Himachal Pradesh
Public Service Commission

No.03-24/2024-PSC (R-II) Dated: 21-03-2025

The syllabus for the descriptive type Subject Aptitude Test (SAT) for the recruitment to the post **of Environment Officer (Class-I, Gazetted)** in the **Department of Environment Science, Technology and Climate Change, Himachal Pradesh** shall be of **03 hours** duration having **120 marks**. The SAT paper shall cover the following topics of **M.Tech Civil Engineering** level:

1. GEOTECHNICAL ENGINEERING:-

Advanced Soil Mechanics: Effective stress, permeability, consolidation (1D, 2D, 3D, radial), Shear strength (UU, CU, CD tests), stress-paths and critical state model, Behaviour of Indian soils (black cotton, laterites).

Advanced Foundation Engineering: Bearing capacity (Terzaghi, IS code method), settlement analysis for shallow/raft foundations, deep foundations: pile capacity, settlement, lateral resistance, Winkler Model, Problematic soils and remedial measures.

Soil Dynamics: SDOF/MDOF response, damping, cyclic soil behaviour and liquefaction, Seismic wave propagation and dynamic pile analysis.

Underground Excavation in Rocks: Rock classification, in-situ stress, failure criteria and tunnel design (NATM RMR).

Machine Foundations: Vibration modes, dynamic stiffness, damping and block foundation design.

Exploration and Field Testing: Site investigation, SPT, SCPT, Plate load and shear tests.

2. TRANSPORTATION ENGINEERING:-

Traffic Engineering: Traffic Flow characteristics, Highway Capacity and performance characteristics, Un-signalized Traffic interaction design.

Pavement Materials and Design: Components of flexible and rigid pavements, IRC method of flexible and rigid pavement design.

Highway Construction and Maintenance: Bitumen Grading System, Maintenance and Rehabilitation of Asphalt pavements.

Urban Transportation System Planning: Fundamentals of Transportation planning, Trip Generation, Trip Distribution.

Geometric Design of Transport Facilities: Classification of Roads, Design of Road Segment, Road width and median width, design of intersection: Roundabouts.

3. WATER RESOURCES ENGINEERING:

Advanced Hydrology: Runoff Hydrographs and Unit Hydrographs, flood estimation and routing, prediction of peak flow, introduction to hydrometeorology: Climatic parameters and data recording.

Advanced Hydraulics: Uniforms and critical flow in open channels, hydraulic jump as energy dissipater, sediment transport and river mechanics, dams, purpose, classification and site identification.

Advanced Fluid Mechanics: Conservation of mass, Momentum and Energy, Navier-stokes equations, Laminar flow: Plane Poiseuille flow and flow between Co-axial cylinders, **Turbulent flow:** Reynolds stresses and Prandtl's mixing length theory, boundary layer theory.

Water Resources Planning and Management: Hydrologic Cycle and watershed zoning, Rainfall-Runoff and Flood Routing, Sustainable Water Resources Development and IWRM, Irrigation Scheduling and techniques.

Groundwater Engineering: Aquifers: characteristics and classification, Darcy's Law and Dupit's Assumptions, Well Hydraulics: confined and unconfined aquifers, Artificial recharge and saline water intrusion.

River Mechanics and Sediment Transport: River Mechanics: Meandering rivers and scour problems, threshold of particle transport: Critical velocity and shear stress, sediment load estimation: du Boys and Shields methods.

4. STRUCTURES ENGINEERING:-

Continuum Mechanics: Stress at a point, Mohr's Circle and octahedral stress, strain-displacement relationship and compatibility, stress-strain relationship, elements of plasticity: yield criteria and hardening.

Structural Dynamics: Fundamentals of vibrations for SDOF systems (Free and forced vibrations), MDOF systems: Mode superposition method, continuous systems: equations of motion and Hamilton's Principle.

Advanced Concrete Technology: Cement chemistry and aggregates for concrete, concrete behaviour: Properties of fresh concrete, Durability, special cement and concrete, shrinkage and creep.

Reliability-Based Structural Design: Introduction to probability and modelling of load effects, reliability of structural systems, load and resistance factor design (LRFD).

Earthquake Engineering: Earthquake causes, magnitude, intensity and ground motions, linear earthquake analysis: modal and response spectrum analysis, non linear analysis,

Pushover analysis and Ductility Considerations, Earthquake resistance Design: RC frame, Shear wall, Codal provisions (IS: 1893-2016, IS: 13920-2016).

Bridge Engineering: IRC loading and impact factors, design of RCC slab culvert and T-Beam bridges, Design of substructures: Piers and Abutments.

5. CURRENT ENVIRONMENTAL ISSUES AND THEIR MANAGEMENT:-

Global Warming, Greenhouse Effect and Ozone Problems, Acid Rain, Atmosphere Turbidity and Nuclear, Other environmental Issues, Environmental Policies and Regulations, Environmental Treaties and Conventions.

6. ENVIRONMENTAL POLLUTION:

Air pollution, Water pollution, Noise and Land pollution & Thermal Radiation pollution.

7. ENVIRONMENT IMPACT ASSESSMENT:

Overview of EIA, EIA methodology, Prediction and Assessment of Impact, Public Participation, Environmental Management and ISO Certification.

8. REMOTE SENSING AND GIS:

Introduction to remote sensing, Microwave sensing, Aerial Photographs and Satellite Imageries, Digital Image Processing, Application of Remote Sensing in Environmental Management.

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PART-I (60 MARKS)

1. ENVIRONMENTAL CHEMISTRY:-

Types of chemical reactions, stoichiometric calculations, solutions, chemical thermodynamics, fundamentals of process kinetics, gas laws, ways of shifting chemical equilibria. Equilibrium calculation, alkalinity, acidity, buffers, buffer index. Solubility equilibrium for slightly soluble salts, effect of other solutes on salt solubility, competing acid-base equilibria, effect of complexions, hydrolysis, computing total soluble species concentration Oxidation-reduction processes, stability diagrams, redox potential. Fundamental of Process kinetics: Reaction rate, order and stoichiometry. Fundamental of surface and colloidal chemistry: surface charge on colloidal particles, electric double layer, adsorption isotherm. Basic concepts of quantitative analytical chemistry. Instrumental methods of analysis.

2. AIR POLLUTION AND CONTROL:

Air Quality and Standards, Important air pollutants, their sources, characteristics and effects. Sampling and Analysis: Ambient air sampling, stack sampling, Air quality standards, Air Pollution Meteorology and Dispersion Models, Atmospheric motion, Lapse rate, atmospheric stability,inversion, atmospheric dispersion, maximum mixing depth, Diffusion models, plume rise, Control of Particulates, Characteristics of particulates. Filters, gravitational, centrifugal-multiple type cyclones, prediction of collection efficiency, pressure drop, wet collectors, Electrostatic Precipitation theory-particle charging-particle collection-ESP design procedure, Control of Gaseous Pollutants, Adsorption, absorption, Emission control in coal-fired power plants and other important industries. Condensation and incineration, Automobile Pollution, Legislation for motor vehicle emission control, control of automobile pollution, internal combustion engines, modification of IC engines to reduce emission, air fuel ratio, catalytic converters, Odour pollution and control, Indoor air pollution, Noise pollution and control.

3. ADVANCED WATER TREATMENT:

Types of Sedimentation and coagulation, settling tests, scale up, Batch flow and continuous flow operations, Coagulation, mechanisms of coagulation, effect of turbidity and alkalinity, chemistry of coagulants, Flow through beds of solids: Slow sand filters, rapid sand filters, ion exchange units, adsorption towers, contacting towers, flow through expanded beds, flow through porous plates and membranes, Gas transfer and Disinfection Mechanism of transfer, film coefficients and equilibrium relationship, gas disperses, packed columns, tray columns, spray units. Disinfection, mechanism, different agents, Advanced treatment operations: Adsorption, isotherms, reverses osmosis, electro-dialysis, ultrafiltration, etc., Applications of Unit Operations in Water Treatment and Design of Physical Facilities.

PART-II (60 MARKS)

1. ADVANCED WASTEWATER TREATMENT:

Kinetics of Biological Growth, Nutrition and growth conditions, Effect of environmental conditions, bacterial growth in terms of numbers and mass, growth curve, interpretation of curve, substrate limited growth, Monod's expression, substrate utilization and cell growth, effect of endogenous metabolism, inhibition, effect of temperature, application of growth and substrate removal kinetics to biological treatment, Reactors and Reactor analysis, Types of reactors and their analysis, Biological Processes, Fundamentals and design concepts of aerobic treatment processes. Anaerobic treatment processes, Nutrient removal and Pond treatment processes: Biological processes for nitrogen and phosphorus removal, Different pond treatment systems, Biological processes for sludge processing.

2. MICROBIOLOGY AND ECOLOGY:

Microorganisms - classification, prokaryotic and eukaryotic cells, structure, characteristics, nucleic acids, DNA and RNA, replication, Recombinant DNA, Viruses, their detection and quantification. Microscopy, Measurements and Isolation of Microorganism, Different Cultures, Media and Techniques of Staining and Enumeration of microorganism, Enzyme and enzyme kinetics, Metabolism, respiration, fermentation, Glycolysis, Krebs's cycle, carbohydrate, protein, lipids, significance of energetics,Chemical composition of cell and nature of organic matter used by microorganisms. Metabolic classification of microorganisms: phototrophs, chemotropism, applications in environmental engineering, Distribution of microorganisms, indicator organisms, coliforms - fecal coliforms - E.coli, Streptococcus fecal is differentiation of coliforms - significance - MPN index, M.F. technique, standards. Microbiology of wastewater treatment processes such as activated sludge process, trickling filter, anaerobic processes, Introduction to Microbiology of Soil and Air and Industrial Microbiology, Microbiology of bioremediation and solid waste treatment, Bio-sphere, earth energy budget, Ecosystem, Uniformitarianism, the ecology of population, Ecosystem and communities: Physical and biological properties

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PART-I (60 MARKS)

1. ENVIRONMENTAL GEOLOGY AND ATMOSPHERIC SCIENCE:-

Environment and Environmental Geo-Science- Definition, evolution, characteristics principles and history of Environment and environmental sciences, Fundamental concepts, primary differentiation and formation of core, mantle, crust, magma generation, dynamics of earth, Plate tectonics-sea floor spreading, mountain formation, Continental drift theory, Earth's Magnetic field, types of seismic waves and their role in the study of earth's interior, Geomorphological process: Formations and classification of rocks rock cycle, fold and fault, major types of fold and faults, Weathering and their types, mass wasting and its types volcanism, types, volcanic materials, process and effects of volcanism, Soil profile, soil classification, soils of India, Environmental Geochemistry: Concept of major, minor and trace elements, Mobility of elements, geochemical cycles, Geo-indicators, Resources and reserves, Mineral resources and reserves, Oceans as new areas for exploration of mineral resources, Mineral resources of Himachal Pradesh, Atmosphere: Different layers and their characteristics; meteorological aspects- inversions, mixing height, wind-rose, electromagnetic radiations, solar radiation and terrestrial radiation, heat budget, temperature measurements and controls, Environmental lapse rate, humidity, mixing ratio, dry and wet adiabatic lapse rate, clouds-types and their characteristics and atmospheric stability, atmospheric transport, diffusion and dispersion, Weather and Climate: elements of weather and climate, classification, energy balance in atmosphere, greenhouse effect, atmospheric general circulation, precipitation and types of storms, Indian monsoon, El Nino, La Nina effect and western disturbances, Geostrophic wind and gradient wind, cyclones, atmospheric moisture: forms of cloud condensation; precipitation, thunderstorms, floods and droughts, global climate variability and climate change, introduction to weather forecasting models. Empower with geological methods to reduce potential of natural processes to sustain a healthy biosphere on earth. Records of climate change (glacial cycles, ocean sediments, corals & tree rings) Indian Climate Change and Indian Summer Monsoon.

