochemical smog with examples and their effects and control measures. Global warming and green house effect, acid rain, ozone hole. Assessment of air quality, air sanitation. Examples of air borne microbial diseases. Water pollution- Organic wastes, in water, chemical pollutants, heavy metal pollutants. Water analysis for chemical detection. Eutrophication. Soil pollution-Pesticides and its types, herbicides and its types, industrial wastes, biodegradable and non biodegradable, with examples. Radioactive wastes-sources and management. Measurement of the level of pollution- Chemical oxygen demand. Suspended solids. Biological oxygen demand. Ammoniacal nitrogen content and biological indicators. Biological magnification. Sources and effects of noise pollution. Noise standards. Environmental education, major conservation efforts of World Wildlife Fund, International Union for Conservation of Nature (IUCN), United Nations Environment Programme (UNEP), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Environmental Information System (ENVIS).

#### **Module 5 (5 marks)**

Microscopy- basic principle and technique of compound and electron microscope. Principle, basic technique and uses of photoelectric colorimeter and spectrophotometer. Basic techniques and application of chromatography, paper, thin layer, gel, gas liquid, high pressure liquid chromatography. Principle and basic technique of electrophoresis like gel electrophoresis and poly acrylamide

electrophoresis. Basic technique of recombinant DNA technology and its applications. Basics of blotting techniques and its application. Basic principles of PCR and its applications. Measurement of radioactivity- Geiger- Muller and Scintillation counters, autoradiography and its applications. Biotechnological management of solid and liquid wastes. Uses of immobilized enzymes with examples.

**NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper**