Syllabus for Nuclear Medicine Technologist

(Syllabus is only Indicative. The questions can assess any aspect of knowledge, aptitude, attitude and practical skills, which is expected from a trained person to work efficiently at the advertised post)

Part B

Core Subject

- Human anatomy including Nervous System, skeletal system, circulatory system, respiratory system, digestive system, excretory system, endocrine system and reproductive system.

- Human Physiology including Cell structure, Haematology, Reticulo endothelial system, Nervous System, skeletal system, circulatory system, respiratory system, digestive system, excretory system, endocrine system and reproductive system, Blood and Environmental Physiology.

- **Hospital Practice & Patient Care:**

  - Patient: As an individual, the reactions of patient and his family to illness.
  - Qualities – Professional and Ethical behaviour expected.
  - Role and responsibilities of a laboratory technician in the health team
  - Hospital staffing and organization.
  - Inter personal relations and communications.

- **Patients records & reports & legal implications**

  - Care of the Patient:
    - Maintaining therapeutic environment
    - Temperature
    - Lighting
    - Noise and humidity
    - Cleanliness
    - Psycho – social environment
    - Meaning and its importance.

- **Basic care & needs of the patient**

- Hygiene needs
- Physical Comforts

➢ **Care of the Patient:**

- Vital signs: Temperature, pulse, respiration and
- Blood pressure: Normal and abnormal factors causing the variation
- Gastric lavage, Nasogastric aspiration

➢ **First Aid**

➢ **Principles of Asepsis**

➢ **Sterilization:**

- Methods of sterilization. Use of central Sterilization department
- Care and identification of instruments

➢ **Drugs in the Department**:

Storage, classification, Labelling and checking, regulations regarding dangerous and other drugs, units of measurement.

➢ **Chemicals used in Labaratory:**

➢ **Instruments used in various Sections:**

Microscope, Colorimeter, Cell counter, Auto Analyzer, Flame, Photometer, Autoclave, Hot air oven, Incubator, Centrifuged.

➢ **Laboratory Principles:**

- General Laboratory techniques and procedures.
- Specimen collection and processing. Basic Chemistry.
- Concepts of Molecular Weight, Atomic Weight, Normality, Molarity standards, Acids, bases, salts.
- Concepts of acid base reactions and hydrogen on concentration.

➢ **Basic Biochemistry:**

- Carbohydrates: Glucose; fructose; galactose; lactose; sucrose; starch and glycogen (properties and tests, Structure and function)
- Proteins: Amino acids, peptides, and proteins (general properties & tests with a few examples like glycine, trytophan, glutathione, albumin, hemoglobin, collagen)

- Lipids: Fatty acids, saturated and unsaturated, cholesterol and triacyglycerol, phospholipids and plasma membrane.

- Vitamins: General with emphasis on A,B2, C, E and inositol (requirements, assimilation and properties)

- Minerals: Na, K, Ca, P, Fe, Cu and Se.(requirements, availability and properties)
- Hormones and their receptors basic concepts in metabolic regulation with examples, insulin, glucagon's and thyroxine
- Metabolism: General whole-body metabolism (carbohydrates, proteins, lipids)
- Clinical Biochemistry: Blood sugar, urea, creatinine and Bilirubin, cholesterol etc and significance of their estimation.
- Basics of computer and image hard copies production in Nuclear Medicine, including X-Ray film image processing techniques.
- Types of nuclear medicine image e.g. static image, dynamic, list mode, frame mode, gating, tomographic mode. Image and data processing: region of interest, time activity curve generation, effect of matrix size, pixel size, zooming and smoothing of image.
- Nuclear Medicine image hard copies, glossy prints, paper prints etc., X-Ray films, types, basic film structure & quality, choosing films for different studies, film processing techniques: dry and wet processing, manual and automatic. Wet film, processing solutions. Film processing rooms, film processing equipment's.

➢ **Nuclear medicine physics**

- Basics Physics: Elementary introduction to structure of matter, elements, compounds and mixtures, molecules and atoms. Atomic & Nuclear structures, atomic models, Periodic table, simple ideas of quantum mechanics, Mass energy equivalence, fluorescence, Phosphorescence, luminescence, electromagnetic spectrum. Electricity, Magnetism and Electromagnetic induction: Electricity in ionized gases-electric charges-electric induction- Coulomb law-unit of charge-resistance-ohms law- electric power-Joules law. Magnetism-magnetic properties-electromagnetic effect-electrical instruments like Voltmeter, Ammeter & Multimeter. Transformer, transistor, rectifier, pre amplifier, pulse amplifier, power supply, circuits. Filters and their types.
- Radioactivity: Discovery of radioactivity, Natural & Artificial Radioactivity, Isotopes and nuclides, binding forces between nuclear particles, types of radiation, alpha, beta particles and gamma radiation. Mechanisms of radioactive decay, physical, biological and effective half-life. Interaction of X-rays & ɤ-rays with matter - Radiation intensity & exposure - radiation dose - Radiation quality – law of exponential attenuation – half value thickness, tenth value thickness – linear attenuation coefficient – Scattering – photoelectric effect – Compton-scattering – pair production – particle interactions.