2. ENVIRONMENTAL BIOLOGY:-

Concept and scope of Ecology: Definition and scope of ecology, branches of ecology, human ecology an humans settlement, Historical background of ecology, relevance of ecology to humankind, level of organization in ecology, Relationship of ecology with other branches of science, Origin and Evolution of Biological Diversity: General classification of biological diversity (plants and animals), growth and morphogenesis in plants and animals, basics of photosynthesis, transpiration, biological nitrogen fixation, Physiological, biochemical and genetic mechanisms associated with adaptations of plants and animals, Ecosystems Concepts and Dynamics: Principle and concept of ecosystem, types of ecosystems, Biotic and Abiotic components of ecosystem, biomes, ecotones and edge effect, ecological niche and

equivalents, ecotype, ecophene and ecological indicator, Biogeochemical cycling Carbon, Nitrogen, Phosphorus and Sulphur and Hydrological cycles and microbial
ecology, C3 and C4 pathways and their significance, Ecological pyramids of number, biomass and energy, food chain, food web and tropic levels, ecological amplitude and ecological niches, ecological energetics, Decomposition, Ecosystem stability, Ecological Succession, Primary and secondary productivity of different ecosystems in the world methods of measurements of productivity and the factors affecting productivity, Population and Community Dynamics: Characteristics of population, concept of carrying capacity, Population growth and regulation, population fluctuation, dispersion and meta-population, concept of r and k species, key stone species, definition of community, its characteristics, diversity, dominance, structure, stratification, periodicity, fluctuation within community, interdependence within community, Study of different ecosystems: Forest ecosystem- Forest as an ecosystem, distribution of forests, types of forests, economics and ecology of forest, role of forests in protection of species regulation of climate and production of various produce, Grassland ecosystem - Distribution and types of grasslands, rangelands and biodiversity in grassland, and productivity in grasslands, Desert Ecosystem and Wastelands- Desert as ecosystems, hot and cold deserts, productivity, characteristics and global distribution of deserts; Desertification process; Types and distribution of wastelands in India, Aquatic Ecosystem: Lentic and lotic ecosystem, structure, energy flow and productivity in estuaries, marine ecosystem, structure biodiversity and productivity in, marine ecosystem, Wetland Ecosystem: Distribution, energetics and productivity in wetlands. Biodiversity and economic importance of wetlands.

3. **ENVIRONMENTAL DISASTERS: MITIGATION AND MANAGEMENT :-**

INTRODUCTION TO DISASTERS: Disasters: Meaning and definitions, difference between disaster and hazard, causal factors, development leading to disaster, characteristics of disasters, forecasting and warning of disasters, elements of early warning systems Classification of Disasters: Natural and man-made hazards, hazard zonation and risk assessment, mitigation strategies, Man- Made Disasters: Types and nature of man-made disasters, general effects and mitigation strategies for manmade disasters, Biological Disasters: Meaning, types, vulnerability, effects, preparedness and mitigation of Biological disasters, Chemical and Radiological Disasters: Causes, impacts and management of chemical and radiological disasters, **NATURAL DISASTERS- I:** Natural Disasters: Introduction, meaning, nature and types of natural disasters, general effects of natural disasters, Earthquake and Seismic Hazards: Origin and severity of earthquakes, effects of earthquakes, risk evaluation, seismic zonation of India with special reference to Himalayan Region, earthquake mitigation measures, Volcanic Eruptions: Nature, causes, monitoring and mitigation of volcanoes, Landslides: General characteristics, causes, vulnerability, effects, prediction and warning and risk reduction mitigation measures, Snow Avalanches: Formation of avalanches, classification, mitigation and management of avalanches, **NATURAL DISASTERS- II:** Floods: Causes of flood, flood and draught, erosion and sedimentation, flood prone areas of India and associated hazards, assessment and management of flood, Cyclones: Nature and genesis, anticyclones, weather associated with cyclones, Geological changes and other effects, Tsunami: Origin and nature, causes of tsunamis, wave propagation, impact on coastal areas, warning and prevention, tsunami mitigation measures,

Drought: Meaning, types, general characteristics, causes and impacts, prediction and warning and mitigation measures, Heat and Cold Waves: Causes and impacts, prevention, preparedness and response, **DISASTER MANAGEMENT:** Disaster Management: Definition, objectives and scope of disaster management, elements of disaster management, role of professionals in the management of disasters, disaster management cycle, Disaster Response: Response plans, search, rescue and evacuation, community health and casualty management, vulnerability assessment & Risk analysis with respect to various disaster, corporate social responsibility (CSR), **DISASTER MITIGATION AND PREPAREDNESS:** Disaster Preparedness: Disaster preparedness plans, pre-requisites of preparedness planning, role of Information Technology, education, communication, and awareness in preparedness, Rehabilitation and Reconstruction (R and R): Social and economic aspects of R and R, Housing, relocation, retrofitting, repairing and strengthening of houses, reinstating livelihoods, national policy on disaster management, Institutional framework (NDMA, SDMA, DDMA, NDRF & ODRAF).

4. CURRENT ENVIRONMENTAL ISSUES AND THEIR MANAGEMENT:

GLOBAL WARMING, GREENHOUSE EFFECT AND OZONE PROBLEMS: Global Warming Potential, Possible Impact of Global Warming, Greenhouse Effect – Policy Response, Kyoto Protocol, EI-NINO- Climate Cycle, Ozone in the Atmosphere, Ozone Depletion Process, Ozone Hole, Worldwide, Ozone Trends, the Montreal Protocol, Consequence of Ozone Depletion, **ACID RAIN, ATMOSPHERE TURBIDITY AND NUCLEAR:** Introduction, Nature and Development of Acid Rain, Acid Rain and Geology, Acid Rain and Aquatic Environment, Acid Rain and Terrestrial Environment, Acid Rain and Build Environment, Acid Rain and Human Health, Mitigation of Acid Rain Problems, Aerosol types, Production and Distribution, **OTHER ENVIRONMENTAL ISSUES:** Introduction, Consequences of global CO_2 changes; Strategies for Conservation of Environmental Changes Induced by CO_2 Rise, Problems of slums in urban cities, Cancer and AIDS, Descriptive and analytical markers and indicators of pollutants in the body; Water-borne, air borne, vector borne, genetic, contagious and non-contagious diseases and their management, Sanitation measures to control infectious diseases, Environmental problems in India (Narmada Dam, Tehri Dam, Almetti Dam, Soil erosion, Formation and reclamation of usar land, alkaline and saline soil; Unsustainable Agricultural Practices and Land Use Planning); recent problems like Delhi smog, crop burning, **ENVIRONMENTAL POLICES AND REGULATIONS:** Fundamental principles of environmental protection, Constitutional perspective: Fundamental right to wholesome environment, directive principles of state policy, National Environmental Policy, Environmental regulatory framework in India, Role of international Environmental Agencies-UNEP, GEF, UNFCC and IPCC, **ENVIRONMENTAL TREATIES AND CONVENTIONS:** Stockholm Convention (1972), Basel Convention (1989, 1992), Earth Submit at Johannesburg (2002), Earth Summit Rio De Janeiro (1992, 2012), Kyoto Protocol, 1997; Montreal Protocol, 1987; Ramsar Convention on Wetland, 1971, Paris Agreement (2015), Rotterdam Convention on Prior informed consent procedure for certain hazardous chemicals and pesticides in International schedule, Agenda 21, sustainable development goals, India's role in various conventions and contributions.

5. ENVIRONMENTAL POLLUTION:

Introduction: Definition and sources of pollution**,** Different types of pollution**,** Global and regional scenario of pollution**, Air Pollution:** Types and sources of air pollutants, Reaction of pollutants in atmosphere; atmospheric diffusion and stack performance, air quality standards**,** Introduction of basic instruments for sampling and analysis of air pollutants**,** Effects of air pollutants on flora and fauna, Biological indicators of air pollution, Bio-monitoring of air pollutions**, Water Pollution:** Sources and kinds of water pollution, water quality standards**,** Effects of water pollutants on plants (phytoplankton and macrophytes); Effects of water pollutants animals (zooplankton, macro-benthic invertebrates and fish)**,** Eutrophication and its impacts on organisms and communities, Impact of heavy metals, halogens, radio-nuclides on aquatic flora and fauna, **Noise and Land Pollution:** Physiological, social and psychological effects of noise**,** Methods of noise abatement; shock waves and SST; Noise control in vehicles**,** Industrial noise control and effects**,** National and International standards**,** Soil pollution, Sources and management of municipal solid waste, Biodegradable & Non-Biodegradable waste, Hazardous and Non Hazardous waste, Biomedical waste, Hazardous waste and Industrial waste & Agricultural waste**, Thermal Radiation Pollution:** Thermal pollution: Concept of thermal pollution, sources of thermal pollution, thermal power plant pollution, thermal effects on aquatic life, impacts on water quality, prevention of thermal pollution, Radiation pollution: Causes, effects (health hazards) and control measure of radiation pollution, Applications of ionizing isotopes in waste water and air pollution analysis and treatment.

6. NATURAL RESOURCES: CONSERVATION AND MANAGEMENT:

Natural Resources: Flora: Natural resources: introduction, characteristics and classification**,** Concept of endemic, extinct and threatened species (endangered, rare, vulnerable and indeterminate species)**,** Plants as a natural resource: a general account with reference to timber, food and medicines**,** Degradation of plant resources: Causes and Consequences**, Natural Resources: Water and Animals:** Wild life as natural resources: A general account with special reference to game wildlife and food, wildlife of India**,** Depletion of wildlife: causes and consequences**,** Fisheries: Status and conservation with special reference to India and Himachal Pradesh**, Natural Resources: Soil and Minerals:** Soil as a natural resource, a general account with reference to nutrients and soil biota**,** Role of agricultural practices, wind and water erosion in soil degradation**,** Origin, distribution and uses of economically important minerals; exploitation of mineral resources from oceans with special reference to India**,** Impact of exploitation of minerals on environment, methods of conserving the mineral resources**, Natural Resources: Energy:** Energy, demand and supply scenario in India, energy conservation measures**,** Coal, oil and natural gas (physico-chemical characteristics and energy content of coal, petroleum and natural gas)**,** Principles of generation of Hydro energy, wind energy, tidal energy, solar energy, nuclear energy, Biogas, firewood, petero-plants, dendro-thermal energy and their application; impacts of large scale exploitation of different forms of energy**, Natural Resources: Conservation Strategies and Management:** In-situ conservation of plants and animal species: Natural Parks, Biosphere reserves and sanctuaries**,** Ex-situ conservation: Botanical gardens, Zoological parks, tissue culture techniques, cryo-preservation of pollen, seeds and sperms**,** Conservation of forests, social forestry and agro-forestry, carbon sequestration**,** Conservation of soil and management of grasslands and wetlands.

7. ECOTOXICOLOGY AND RADIATION IMPACTS:

Concept and Historical Background: Origin and scope of toxicology, relationship with other sciences**,** Development of environmental toxicology (Historical and evolutionary Perspective)**,** Classification of toxicants, natural and synthetic toxins, sources of toxicants**,** Basic concepts of toxicology, types of toxicity, acute and chronic toxicity**,** Toxicants and toxicity, factors affecting toxicity, types of toxins and basic mechanism of action**, Mode of Action and Effects of Toxicants:** Environmental Toxicants: Mode of action of toxicants, factors affecting the metabolism of xenobiotics; transport process mechanism of toxicants, mode of action and impacts of Arsenic, Cadmium, Lead, Mercury, Carbon-Monoxide, Nitrous Oxide, Sulphur Dioxide, Ozone, Cyanide, mode of action of pesticides**,** Toxicity impacts: Health impacts of toxicants on human and aquatic life, long- term effects-chronic, carcinogenic, mutagenic and teratogenic effects**, Occupational Health:** Health problems related to occupation (due to dust, heat, stresses, chemicals, toxic gases, insecticides and pesticides and metals) Risk Assessment and Management in the Workplace (Workplace Exposure Assessment, Risk Management in the Workplace), Dose response relationship, LD 50, LC 50, toxicity testing, acute toxicity tests**,** Sub-acute and chronic toxicity tests, heavy metal toxicity tests**, Radiation Impacts:** Natural and man-made radiation, application of radiations, sources of ionizing radiation, types of ionizing radiation, radiation dose and units, direct and indirect effects**,** Dose limits, radiation hazard**,** Personal protection and house-keeping and safety rules**, Effects of Radiations:** Molecular and cellular radiobiology: Biological effects of radiation, Radiation lesions in DNA, Major types of DNA repair, DNA damage and repair, chromosomal aberrations and gene mutations, cell death, cell survival curve, consequences of unrepaired DNA damage, radiobiological definition of cell death, cell cycle effects**,** Impact of radiations on biological molecules (proteins, nucleic acids, lipid and carbohydrates), Radio-protectors and Industrial safety requirements, industrial radio-protector.

PART-II (60 MARKS)

1. ENVIRONMENT IMPACT ASSESSMENT:

Overview of EIA: Objectives and developmental Concept, origin of EIA, Benefits of EIA, Indian directions guidelines (GOI different notification of EIA)**,** Rapid and comprehensive EIA perspectives, Sources and collection of data for EIA. Measurement of Impact (Physical, social, economic, natural)**, EIA Methodology:** Outline of EIA process, Screening, Scoping, Purpose of scoping, impact implications, Baseline studies and superimposition of projected plant emission impacts; reliability of database; intrinsic and external database supports and interpretation; checklist, matrices, Overlays and Geographical Information System, Impact analysis and Predictions, Environmental Impact Statement [EIS]; Public hearing as part of EIA; EIA report, **Prediction and Assessment of Impacts:** Prediction and Assessment of Impacts on Water Environment, Air Environment, Noise Environment, Biological Environment, Cultural and Socio-cultural Environment, EIA of River valley project, Hydro power project, Cement plants and Mining**,** Prediction and assessment of: Impact of tourism on environment, impact on flora and fauna in Himalayan region**, Public Participation:** Social

impact assessment (SIA), Strategic Environmental Assessment (SEA), types of impacts, Public involvement, Public Hearing compulsion, restoration and rehabilitation methodologies, Mitigation criteria, Project modification, Post project analysis, **Environmental Management and ISO certification:** Environmental Management Systems (EMS), ISO 14000 (EMS). Components of Environmental Management System-Objectives, Policies, Implementation and Review, Life Cycle Analysis –LCA. Waste minimization and product augmentation.

2. REMOTE SENSING AND GIS:

Introduction to Remote Sensing: Definition of remote sensing; introduction to concepts and systems, Scope of remote sensing**,** Electromagnetic Spectrum; Radiation principles; image characteristics**,** Remote sensing systems; remote sensing platform**,** Sources of remote sensing information; advantages of remote sensing**, Microwave Sensing:** Types of microwave systems, advantages, band designation, range resolution, azimuth resolution, real and synthetic aperture systems**,** Radar equation, radar return and image, Signatures, dielectric properties and interaction with vegetation Surveying**,** Leveling, Triangulation, Geo-datic survey**, Aerial Photographs and Satellite Imageries:** Interaction between light and matter, Characteristics of aerial photographs, Visual interpretation of aerial photographs and satellite imageries, Instruments used in interpretation, Path and Row Index Maps; selecting and ordering images, **Digital Image Processing:** Introduction to digital image processing, basic concept and principle, imagerectification and restoration, Image enhancement; manipulation; image classification; the output stage; data merging; conclusion, **Application of Remote Sensing in Environmental Management:** Remote sensing in natural resource management - forest resources, waterresources, land resources and mineral resources, Hazard and disaster mapping and management, Introduction to GIS; principle of GIS; terminology used in GIS; space and time in GIS, Maps and its characteristics, map scale, map symbology; spatial relationship;data structure and spatial analysis in GIS; GIS data; software used in GIS.

3. ENVIRONMENTAL CHEMISTRY AND GREEN TECHNOLOGY:

Concept and Scope of Environmental Chemistry: Nomenclature, segments of environment, Concept and scope of Environmental Chemistry**,** Chemistry of biologically important molecules, chemistry of water, hydrogenboding in biological systems**,** Chemistry of various organic and inorganic compounds**,** Chemistry of hydrocarbon decay, environmental effects, effects on macro and microorganisms**, Fundamentals of Environmental Chemistry:** Stochiometry, Gibb's energy, chemical potential**,** Chemical equilibrium, Acid-base reaction, solubility product, solubility of gases in water**,** Solubility product, solubility of gases in water the carbonate system unsaturated and saturated hydrocarbons**,** Surfactants: Cationic, anionic and nonionic detergents, modified detergents**,** Pesticides: Classification, degradation, analysis, pollution due to pesticides and DDT problems, organochlorides, organophosphates, organo-carbamates, herbicides**,** Synthetic Polymers: Microbial decomposition, polymer decay, ecological and consideration, Photosensitize additives, **Environment and Global Warming:** Chemical composition of Air: Classification of Elements, Chemical speciation**,** Chemical process for formation of inorganic and organic particulate matter**,** Thermo-chemical and Photochemical reaction in the atmosphere, Oxygen and Ozone chemistry, Chemistry of Air pollutants; photochemical smog. O3, N0x, HC CFCS and PAN**,** Chemistry of greenhouse gases, emission of CO2,

Consequences of greenhouse gases, their control and remedial measures, threats of Global warming**, Principles of Green Technology:** Overview of green chemistry, principles of sustainable and green chemistry**,** Waste minimization and climate change**,** Introduction to nano-materials and green nanotechnology**,** Nano-medical application of green nanotechnologies**, Application of Green Technology:** Green technology in industries, fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources, solar photovoltaic technology**,** Bio fuel production (bio-ethanol and biodiesel)**,** Biomass, prevention/ minimization of hazardous/ toxic products, production of biodegradable materials, concept of green building.

4. RESEARCH METHODOLOGY, STATISTICS & COMPUTER APPLICATIONS:

Introduction to Research and Scientific Writing: Characteristics and types of Scientific Research**,** Organizing Scientific Research: Experimental Design, Research Methodology, Sampling designs**,** Writing research proposals, research paper, reviews, thesis, conference reports, book reviews, project reports, reference writing and scientific abbreviations**,** Preparation and delivery of scientific presentations**, Basic Concepts of Statistics:** Importance and scope of Statistics**,** Primary and secondary data - collection of data**,** Sampling of data - random and non-random sampling**,** Diagrammatic (Line, bar, pie diagram) and Graphic (Histogram, frequency polygon, frequency curve, cumulative frequency curve) representation of data, Measures of central tendency – Mean (AM, GM and HM), Mode and Median, Measures of dispersion, skewness and kurtosis**, Probability Distribution:** Probability distribution - Binomial distribution**,** Poison distribution**,** Normal distribution**,** Test of hypothesis, two types of errors**,** T-Test for assumed population mean and comparison of two samples**, Statistical Tests:** Chi square tests and its application**,** Co-relation and regression**,** Principles of design of experiments. Examples of CRD and RBD**,** Analysis of variance (one way and two way analysis of variance)**, Computer Application and Environment System Analysis:** Basics of Computer: meaning, definition, types and main parts, structure of Central Processing Unit (CPU); Software: Meaning and types, Application of Software, System and customized software, software piracy; Booting: meaning and types**,** Operating System and Memory: meaning and types of operating systems, i.e. UNIX, LINUX, MS-DOS, Microsoft Windows; Memory: meaning and types, Storage capacity and Storage media**,** Computer Networking and Cybercrime: meaning, types of network, data security, password, firewall, encryption, backups, wireless networking; Internet: Benefits of internet, web browsing, Digital/Cybercrime, Application of computers in Environmental Sciences, Environment System, Analysis, Meteorology and Climatology, Surface and Groundwater Hydrology, Environmental Management and Decision Analysis, Databases, Satellite Data, Image Processing and Remote Sensing; Software Models.

5. TECHNIQUES IN ENVIRONMENTAL MONITORING AND ANALYSIS:

Sampling Methods: Sampling methodologies for Air, Water, Soil, Noise and Radioactivity in environmental matrices. Sampling protocols- Selection of sites, Time and frequency for sampling, Preservation, Storage and Handling of samples. Good Laboratory Practices, **Analytical Instruments:** Principles, working and applications of High volume sampler, Respirable Sampler, Impactors, Cyclones, Particle Size Analyser, Gas Analysers, Spectrophotometer (UV-Visible), Flame Photometer, Atomic Absorption spectrophotometer

(AAS). Head space analysis, leaching tests, and immunoassay, **Advanced Microscopy and Chromatographs:** Principles, working and applications of Phase contrast, fluorescent, polarization Microscopes, SEM. Gas Chromatograph (GC), GC-MS, HPLC, Ion chromatograph, X-ray diffraction, ED-XRF, WD-XRF, ICP-MS, ICP-AES**, Radiation Detectors and Monitors:** Principles and working of radiation detectors- gas filled, scintillation (inorganic and organic) and semiconductor. Principles and working of Alpha Counter, Beta Counter, Gamma-ray Spectrometer, Liquid scintillation Counter, Beta-Gamma survey meters, Alpha, Beta and Gamma contamination Monitors.