➢ **Physics of Nuclear Medicine Instrumentation**

- Radiation detectors: Construction and Principles of Operation – lonization Chamber – Isotope calibrator – Proportional Counter – Geiger muller counter – Voltage calibration of a Geiger Mueller tube, optimum operating condition – Dead time correction – Uses of Gas – filled detectors – Semiconductor detectors.
- Scintillation detector: Thallium activated Sodium iodide crystal – Photo multiplier tube, electron multiplication, high voltage supply, Shielding, collimators, field of view. Well counter – construction, design of shielding. Signal output, Pre-amplifier – reasons for use – Voltage amplifier – liquid scintillation detector.
- Spectrometer: Basic principles of Pulse – height analyzer single channel and Multi – channel analyzers. Optimum operating conditions, window settings – Determination of gamma energy spectrum, Integral and differential counting. Spectra of commonly used radio nuclides e.g 1131, Tc99, Cr51, Cs137. Problems in radiation measurements with worked examples.

➢ **Mathematical application and counting statistics**

- Basic mathematics covering integration, disintegration, vector, function, radioactivity calculations, use of various types of graphs to display or represent the radioactivity calculations (linear, semi log, logit-log, Log-Log etc). Types of measurement error, Precision and Accuracy, Nuclear counting statistics, Mean, Mode, Median, Poison, Normal (Gaussian) distribution, Standard deviation, coefficient of variation, Probable error, confidence limits, Percent standard deviation, Statistical tests. – Chi – square test, Figure of Merit test, students test.

- Gamma camera: Camera head construction and principle of operation, Collimators – parallel multi hole, high resolution, high sensitivity, pin hole, diverging & converging hole, slant hole. Scintillation crystal, optical coupling, Photo multiplier tubes, per amplifiers. Pulse height analyzer, Timer, Data Processor and their function. Application of Cathode ray tube, persistence scope. Resolving time characteristics, Gamma camera Uniformity and intrinsic resolution, Sensitivity, Total – system resolution, Spatial volume resolution saturation.

➢ **Computerized Tomography**: Basic principle of Computed Tomography, Generations of CT. X-ray tube, Filters, Collimators, CT detectors, Data Acquisition System (DAS), CT Image Quality, CT Dose Vs image quality. Image Formation in CT, Image Reconstruction, Hounsfield Unit, Windowing, image display, CT artifacts. Helical CT scan: Slip ring technology, Advantages, Multi Detector CT, Cone-beam geometry, Reconstruction of helical CT images, CT Fluoroscopy, HRCT, Post Processing Techniques: MPR, MIP, Min IP, 3D rendering: SSD and VR. Contrast material, contrast reaction, contrast material doses and route of

administration. Whole body CT acquisition.

- **Basic Radiation Physics**

  - Atomic structure, atomic number, mass number, isotopes, radioisotopes, radioactivity, specific activity, types of radioactive disintegrations, electron capture, characteristics of alpha, beta and gamma rays, energy ionizing radiation, half-life (Physical, Biological), effective half life, isomeric transitions, secular, transient and no-equilibrium, production of radioisotopes and X-rays (characteristic and Bremsstrahlung), neutron sources.

  - Interaction of Radiation with Matter

  - Interaction of charged particulars with matter, interaction of neutrons with matter, range of charged particles, interaction of photons with matter (photoelectric, Compton and pair production), absorption and attenuation of photons, Half Value Thickness (HVT) and Tenth Value Thickness (TVT).

- **Radiation Quantities and Units**

  - Radiation Detection

  - Principal of radiation detection, gas detector (ionizing chamber, proportional counter and GM counter), solid state detector (scintillator, semiconductor and Thermoluminescent Dosimeter {TLD}), liquid scintillation counting systems, radiation monitoring instruments, personnel monitoring, area monitoring, environmental monitoring, direct reading devices, calibration and response of radiation monitoring instruments.

- **Radiopharmacy**

  - Basic principles involving the radio chemical reactions regarding the binding efficiencies and the working principles of various isotope generators used in Nuclear Medicine department.
  - Basics of radiation chemistry:

    - (a) Atomic and molecular structure (b) Bonding: Electrovalent, covalent, Dative covalent bond and hydrogen bonds (c) Valency, Atomic wt., - Molecular wt -Normality and molarity of solution, (d) Acids and Bases - Hydrogen Ion concentration - pH value - The role of pH in the preparations of radiopharmaceuticals -(e) chemical reaction - solute - Solvents - Solubility - crystallization - (f) The chemical elements which are necessary for life (carbon - Hydrogen, oxygen and nitrogen, Phosphorous, Iron etc.). (g) Fundamental chemistry of carbohydrates and carbonyl groups (h) - Oxidation and Reduction (i) proteins and amino acids. Lipids and profiles.