6. ENVIRONMENT LAW, GOVERNANCE, ETHICS AND POLICY:

Introduction to Environmental Laws: Historical background of Environmental Law and Policy in India, Constitutional mandate for environmental protection, Environmental Protection: Issues and Problems, Key International Efforts for Environmental protection, Sustainable Development: Essential features and Legal Implications, UN Framework Conventions on Climate Change, 1992, Kyoto Protocol, 1997, **Environmental Protection Law:** Environmental laws, environmental Policy in India, Indian Constitution and Environmental Protection, Environment (Protection) Act, 1986: Salient Features, Powers of Central Government under EPA, Prevention, Control and abatement of environmental pollution under EPA, Hazardous wastes (Management, Handling and Transportation) Rules, 2008, Public Liability Insurance Act, 1991, **Pollution Abetment and the Law:** Water (Prevention and Control of Pollution) Act, 1974: Salient Features, Powers and Functions of CPCB and SPCB under Water Act, Air (Prevention and Control of Pollution) Act, 1981, Powers and Functions of CPCB and SPCB under Air Act, Noise pollution (Regulation and Control) Rules, 2000 (Note: Only relevant provisions of the above Acts), **Natural Resource Conservation and the Law:** Wildlife (Protection) Act, 1972: Salient Features, Protected Areas and Trade and Commerce under WPA, National Forest Policy, Forest Conservation Act, 1986, Biological Diversity Act, 2002, **Judicial Activism and Environmental Protection**: Judicial Response towards Environmental Protection, Public Nuisance under IPC (Sections 268,277,278,284, 290,291), Sections 133-143 of Criminal Procedure Code, 1973, Role of UN authorities in protection of Global Environment, Evolution of International Environmental Law, International Environmental Law and the Challenge of Globalization, Recent Trends in International Law, National Green Tribunal (NGT).

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Syllabus for the descriptive **Subject Aptitude Test (SAT)** for the recruitment to the post of **Environment Officer (Class-I, Gazetted)** in the **Department of Environment Science, Technology** and **Climate Change, Himachal Pradesh** 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 **Master of Science (Botany) level.**

PART-I (60 MARKS)

1. BIOLOGY AND DIVEERSITY OF ALAGAE AND FUNGI:-

Algae: Algae in diversified habitats (terrestrial, freshwater, marine), Thallus organization in algae, Cell ultra-structure, Reproduction (Vegetative, asexual, sexual) and patterns of lifecycle, Criteria for classification of algae (pigments, reserved food, flagella), Fine structure of algal plastids, Algal blooms, Algal bio fertilizers, Economic importance of algae, General account of lichens and their economic importance, **Fungi:** General characteristics of fungi, their significance to human, organization of fungal cell, thallus and modifications thereof; ultra structure, reproduction(vegetative, asexual, sexual), recent trends in classification, Comparative study of habit, habitat, somatic organization, anamorphs, teleomorphs and evolutionary tendencies ,in any of these phases in the life cycle of the members of Dictyosteliomycota and Myxomycota (Dictyostelium, physarum) Chytridiomycota and Oomycota (olpidium, synchytrium, Allomyces, Plasmodiophora, Saprolegnia, Pythium, Pyytophora and Downy mildews), Zygomycota (within members of Zygomycetes),Ascomycota (Ascocarp development, ascocarp types, centrum types and their bearing on classification, with emphasis on Protomyces, Taphrina, Yeast, Penicillum, Aspergillus, Chaetomium, Neurospora, Claviceps and Venturia; and general account of powdery mildews and Discomycetes, Basidiomycota, (basidiocarp types, development, general account of Hymenomycetes, Ustilaginomycetes and urediniomycetes, Alternaria, Helminthosporium, Cercospora, Colletotrichum, Pyricularia, Fusarium, Sex hormones in fungi, Heterothallisum and parasexual cycle in fungi, nutrition in fungi(saprophytes, parasites, predators, symbionts), importance of Fungi indifferent microbiological and Biotechnological processes fungi in food and food industry , as agents of bio deterioration and biodegradation, in agriculture, in medical biotechnology and as agents of biotransformation, biosorption and biomining.

2. BIOLOGY AND DIVERSITY OF MICROBES AND PLANT PATHOGEN:-

Plant Pathology: History of plant pathogens, concept, diagnoses, classification, importance and identification of unknown diseases; symptomology and disease development, Host-pathogen interaction at plant and cellular level: Mechanism of pathogen attack and defense: Physical, Physiological, biochemical and molecular aspects, Host-pathogen- interaction at population level: Transmission and spread of plant pathogens, disease epidemics,, modeling and disease forecasting to control crop losses, Management of plant disease: Chemical, Biological, IPM system, development of transgenics, biopesticides, plant diseases clinics, quarantine, Genetics of plant disease: Gene for virulence and a virulence. Their application in resistance and susceptibility, induced resistance (immunization), Specific plant disease caused by diverse pathogens: Black wart disease of potato, Club root of crucifers, damping of seedlings, late blight of potato, downy mildew of grapes an bajra, stem gall of coriander, peach leaf curl, powdery mildew of wheat and apple, apple scab, general account of rusts,

smut and bunts, Fusariam wilt of tomato, rhizome rot of ginger, tikka disease of groundnut, red rot of sugarcane, brown leaf spot and blast of rice. Bacterial blight bean, common scab of potato, fire blight of apple, citrus canker, potato leaf roll, potato spindle tuber, tobacco mosaic virus, **MICROBES:** History and scope of microbiology, landmarks in microbiology, major groups of microorganism, characterization, identification and classification of microorganism, **Structure of Bacteria:** Structure and fine structure of cell and of internal and external structure to cell wall, spores and cysts. Nutrition of bacteria: modes of nutrition, nutritional types, growth characteristic, **reproduction and genetic recombination:** Binary fission, resting structure, conjugation, transformation and transduction; mechanism of antibacterial action, General account of Rickettsia, Chlamydeae, Mollicutes and disease caused by them, **Virus:** History, structure and classification, plant and animal viruses, nature and transmission, genome organization (TMV, CMV, CAMV and Gemini viruses), isolation and purification, detection, identification and economic importance; Bacteriophages, viroids and prions nature and importance, Viruses in cancer; **Principals of immunology:** general account of immunity, allergy antigen- antibody, serology and types of vaccines, Applications of microbes in agriculture (Biofertilizers, biopesticides), industry (alcoholic beverages, citric acid, penicillin production), environment (pollution indicator and control), and genetic engineering.

3. BIOLOGY AND DIVERSITY OF BRYOPHYTES PTERIDOPHYTES :-

BROPHYTES: General Introduction and Salient feature of Bryophytes. Classification of Bryophytes, A general account of Marchantiales, Jungermanniales, Anthoceerotales, Sphagnales, Funariales and Polytrichales (emphasis is not to be placed on Families or type Studies), A general account of Peristome in Mosses, Origin of land Plants including Fossil evidence, Primitive versus Advanced/ Derived feature and Evolutionary Lines within Bryophytes, Morphogenesis in Bryophytes, Distribution and Ecology of Bryophytes in India with particular reference to Himachal Pradesh, Ecological importance of Bryophytes, Economic importance of Bryophytes, **PTERIDOPHYTES:** General introduction and salient feature of pteridophytes; comparision among archegoniatae, Classification of Pteridophytes, Introduction to Palaebotany, some basic principles and techniques, A general account of the following fossils pteridophytes: Rhynia, Horneophyton, Trimerophyton, Psilophyton, Zostero phyllum, Asteroxylon, Lepidodendron, Sigillaria, leuromeia, Nathorstiana, sphenophyllum, sphenophyyostachys, Calamites, Cladoxylon, Etapteris, Ankyropteris and Osmundites, Salient feature of Psilopsida, Lycopsida, Sphenopsida and Pteropsida (Emphasis is not to be placed on orders, Families or Types studies, Structure and Evolution of Stelar system in Pteridophytes, Telome Theory Natural and Induced Implications of Apogamy in Pteridophytes, Natural and Induced implications of Appspory in Pteridophytes, Heterospory and seed habit in Pteridophytes, Distribution and Ecology of the Ferns of the Himalayas with particular reference to Himachal Pradesh, Cytological Evolution in Pteridophytes, Economic importance of Pteridophytes.

4. PLANT RESOURCES UTILIZATION AND BREEDING:-

Forest Products Wood and Timber: General Introduction, Formation and Composition of wood, Difference between softwoods and hardwoods, Sapwood and Heartwood, Storied and Nonstoried wood, and between Ring porous and Diffuse porous woods, Definitions of various

types of annual Rings; Properties and seasoning of woods; uses of woods, structure and identification important timber plants namely

Pinus, Cedrus, Tectona and Populus, Non wood forest **Products: I-** Bamboo-The **Green Gold of India, Its structure, Properties and uses, Non wood Forest products: II-Cork–** Its structure, properties and uses**, Non wood Forest products: III –Tannins and Dyes :** A general account**, Non wood Forest products : IV-Gums and Resins –**A general account**, Plant resources I–Aromatic Plants-** a general account , essential oils and Perfumery**, Plant resources: II-Psycho active drugs and poisons from plants:** a general Account**, Plant resources III- Fruits and Nuts-** a list of important fruits and nuts with particular reference to Himachal Pradesh (Details are not required)**, Plant resources IV-Under exploited/ under utilized plants-**Winged or Goa Bean (*Psophocarpus tetragonium*); Jojoba or hohba (*Simmondisa chinensis*), Guayule or Wuyule (*Parthenium argentatum*), Leucaena or subabul (*Leucaena ieucocephala*) and Triticale (*Triticosecale*). A general account, of Edible wild plant**, Plants resources V- Ornamental Plants-** A list of important ornamental plants of Himachal Pradesh, Economic importance of flowers, **Plant resources VI- Bioenergy (biofuels) of plant origin-** A general account of fuel wood, energy Plantations, organic waste materials for energy, petroleum plants. Alcohol Fuel and Biogas, A general account of the origin of cultivated Plants with special reference to Vavilov's centres of origin, A general account, of Plant introduction and Acclimatization, Methods and modes of reproduction in relation to breeding Self pollinated, Cross pollinated, Vegetatively propagated and Apomictic Plants, A general accounts of Inbreeding Depression and Heterosis; Exploitation of Hybrid Vigour; Production of Hybrids, Composites and Synthetics**.**

5. CELL AND MOLECULAR BIOLOGY :-

Structural organization of plant and animal cell: Cell Wall: structure, function and biogenesis, Plasma membrane: structure, models, functions, sites for ATPases, ion carries, channels and pump, Plasmodesmata: structure, role improvement of molecules,

comparison with gap junctions, Plant vacuole: Tonoplast membrane, ATPase as storage organelle, Structure and functions of micro bodies: Golgi apparatus, lysosomes, endoplasmic reticulum, Chloroplast and mitochondria: Structure, genome organization, gene expression, nucleocytoplasmic interactions, biogenesis of mitochondria, Nucleus: structure, nuclear pores, nucleosome organization, nucleolus, The cytoskeleton: Organization and role of micro tubules and micro filaments, motor movements, implications in flagellar and other movements, Cell cycle and apoptosis: Control mechanism, role of cyclins, cyclin- dependent linases, cytokinesis and cell plate formation, mechanism of programmed cell death, Gene expression: DNA structure; A, B, and Z forms; replication, damage and repair, Transcription, promoters and transcription factors, splicing, mRNA transport, rRNA biosynthesis, difference in prokaryotes and eukaryotes, Transcription: structure of ribosome, mechanism of translation, initiation, elongation and termination, structure and role of RNA, Regulation of gene expression in prokaryotes and eukaryotes, Protein sorting: Targeting of proteins to organelles.

6. BIO STATISTICS AND COMPUTER APPLICATION :-

Brief description and tabulation of data and its graphical representation, Measures of central tendency and dispersion: mean, median, range, standard deviation and variance. Correlation

and simple linear regression, Sampling: Sampling Techniques, sampling errors, Framing Hypothesis, level of significance, test of significance (F & t test), chi-square test, Introduction of digital computers; Organization; low-level and high level languages; binary number system, Flow charts and programming techniques, Introduction to programming in Q Basics, Introduction to data structure and database concepts; introduction to internet and its application Introduction to MSOFFICE software, covering word processing; Spread sheets and presentation software, Computer Oriented Statistical Techniques, Frequency table of single discrete variable, Computation of mean, variance and standard deviation; t-test, correlation coefficient, Bioinformatics.

7. BIOLOGY AND DIVERSITY OF GYMNOSPERMS:-

General Introduction and Salient feature of Gymnosperms, Comparison among Tracheophyta, Classification of Gymnosperms, Introduction to Palaeobotany, some basic principles and techniques, A general account of the following Fossil Cycadopsida: Archeopteris, Tetrasticha, Heterangium, Lyginopteris, Sphaerostoma, Telangium, Crossotheca, Medullosa, Pachytesta, Whittleseya, Aulotheca, Doleerotheca, Calamopitys, Glossopteris, Hirsutum, Caytonia, Williamsonia, wiellandiella, Cysadeoidea, Pentoxylon and Palaeocycas, A genereal account of following fossil Coniferopsida: Eristophyton, Mesoxylon, Cordaites, Fossil Conifers and Trichophys, Salient feature of living Cycadales, Coniferales (including Taxus) and Ginkogoales (Emphasis is not to be placed on families or Type Studies,) A general account of Ephedrales,Welwitschiales and Genetales, Distribution of Conifers in India with particular reference to Himachal Pradesh, Economic Importance of Gymnosperms, Structure, Identification and Evolution of wood in Conifers, Structure, Properties and Uses of the following commercial timbers: Blue Pine, Chirpine, Deodar, Cypress and Yew, Structure, Identification and Evolution of Bark in living gymnosperms, Comparative account of the Leaf Anatomy of the living gymnosperms, Comparative study of Males cones of living gymnosperms, Pollination mechanism in living gymnosperms, Comparative study of Female Cones of living Gymnosperms, Comparative study of Males Gametophytes of living Gymnosperms, Comparative study of Females Gametophytes of living Gymnosperms, Structure and evolution of Archegonium in Gymnosperms, Cytological Evolution in Gymnosperms.

8. BIOLOGY AND DIVERSITY OF ANGIOSPERMS-I :-

Morphology: Fossil Angiosperms, Origin and evolution of Angiosperms (Special reference to Bennettitales, Gnetalean, Caytonialean and herbaceous origin theories), Taxonomy: Systems of angiosperm classification, Phenetic vs Phylogenetic system, Relative merits and demerits of major systems of classification, International code of Botanical Nomenclature: History, Principles and rules, Type method, Principles of priority and its limitation, Names of Hybrids and cultivars, The Species Concept, Taxonomic hierarchy, species, genus, family and other categories, Principles used in assessing relationship, delimitation of taxa and attribution of rank, Modern Taxonomy: Inputs for taxonomy, Taxonomy in relation to anatomy, embryology, palynology, cytology, secondary metabolites in Plants, Numerical taxonomy, Concepts, Characters and attributes, OTU's, Cluster analysis, Cladistics, Systematic in practices, Importance and role of herbarium, specimens and their preparation, Botanical

Garden, Importance and role, Value of computers and databases for identification, Concepts of Phytogeography, Endemism, hotspots and hottest hotspots, Plant exploration, invasion and introductions, Local plant diversity and its socio-economic importance, Plant Resource Conservation: Principles of conservation ii)Extinctions, Environmental Status of plants based on I.U.C.N, Strategies for *In-situ* and *Ex-situ* conservation, Principles and practices.

PART-II (60 MARKS)

1. CYTOGENETICS & EVOLUTION:-

Chromosome Organization: Structure of chromosomes, DNA packaging and DNA replication, Meta phase chromosomes, centromere, Kinetochore, Telomere and its importance, Hetero chromatin and euchchromatin, Chromosome banding, Polytene and lamp brush chromosomes, Sex chromosomes, sex determination and dosage compensation in Drosophila and human, Mendelian and non-Mendelian Inheritance: Mendelian inheritance and its modification, Maternal effect, Epigenetic inheritance, Extra nuclear inheritance, Variation in Chromosome structure and number, Brief description of gene expression: Consequences of Mutations Occurrence and causes of gene mutation, DNA repair, Quantitative genetics: Quantitative traits, Poly genetic inheritance, Heritability, Population genetics and evolution: Gene in populations, The Hardy-Weinberg Equilibrium, Factors that changes allele frequencies in populations: Mutations, Migration, Natural selection, Random genetic drift, Genetic load, Origin and evolution of species: Biological species concept, Anagenesis and cladogenesis, Alllopatric, para patric and sympatric speciation, Gradualism and punctuated equilibrium, Neo-Darwinism, The shifting-Balance Theory of Evolution, Molecular evolution**:** Experimental approaches used to compare species at molecular level, Phylo genetic trees, Molecular drive-a cohesive mode of species evolution, Neutral theory of Molecular Evolution.

2. IMMUNOLOGY AND BIOTECHNOLOGY:-

Introduction to Immunology: Innate and acquired immunity, characteristics if immune response, humoral and cellular immunity, benefits and damaging effects of immunology, Cell and tissues of immune system: Cell of immune system, primary and secondary lymphoid organs, Antigens: Immuno genes, major classes of antigens, physical and chemical properties of antigens, Immunoglobulin's: Structure and functions of immunoglobulin's, classes and subclasses of human immunoglobulin's, polymorphism, primary and secondary immune response, Complement System: Complement proteins, pathway of complement activation, Antigen-antibody reaction: Precipitaition, agglutination, Immuuno fluorescence, radio immune assay, ELISA, immune blotting, Monoclonal antibodies: Hybridoma, Isolation and characterization of monoclonal antibodies, Hypersensitivity: Anaphylaxis, antibody-mediated cytotoxic and immune complex reactions, delayed–type hypersensitivity, BIOTECHNOLOGY: Scope, significance, microbes and microbial systems and their improvement for biotechnological use, Principles and techniques of plant cell culture, Principles and applications of DNA recombinant technology to agricultural and human diseases. Aims, strategies for development of transgenics (with suitable examples),

intellectual property rights, possible ecological risk and ethical concerns. Construction of genomic/c DNA libraries, PCR and DNA finger printing, Fermentation technology, design, process, scale up downstream processing, production of antibiotics, beverages, enzymes; Ethanol and methane from biomass; bioremediation, biopesticides and biosensors, single cell protein.

3. BIOLOGY AND DIVERSITY OF ANGIOSPERMS–II

Plant Development: Apical, lateral and intercalary meristems-their ultra structure, histochemistry and organogenesis, Anomalus growth-stem, Ecological anatomy, **Reproductive Biology: Male Gametophytes: (i)** Structure of anthers (**ii)** Micro sporogenesis (**iii)** Role of tapetum **(iv)** Pollen development, **(v)** Male sterility **(vi)** Sperm dimorphism **(vii)** Pollen tube growth and guidance, **Female Gametophytes: (i)** Ovule development **(ii)** Mega sporogenesis **(iii)** Structure and organization of the embryo sac **(iv)** Nutrition of the embryo sac, Pollen pistil interaction fertilization, Pollen stigma interaction, sporophytic and gametophytic self incompatibility (Cytological, biochemical and molecular aspects; *In vitro* fertilization), Seed Development, Endosperm development during early, maturation and desiccation stages, Embryogenesis, ultra structure and nuclear cytology; cell lineage during late embryo development, Embryo culture, Seed Dorman Importance and types of Dormancy, Overcoming seed dormancy, **Palynology:** Basic techniques to study pollen, Pollen viability and storage, Pollen allergy, **Tissue Culture:** Methods of tissue culture, Nutrient Media, Haploid induction; fundamental aspects, Protoplasts; their isolation, culture and fusion, Applied aspects of tissue culture, Applied aspects of cultivated plants, growth regulators and their use in horticulture, Clonal propagation, Propagation of pathogen-free plants, Germs-plasma storage and conservation.

4. PLANT PHSIOLOGY:-

Plant –water relations, transport of solutes: Physicochemical properties of water, water potential, apparent free space, bulk movement of water, SPAC, passive and active solute transport, Stomatal physiology: Chemio-osmotic mechanism of stomatal movements, hormonal regulation and significance of calcium ions, Photochemistry and Photosynthesis: General concepts and historical background, evolution of photosynthetic apparatus, photosynthetic pigments and light harvesting complexes, Photo-oxidation of water, mechanism of electron and proton transport, carbon assimilation: the calvin cycle, photorespiration and its significance, the c4 cycle, the CAM pathways, biosynthesis of starch and sucrose, physiological and ecological considerations, Respiration : Over view of plant respiration, glycolysis, the TCA cycle, electron transport and ATP synthesis, structure and functions of ATP, pentose phosphate pathways, glyoxylate cycle, alternative oxidase system, Nitrogen fixation, nitrogen and sulphur metabolism: Overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction, ammonium assimilation, sulphate uptake, transport and assimilation, Sensory photobiology: History of discovery of phyto chromes and crypto chromes, their photochemical and biochemical properties, photobiology of light- induced responses, cellular localization, molecular mechanism of action of photo morphogenetic receptors, signing and gene expression, Plant growth regulators and elicitors: Physiological effects and mechanism of action of auxins, gibberllins, cytokinins, ethylele, abscisic acid, The flowering process: Photo periodism and its

significance, endogenous clock and its regulation , floral induction and development- genetic and molecular analysis, role of vernalization.

5. BIOCHEMISTRY :-

A review of laws of thermodynamics, redox potentials, Carbohydrate-classification, occurrence, structure and function of monosaccharide's, oligosaccharides, Lipids-classification, occurrence structure and importance of acryl lipids and phosphates, biosynthesis of fatty acids, β- oxidation and role of polyunsaturated fatty acids, Outlines of Nitrogen fixation, symbiotic and non-symbiotic, Amino acids, peptides and proteins. Occurrence, structure and function of amino acids, stereo isomers, Synthesis of amino acids by reductive amination, GS-GOGAT system, transamination, classification of proteins according to solubility, structure and function of proteins. Conjugate proteins, lectins and their importance, proteins synthesis, transcription, translation degradation, and protein folding, Protein- ligand, protein- protein, nucleic acid-protein and nucleic acid-ligand interactions. Enzymes- classification, mode of action, enzyme kinetics (Michaelis- Menten Constant), Enzyme inhibition. Coenzymes, cofactors, Ribozymes, Nucleic acid bases-their structure. Structure and function of DNA, genetic code, different kinds of RNA and their origin. Role in protein, synthesis and in reverse transcription. DNA polymorphism, Biosynthesis and function of secondary metabolites phenolics, flabonids, terpenoids, Alkaloids and steroids, suberins, Importance of AcetylCo.A and Shikimic acid in intermediary metabolism, chemical foundations of biology e.g. pH, acids, bases, buffers, weak bonds, free energy, resonance, isomerisation etc.

6. ECOLOGY:-

Climate, soil and vegetation patterns and organization : Life zones, major biomes, vegetation, soil types, concepts of community, ecological succession, Ecosystem organization : Structure and functions, primary production, energy dynamics, litter fall arid decomposition, global biogeochemical cycles, minerals cycles in terrestrial and aquatic ecosystems, Population growth and dynamics: Models of population growth (Stochastic and time lag), reproduction strategies, mating preference, spacing r and k selection, case studies in population dynamics, Predation: Predators-Prey interaction, Host parasite interaction, role of predation in nature, Competition and Mutualism: Types and theories of competition, commensalism and mutualism, Plant- Pollinator and animal interaction, Niche theory, Biological diversity: Concepts and levels, role of biodiversity in ecosystem functions and stability, speciation and extinction, IUCN categories of threat, distribution and global patterns, Terrestrial biodiversity hot spots, Environmental pollution: Types, sources, effects on plant and animal ecosystems, Greenhouse gases, Ozone layer ozone hole, consequences of climatic change, Ecological management: Concepts, sustainable development, sustainability indicators, degraded ecosystem and their regeneration with special reference to waste lands, forests and aquatic ecosystems.

7. ADVANCED TOPICS IN MYCOLOGY:-

Ecology of fresh water fungi, thermophiles and psychrophiles, Domestication and Mycophagy: edible and poisonous mushrooms, mushroom toxins, cultivation technology for

button and oyster mushrooms, diseases and pests of button mushrooms, nutritive value of mushrooms, Mycotoxins and their medical and veterinary effects.

8. ADVANCED TOPICS IN APPLIED MICROBIOLOGY:-

Food Microbiology: Types of micro organisms in food, Food spoilage, Methods of food preservation, Food poisoning, Micro biology of milk and milk products, Industrial Microbiology: Types of fermentation, Fundamentals of Bioreactor design, Microbial production of acetic acid, alcohol, cyanocobalamin, citric acid and penicillin, Yeast as fermentative agent in food and beverage production, **Environmental and agricultural Microbiology:** Microbiology of air, Water and sewage, Microbial degration of organic matter in soil, Nitrogen fixation by microorganisms, Microbial pesticides**, Medical Microbiology:** Mechanisms of microbial pathogenecity, Host-parasite interactions**, Immunology:** Nature of antigen and antibody, Types of immunoglobulin's, **Types of immunity:** Brief account of active, passive, innate, and acquired immunity, Common antigen: antibody reactions agglutination, precipitation, complement fixation, immunofluorescence, radioimmunoassay, Enzyme-Linked Immunosorbent Assay (ELISA), neutralization, Brief account of hypersensitivity and autoimmunization.

9. ADVANCED TOPICS IN PLANT PATHOLOGY:-

Disease due to non-parasitic agents: Adverse climatic conditions, mechanical and chemical injury, adverse soil conditions. Disease due to deficiency, excess or imbalance of the elements essential to plant growth, correction of deficiency disease. Toxicity diseases, Angiosperms, algae and protozoa as plant pathogens, plant injury due to insects, mites nematodes and other pests, Roots diseases: Pre-emergence killing, damping off, seedling blight, root rots caused by cortical parasites, vascular wilt diseases. Hypertrophy disease, Non-parasitic root pathogens, pre disposing factors, Control of root diseases, Diagnosis and management of plant diseases, Mechanism of disease induction by fungi, bacteria, mycoplasma and viruses, Mechanism of action fungicides.

10. WOOD SCIENCE, FOREST BIODIVERSITY AND PLANT RESOURCES:

Structure of Vascular Cambium and its role on wood formation: Biochemical components of wood and their distribution in woody cell wall, Basic Structure, Formation and Modifications of the Woody cell Wall, Structure, Identification and Evolution of Dicot woods with particulars reference to Sal, Teak, Shisham, Walnut, Mulberry, Indian Oak, Toon and Himalayan poplar, A general account of texture, figure, spiral grain and knots in woods, **Plant Resource III-Woody Plants (Shrubs, Lianasand Trees)**-Economic importance of woody plants and their distribution in Himachal Pradesh, **Forest Conservation :** Factors contribution to the loss of forest biodiversity.

11. BIODIVERSITY, BIOPROSPECTING, ETHNOBOTANY & SUSTAINABLE UTILIZATION OF PLANT RESOURCES:-

Biodiversity, Concepts, Extent and status of biodiversity in India, Cause of biodiversity loss Mechanism for sustainable utilization of Biological resources, Himalayan Plant Resources, Waste land Management in Himalayan region, Strategies for in situ and ex situ conservation of Biodiversity, Remote sensing and Bio resources, Bio-indicators, Traditional Botanical Knowledge, Methods of Research in Ethnobotany, Sources in informatics of Medicinal Plant,

Global importance of Medicinal Plant, Economic aspects of Exploitation of Medicinal plants, Conservation of plant genetics resources: The role of Biotechnology.

12. ADVANCED PLANT PHYSIOLOGY

Some important phyto chemical techniques: Principles and applications of chromatography, electrophoresis, centrifugation and tracer techniques, Physiology and biochemistry of phyto chromosome: Structure, biosynthesis, metabolism, transport, function and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid, brassino steroid, polyamines, jasmonic acid and salicylic acid, Synthetic growth regulators: Discovery, chemical nature, effects on growth on growth and development and mechanism of action of cycocel, Phosphon D, B-nine, AMO 1618, morphactin, phenolics, Signal transduction: Overview, receptors and G proteins, phospholipid signaling, role of cyclic nucleotides, calcium- calmodulin cascade, diversity in protein kinases and phosphatase, sucrose- sensing mechanism, Seed Physiology: Seed viability, longevity, biochemical deterioration, seed dormancy, metabolism of germination seeds, environmental and hormonal control of seed dormancy/germination, Senescence: Physiological and biochemical basis of senescence, Stress Physiology: Concept of biological stress, plant responses and mechanism of tolerance of various abiotic stresses- Water- deficit stress, salinity stress, heavy metal toxicity and stress, freezing and heat stress, oxidative stress.

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Syllabus for the descriptive **Subject Aptitude Test (SAT)** for the recruitment to post of **Environment Officer (Class-I, Gazetted)** in the **Department of Environment Science, Technology and Climate Change, Himachal Pradesh** 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 **Master of Science (Chemistry) level.**

PART-I (60 MARKS)

1. INORGANIC CHEMISTRY:-

Group theory: The concept of group, Symmetry elements and symmetry operations, Assignment of point groups to Inorganic molecules, some general rules for multiplications of symmetry operations, Multiplication tables for water and ammonia, Representations (matrices, matrix representations for C_2V and C_3V point groups irreducible representations), Character and character tables for C_2V and C_3V point groups. Applications of group theory to chemical bonding (hybrid orbitals for σ-bonding in different geometries and hybrid orbitals for π-bonding. Symmetries of molecular orbitals in BF_3, C_2H_4 and B_2H_6., **Non-Aqueous Solvents:** Factors justifying the need of Non-Aqueous solution Chemistry and failure of water as a Solvent. Solution chemistry of Sulphuric acid: Physical properties, Ionic self-dehydration in H_2SO_4, high electrical conductance in spite of high viscosity, Chemistry of H_2SO_4 as an acid, as a dehydrating agent, as an oxidizing agent, as a medium to carry out acid-base neutraliza+1tion reaction and as a differentiating solvent. Liquid BrF3: Physical properties, solubilities in BrF3, self-ionization, acid base neutralization reactions, solvolytic reactions and formation of transition metal fluorides, **Inorganic Hydrides:** Classification, preparation, bonding and their applications. Transition metal compounds with bonds to hydrogen, carbonyl hydrides and hydride anions. Classification, nomenclature, Wade's Rules, preparation, structure and bonding in boron hydrides (boranes) and carboranes, **Organic Reagents in Inorganic Chemistry:** Chelation, factors determining the stability of chelates (effect of ring size,oxidation state of the metal, coordination number of the metal); Use of the following reagents in analysis: Use of Dimethylglyoximein analytical chemistry, Use of EDTA, 8-Hydroxyquinoline, Thiosemicarbazones, Dithiazone and 1,10-Phenanthroline in analytical chemistry and chemotherapy, **Supramolecular Chemistry:** Introduction, Some important concepts, Introduction to Recognition, information and complementarity, Principles of molecular receptor designs, Spherical recognition (cryptates of metal cations) Tetrahedral recognition by macrotricyclic cryptands, Recognition of ammonium ions, Recognition of neutral molecules and anionic substrates (anionic coordination), **Metal-Ligand Bonding-I:** Recapitulation of Crystal Field Theory including splitting of *d*-orbitals in different environments, Factors affecting the magnitude of crystal field splitting, structural effects (ionic radii, Jahn-Teller effect), Thermodynamic effects of crystal field theory (ligation, hydration and lattice energy), Limitations of crystal field theory, Adjusted Crystal Field Theory (ACFT), Evidences for Metal-Ligand overlap in complexes, *Molecular Orbital Theory* for octahedral, tetrahedral and square planar complexes (excluding mathematical treatment), **Atomic Spectroscopy:** Energy levels in an atom, coupling of orbital angular momenta, coupling of spin angular momenta, spin orbit coupling, spin orbit coupling, Determining the Ground State Terms-Hund's Rule, Hole formulation (derivation of the Term Symbol for a closed sub-shell, derivation of the terms for a *d2* configuration), Calculation of the number of the microstates, **Photoelectron Spectroscopy:** Basic principle, photoionization process, ionization energies, Koopman's theorem, ESCA, photoelectron spectra of simple molecules, (N_2, O_2) Photoelectron spectra for the isoelectronic sequence Ne, HF, H_2O, NH_3 and CH_4 , chemical information from ESCA, Auger electron spectroscopy – basic idea, Lanthanides and Actinides:- Spectral and magnetic properties, comparison of Inner transition and transition metals, Transuranium elements (formation and colour of ions in aqueous solution),uses of lanthanide compounds as shift reagents, periodicity of translawrencium

elements, Nuclear Chemistry: Nuclear binding energy and stability, nuclear models (nuclear shell model and collective model). Nuclear reactions: types of reactions, nuclear cross-sections, Q-value. Natural and artificial radioactivity, radioactive decay and equilibrium, Nuclear fission, fission product and fission yields, Nuclear fusion, Radioactive techniques: Tracer technique, (neutron activation analysis), Counting techniques such as G.M. Ionization and proportional counters.

2. ORGANIC CHEMISTRY:-

Stereochemistry: Introduction to Basic Concepts of Stereochemistry: Isomers and their properties, Threo and Erythro isomers, Chirality, Optical isomerism, Geometrical isomerism, Conventions for configurations- D,L and R,S systems, Racemic mixture and Racimization, Resolution of Racemic mixtures, Measurement of optical activity, optical purity, Streoselective and Streospecific reactions, epimerization, epimers, anomers and mutarotation, Axial Chirality (Allenes and Biphenyls), Planar chirality, Helicity, Chirality involving atoms other than carbon atoms, Prochirality: prostreoisomerism and Asymmetric synthesis, Conformational and streoisomerism of acylic and cylic systems, cyclohexane, decalins, effect of conformation on reactivity in acylic and cyclohexane systems, **Reaction Mechanism:** Structure and Reactivity: Thermodynamic and kinetic requirements, Kinetic and Thermodynamic control, Hammonds postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, **Effect of structure on reactivity**: resonance and field effects, steric effect. Quantitative treatment: Hammett equation and linear free energy relationship, Substituent and reaction constants, Taft equation. Methods of determining Reaction mechanisms, **Aliphatic Nucleophilic Substitution:** Reactivity effect of substrate structure, leaving group and nucleophile. The SN_2, SN_1, mixed SN_1 and SN_2, SET mechanisms & SNi mechanism. The neighboring group mechanism, neighboring group participation by π and σ bonds, anchimeric assistance. Non-classical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements-Wagner-Meerwein, Pinacol-Pinacolone and Demjanov ring expansion and ring contraction. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Esterification of carboxylic acid, transesterification, Phase-transfer catalysis, and ultrasound, ambident nucleophile, regioselectivity, **Aliphatic Electrophilic substitution:** Bimolecular mechanisms- SE_2 and SE_i. The SE_1 mechanism, electrophilic substitution accompanied by double bond shifts, halogenation of aldehydes, ketones, acids and acyl halides. Effect of substrates, leaving group and the solvent system on reactivity. Aliphatic diazonium coupling, Acylation at aliphatic carbon, alkylation of alkanes, Stork-enamine reaction, **Free radical reactions:** Geometry of free radicals, Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate neighboring group assistance, Reactivity in aliphatic and aromatic substrates at a bridgehead and attacking radicals. Effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts (Gomberg Bachmann reaction), Hoffmann -Loffler- Freytag reaction, Hunsdiecker reaction, **Aromatic Electrophilic Substitution:** Arenium ion mechanism, orientation and reactivity, The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles, Diazonium coupling, Vilsmeir - Haack reaction, Scholl reaction, Amination reaction, Fries rearrangement, Hofmann-Martius Reaction, Reversal of Friedel Craft alkylation, **Aromatic Nucleophilic Substitution:** SNAr, SN_1, benzyne and SRN_1 mechanism. Reactivity, effect of substrate structure, leaving group and attacking nucleophile, Von Richter, Sommelet-Hauser, and Smiles rearrangements, Ullman reaction, Ziegler alkylation, Schiemann reaction, **Common Organic Reactions and Their Mechanisms:** Perkin condensation, Michael reaction, **R**obinson annulation, Diekmann reaction, Stobbe condensation, Mannich reaction, Knoevenagel condensation, Benzoin

condensation, Witting reaction, Hydroboration, Hydrocarboxylation, Ester hydrolysis, Epoxidation, **Reagents in Organic Synthesis:** Synthesis and applications of BF_3, NBS, Diazomethane, Lead tetra-acetate, Osmium tetraoxide, Woodward Prevorst hydroxylation reagent, $LiAlH_4$, Grignard reagent, organozinc and organolithium reagent, **Elimination Reactions:** Discussion of E_1, E_2, E_1cB and E_2C Mechanisms and orientation, Reactivity: Effects of substrate structures, attacking base, leaving group and medium. Mechanism and Orientation in Pyrolytic eliminations, Cis elimination, elimination in cyclic systems, eclipsing effects, cleavage of quaternary ammonium hydroxides, Shapiro reaction, Conversion of Ketoxime to nitriles, **Pericyclic Reactions:** Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5 hexatrienes and allyl system. Classification of pericyclic reactions, Woodward-Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions: conrotatory and disrotatory motions, 4n and 4n+2 and allyl systems. Cycloadditions- antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and chelotropic reactions. Sigmatropic rearrangements-Suprafacial and Antarafacial shifts of H, sigmatropic shifts involving carbon moieties, Claisen, Cope and aza-Cope rearrangements, Ene reaction, Ultra Violet and Visible Spectroscopy: Electronic transitions (185-800 nm), Beer- Lambert Law, Effect of solvent on electronic transitions, Ultra Violet bands of carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes, Steric effect in biphenyls, Fieser- Woodward rules for conjugated dienes and carbonyl compounds, ultra violet spectra of aromatic and heterocyclic compounds.. Applications of UV- visible spectroscopy in organic chemistry, Infrared Spectroscopy: Principle, Instrumentation and sample handling, Characteristic vibrational frequencies of common organic compounds, Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance. Introduction to Raman spectroscopy. Applications of IR and Raman spectroscopy in organic chemistry, Nuclear Magnetic Resonance (NMR) Spectroscopy: General introduction, chemical shift, spin-spin interaction, shielding mechanism, chemical shift values and correlation of protons present in different groups in organic compounds. chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei, virtual coupling. Stereochemistry, hindered rotation, Karplus- relationship of coupling constant with dihedral angle. First and second order spectra, Simplification of complex spectra-nuclear magnetic double resonance, spin tickling, INDOR, contact shift reagents, solvent effects. Fourier transform technique, nuclear Overhauser effect (NOE). Introduction to resonance of other nuclei –^{13}C NMR, 2-D and 3-D NMR, Applications of NMR in organic chemistry, Mass Spectrometry: Introduction, ion production—EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, and ion abundance. Mass spectral fragmentation of organic compounds with common functional groups, Molecular ion peak, Meta-stable peak, McLafferty rearrangement. Nitrogen Rule. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination. Introduction to negative ion Mass spectrometry, TOF-MALDI. Problems based upon IR, UV, NMR and mass spectroscopy, Photochemistry – I: Introduction and Basic principles of photochemistry. Interaction of electromagnetic radiations with matter, Types of excitations, fate of excited molecules, quantum yield, transfer of excitation energy, actinometry. Photochemistry of alkenes: cis-trans isomerization, dimerization of alkenes, photochemistry of conjugated olefins, photo- oxidation of alkenes and polyenes Photochemistry of Aromatic compounds: Isomerization, addition and substitution, photo-reduction of aromatic hydrocarbons, Photochemistry – II: Photochemistry of Carbonyl compounds: Norrish Type I and II, Intermolecular and Intramolecular hydrogen abstraction, Paterno-Buchi reaction, α and β-cleavage reactions of cyclic and acyclic carbonyl compounds, Formation of oxetane and cyclobutane from α,β unsaturated ketones, Photo-reduction of carbonyl compounds, Photo-rearrangement of enones, dienones, epoxyketones, Photo Fries rearrangement.

3. PHYSICAL CHEMISTRY:-

Resonance Spectroscopy: Principle and Theory of nuclear magnetic resonance (NMR). Chemical shift and spin – spin coupling. Factors influencing chemical – shift and spin – spin coupling of ^{1}H-NMR. Spin – spin and spin – lattice relaxation processes. Line –width and rate processes. First and second order ^{1}H-NMR spectra. Principle and theory of Electron Spin Resonance (ESR). Hyperfine structure of ESR. Zero – field splitting of ESR signal., McConnell relation.Introduction to Mossbaur spectroscopy (isomer – shift, quadrupole interaction and magnetic hyperfine interaction), **Molecular Spectroscopy:** Rotational spectra of non – rigid diatomic molecules and symmetric - top molecules. Anharmonic oscillator, overtones and hot bands. Diatomic vibrator – rotator (P, Q and R – branches). Rotational – vibrational spectra of symmetric – top molecules. Raman Spectroscopy. Rotational and vibrational Raman spectra of linear and symmetric top molecules, overtones and mutual exclusion principle, **Kinetics of complex reactions:** Consecutive and competitive (parallel) first order reactions. Kinetic vs. thermodynamic control reaction. Free radical reactions; thermal (H_2 – Br_2) and photochemical H_2 – Cl_2) reactions. Rice – Herzfeld mechanism of dissociation of organic molecules viz. dissociation of ethane, decomposition of acetaldehyde as 3/2 or ½ order reactions. Reaction rates and chemical equilibrium, principle of microscopic reversibility, activation energy and activated complex, Transition state theory and its kinetic and thermodynamic formulation. Introduction to Potential energy surfaces. Kinetics in solutions: diffusion controlled reactions, their rates and influence of the solvent. Collisions and transition state theories in simple gas reactions, Lindman and Hinshelwood treatment, Catalytic activity at surfaces: adsorption and catalysis, the Langmuir – Hinshelwood mechanism, the Eley – Rideal mechanism. Examples of catalysis: hydrogenation, oxidation and cracking and reforming (qualitative treatment only). Introduction to fast reactions. Flash photolysis and Stopped flow methods to study the kinetics of fast reactions, **Chemical Thermodynamics-I**: Brief resume of laws of thermodynamics, Free energy functions, Gibb‘s and Helmholtz free energy functions and their significance, Gibbs -Helmholtz equation, thermodynamic equilibria and free energy functions, applications of Gibbs-Helmholtz equation, Clapeyron-Clausius equation, Thermodynamics of Elevation in boiling point, depression in freezing point, relation between osmotic pressure and elevation of boiling point, relation between osmotic pressure and depression in freezing point, **Chemical Thermodynamics-II:** Chemical affinity, applications of chemical affinity, methods for determining the chemical affinity ,partial molar properties, Physical significance of partial molar properties, chemical potential, Gibbs - Duhem equation, variation of chemical potential with temperature and pressure, chemical potential of a pure solid or liquid, chemical potential of a pure ideal gas and mixture of ideal gases, thermodynamic functions of mixing, fugacity, fugacity coefficient, determination of fugacity, variation of fugacity with temperature and pressure, Lewis Randall rule, Duhem- Margules equation, activity, activity coefficient, determination of activity and variation with temperature and pressure, Nernst heat theorem and third law of thermodynamics and its application. Thermodynamic derivation of phase rule and its application to two component systems. Distribution law, its thermodynamic derivation and application, **Non–Equilibrium Thermodynamics:** Basic principles of non – equilibrium thermodynamics: Rate laws, second law of thermodynamics for open system, law of conservation of mass, charge and energy flow, electrokinetic phenomena and expressions for streaming potential, electro- osmotic pressure difference, streaming potential using the linear phenomenological equation, **Colloidal State:** Classification of colloids, charge and stability of colloidal dispersions, Hardy-Schulze Law, gold number, electrical properties of colloids, electrical double layer and its structure, Stern‘s theory of double layer, zeta-potential, electrophoresis and electro-osmosis, emulsions and their classification, emulsifiers, gels and their classification,

Statistical Thermodynammics: Basic Terminology: probability, phase space, micro and macro states, thermodynamic probability, statistical weight, assembly, ensemble, The most probable distribution: Maxwell-Boltzmann distribution, quantum statistics: The Bose-Einstein statistics and Fermi- Dirac Statistics. Thermodynamic probability (W) for the three types of statistics. Lagrange's undetermined multipliers. Stirling's approximation, Molecular partition function and its importance, Applications to ideal gases: The molecular partition function and its factorization. Evaluation of translational, rotational and vibrational partition functions, the electronic and nuclear partition functions. for monatomic, diatomic and polyatomic gases, Thermodynamic properties of molecules from partition function: Total energy, entropy, Helmholtz free energy, pressure, heat content, heat capacity and Gibb's free energy, equilibrium constant and partition function, Heat capacity of crystals and statistical thermodynamics, Third law of thermodynamics and entropy. Ortho- and para-hydrogen, statistical weights of ortho and para states, symmetry number. Calculation of equilibrium constants of gaseous solutions in terms of partition function, Einstein theory and Debye theory of heat capacities of monatomic solids.

PART-II (60 MARKS)

1. INORGANIC CHEMISTRY SPECIAL THEORY - I:-

Inorganic Photochemistry: Basic principles, absorption, excitation, kasha rule, electronically excited state, its life-time and energy dissipation process. Photochemical behavior of transition metal complexes, charge transfer spectraof crystalline and gasous alkali halides. Photochemistry of chromium(III) octahedral complexes, $[Cr(H_2O)_6]^{3+}$ and $[Cr(NH_3)_6]^{3+}$. Photochemistry of cobalt (III) complexes, $[Co(NH_3)_5X]^{2+}$ and $[Co(en)_3]^{3+}$.**Inorganic Reactions and Mechanism:** Substitution reactions in octahedral complexes, acid hydrolysis reactions, base hydrolysis and anation reactions, substitution reaction, reactions occurring without rupture of metal-ligand bond. Substitution reactions of square planar complexes. Theories of trans-effect, labile and inert complexes. Mechanism of redox reactions, **Polymeric Inorganic Compounds:** General chemical aspects (synthesis, properties and structure)of phosphazenes, borazines, silicones, sulphur- nitrogen cyclic compounds and condensedphosphates, ,**Stability of Coordination Compounds –** Stability constants, stepwise formation constants, overall formation constants, relationship between stepwise and overall formation constants, factors affecting the stability constants (with special reference to metal and ligand ions), Difference between thermodynamic and kinetic stability. Determination of stability constants by: Spectrophotometric methods (Job's method, Mole ratio and slope ratiomethod), Bjerrum's method, Polarographic method, **Electronic Spectra – III (Electronic spectra of complex ions):** Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions of d1-d9 ions in Oh and Td environments, Evaluation of 10 Dq, Spectrochemical and Nephelauxetic series, charge- transfer spectra.

PHYSICAL CHEMISTRY SPECIAL THEORY – I:-

Adsorption at solid – gas interface: Concept of ideal and non – ideal adsorption. Heat of adsorption. Types of adsorption isotherms. Single – layer adsorption – Langmuir adsorption isotherm and its derivation. Multilayer adsorption – B.E.T. theory and its kinetic derivation. Application of BET theory in its determination of surface area of the solid. Catalytic activities at surfaces: adsorption and catalysis, Adsorption at solid – liquid interface: Gibbs adsorption equation. Isotherms of concentration and temperature change for the adsorption in solutions. Chromatographic adsorption: column chromatography and its theory. Theory of chromatography involving one solute and several solutes, Solution and Interfacial Behaviour of Surfactants: Definition and classification of surfactants. Solution properties of surfactants:

micelle formation, critical micelle concentration (CMC), dependence of CMC on chain length of the surfactant, micelle shape and size. Thermodynamics of micelle formation, hydrophobic effect (a qualitative view only). Aggregation at high surfactant concentration (a qualitative aspect) to micelles. Surface tension and detergent, Practical application of surfactants, **Electrochemistry:** Quantitative treatment of Debye - Hückel and Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution their limitations and modifications. Pair-wise association of ions (Bjerrum and Fuoss treatment). Determination of association constant (KA) from Debye – Huckel Limiting Law. Extended Debye – Huckel Law. Qualitative treatment of ion – solvent interactions (ion solvation), Chemistry of nano – materials: Definition and historical perspective. Effect of nanoscience and nanotechnology in various fields. Synthesis of nanoparticles by chemical routs and their characterization techniques. Properties of nanostructured material: optical, magnetic and chemical properties. An overview of applied chemistry of nanometerials.

2. Organic Synthesis:-

Organic Reagents: Reagents in organic synthesis: Willkinson catalyst, Lithium dialkyl cuprates (Gilman's reagents), Lithium diisopropylamide (LDA), 1,3-Dithiane (Umpolung) Dicyclohexylcarbobiimide (DCC), and Trimethylsilyliodide, DDQ, SeO_2, Baker yeast, Tri-n-butyltinhydride, Nickel tetracarbonyl, Trimethylchlorosilane. Grubbs Catalysts, **Oxidations:** Introduction, Different oxidative process. Aromatiztion of six membered ring, dehydrogenation yielding C-C double bond, Oxidation of alcohols, Oxidation involving C-C double bond, Oxidative cleavage of ketones, aldehydes and alcohols, double bonds and aromatic rings, Ozonolysis, Oxidativedecarboxylation, Bisdecarboxylation, Oxidation of methylene to carbonyl, Oxidation of olefines to aldehydes and ketones, **Reductions:** Introduction, Different reductive processes. Reduction of carbonyl to methylene in aldehydes and ketones, Reduction of nitro compounds and oximes, Reductive coupling, Bimolecular reduction of aldehydes or ketones to alkenes, metal hydride reduction, Acyloin ester condensation, Cannizzaro reaction, Tishchenko reaction, Willgerodt reaction, **Rearrangements:** General mechanistic considerations-nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Backmann, Hofmann, Curtius, Schmidt, Benzidine, Baeyer-Villiger, Shapiro reaction, Witting rearrangement and Stevens rearrangement, **Disconnection Approach:** An introduction to synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, the importance of the order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity cyclisation reactions, amine synthesis. Protecting Groups: Principle of protection of alcohol, amine, carbonyl and carboxyl groups. Alkene synthesis, use of acetylenes in organic synthesis.

3. NATURAL PRODUCTS:-

Terpenoids: Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, biosynthesis and synthesis of the following representative molecules: Monoterpenoids: Citral, geraniol (acyclic), α-terpeneol, menthol (monocyclic). Sesquiterpenoids: Farnesol (acyclic), zingiberene (monocyclic), santonin (bicyclic), Diterpenoids: Phytol and abietic acid, **Carotenoids and Xanthophylls:** General methods of structure determination of Carotenes: β- carotene, α- carotene, γ- carotene, lycopene and vitamin A. Xanthophylls: Spirilloxanthin, Capsorubin, Fucoxanthin. Carotenoid acids (Apocarotenoids): Bixin and Crocetin. Bio synthesis of carotenoids, **Alkaloids:** Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants.

Structure, synthesis and biosynthesis of the following: Ephedrine, Coniine, Nicotine, Atropine, Quinine and Morphine, **Steroids:** Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol, Androsterone, Testosterone, Estrone, Progestrone. Biosynthesis of steroids, **Plant Pigments:** Occurrence, nomenclature and general structure determination methods. Isolation and synthesis of Anthocyanins (Cyanin and pelargonidin), polyphenols: Flavones (chrysin), Flavonols (quercitin) and isoflavones (daidzein) coumarin, Quinones (lapachol), Hirsutidin. Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway.

4. MEDICINAL CHEMISTRY:-

Drug Design: Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR), factors affecting bioactivity, resonance, inductive effect, isosterism bio- isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-Chemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric, Free-Wilson analysis, Hansch analysis relationships between Free-Wilson and Hansch analysis, Pharmacokinetics and Pharmacodynamics: Pharmacokinetics: Introduction to drug absorption, disposition, elimination using pharmacokinetics. Important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process, Pharmacodynamics: Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotics, biotransformation. Significance of drug metabolism in medicinal chemistry, Antibiotics and Antiinfective Drugs: Antibiotics: Structure, SAR and biological action of antibiotics. Examples: penicillin: penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin, Sufonanmides: Structure, SAR and mode of action of sulfonamides, sulfonamide inhibition and probable mechanisms of bacterial resistance to sulfonamides. Examples: sulfodiazine, sulfofurazole, acetyl sulfafurazole, Sulfagnanidine, Phthalylsulfo acetamide, Mafenide. Sulphonamide related compounds Dapsone. Local antiinfective drugs: Introduction and general mode of action. Examples: sulphonamides, furazolidone, nalidixic acid, ciprofloxacin, norfloxacin, chloroquin and primaquin, Psychoactive Drugs: Introduction, neurotransmitters, CNS depressants and stimulants. SAR and Mode of actions. Central Nervous System Depressant: General anaesthetics, Sedatives & Hypnotics: Barbiturates and Benzodiazepines, Anticonvulsants: Barbiturates, Oxazolidinediones, Succinimides, Phenacemide and Benzodiazepines, Psycotropic Drugs: The neuroleptics (Phenothiazines and butyrophenones), antidepressants (Monoamine oxidases inhibitors and Tricyclic antidepressants) and anti-anxiety agents(Benzodiazepines), Central Nervous System Stimulants: Strychnine, Purines, Phenylethylamine, analeptics, Indole ethylamine derivatives, Therapeutic Agents, SAR and Their mode of Actions: Antineoplastic Agents: Cancer chemotherapy, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antiobiotics and mitotic inhibitors. Biological action of mechlorethamine, cyclophosphamide, melphalan, uracil, and 6-mercaptopurine, Cardiovascular Drugs: Antihypertensive and hypotensive drugs, antiarrrhythemic agents, vasopressor drug acting arteriolar dilators. Biological action of methyldopa, propranolol hydrochloride, amyl nitrate, sorbitrate, verapamil, Atenolol.

5. BIO-INORGANIC AND SUPRAMOLECULAR CHEMISTRY:-

Metalloporphyrins: Porphyrins and their salient features, characteristic absorption spectrum of porphyrins, chlorophyll (structure and its role in photosynthesis). Transport of Iron in microorganisms (sidrophores), types of siderophores (catecholate and Hydroxamato siderophores), **Metalloenzymes**: Definitions: Apoenzyme, Coenzyme, Metalloenzyme, structure and functions of carbonic anhydrase A & B, carboxy peptidases, Oxygen Carriers**,** ***Natural oxygen carriers:*** Structure of hemoglobin and myoglobin, Bohr effect, Modelsfor cooperative interaction in hemoglobin, oxygen Transport in human body (-perutz machanism), Cyanide poisoning and its remedy. Non-heme protiens (Hemerythrin & Hemocyanin), ***Synthetic oxygen carriers:*** Oxygen molecule and its reduction products, model compounds for oxygen carrier (Vaska's Iridium cjomplex, cobalt complexes with dimethyl glyoxime and schiff base ligands), Transport and storage of metals: The transport mechanism, transport of alkali and alkaline earth metals, ionophores, transport by neutral macrocycles and anionic carriers, sodium/potassium pump, transport and storage of Iron (Transferrin & Ferritin), **Inorganic compounds as therapeutic Agents:-** Introduction chelation therapy, synthetic metal chelates as antimicrobial agents, antiarthritis drugs, antitumor, anticancer drugs (Platinum complexes), Lithium and mental health, **Supramolecular Chemistry:** Introduction, Some important concepts, Introductionto Recognition, information and complementarily, Principles of molecular receptor designs, Spherical recognition (cryptates of metal cations) Tetrahedral recognition by macrotricyclic cryptands, Recognition of ammonium ions, Recognition of neutral molecules and anionic substrates (anionic coordination).

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