Enzymes - vitamins, Hormones.

- Basic in Laboratory Techniques:
  - (a). Laboratory glassware (b) Washing and autoclaving of glassware for the use in Radio-pharmacy areas (c) Correct use of Pipettes, Balance, Centrifuge, gloves, syringes, vacuum vials, saline bottles, elution vials etc. (d) hot lab tools for safe handling of active vials and syringes.

- Isotope generators: (a) Production of radio nuclides by artificial methods (b) Accelerator produced radio nuclide (c) Nuclear reactor produced radio nuclides, construction and Principles of generator systems - Ion Exchange system - Solvent extraction system - Parent - daughter relationship-growth of daughter product equilibrium with parent elements etc. Chemistry of Tc99m, Mo99-Tc99m generators Mo99 contamination check, Aluminum break through test etc (f) sterilization.

- Radiopharmaceuticals: Principles of cold kits & lyophilisation, importance of lyophilisation in preparation of cold kits. Common pharmaceutical cold kits, contents, pharmacological properties, physiological principle in use of a particular cold kit, pediatric and adult doses, route of injection, route of excretion, radiation exposure, critical organ for DTPA, GHA, DMSA, MDP, macro aggregated albumin, sulphur colloid, MIBI, Tetrofosmin, Mebrofenin, etc. (c) Labeling procedure of cold kits with required radio isotopes, Quality control tests: RC purity, RN purity, sterility check, Chromatography (Various methods) pyrogen test, bio distribution studies.

- Tracer methods - Behavior of radioactive tracers in biological process - characteristics of radio pharmaceuticals - Half life - (Physical and Biological)

- Dispensing of radio pharmaceuticals - Specific activity, Tracer dose preparation - Tracer dose administration etc.

➢ **Radiation Biology**

➢ **Radiation Safety**

- Operational Limits

- Introduction to natural background radiation, concept of occupational risk, philosophy of radiation protection, system of dose limitation, ALARA, dose limits to radiation workers and general public, AERB/CRP/ national regulatory guidelines, dose constraints for comforters of patients.
- Radiation Hazard Evaluation and Control
- Radiation Accidents, Case Studies and Lessons Learned

- Radiation accidents involving radioisotopes, orphan and vulnerable sources, handling of emergency situations resulting from spillage of radiopharmaceuticals / liquid radioisotopes, misadministration of radiopharmaceuticals and its consequences, general methods of prevention of accidents, loss of radioisotope, fire accidents and explosions; follow up actions through emergency response plans, case studies and mitigation, lessons learned.

➢ **Nuclear Medicine Techniques and procedures**

- TECHNIQUES

1. Ordering nuclear medicine procedure

  - Preparation of the patients before the procedure
  - Care of Patients During the Nuclear Medicine Procedure
  - Care to be taken during the cardiac studies in the NM department
  - Preparation of the radioactive tracer for the study
  - Preparation with resuscitation
  - Specimen collection in a safe manner

➢ **Procedures**

- Diagnostic – In vitro techniques: Principles of Radio immunoassays (RIA) standard curve, data analysis, Quality Control (QC) and applications, Methods of receptor assays, hormones, drugs. IRMA Immuno-radiometric assay, ELISA, RIA, estimation, T3, T4, TSH, thyroid antibodies, and current applications using similar techniques.

- In Vivo Techniques: Non imaging procedures.

- Imaging considerations related to organs such as thyroid/ Parathyroid / Skeletal system /Respiratory System/ Cardiovascular system / Urinary Tract/ GIT / Liver and Hepatobiliary system

- Basic principle of SPECT, SPECT data acquisition, SPECT reconstruction, use of filters in SPECT data processing, software based/ CT based attenuation correction, SPECT CT / PET CT imaging, construction and principle of PET Scanner, PET scanner crystals, co-incidence circuit, attenuation correction techniques of PET images, PET image reconstruction, PET CT image QC, principle of MRI, PET MRI fusion imaging.

- Nuclear Medicine probes: Thyroid probe, sentinel lymph node probe, H pylori probe,

construction and principle of function.

- Newer Computer applications in Nuclear Medicine, DICOM image format, PACS, LAN.
- Radiation Dosimetry:
- Compartmental Model – in-vivo dosimetry using classical dosimetry mechanism, beta dosimetry, gamma dosimetry, geometrical factor, dosimetry of low energy electromagnetic radiation, MIRD formulation – cumulated activity, equilibrium absorbed dose constant, absorption factor, specific absorbed fraction and the dose reciprocity thereon, mean dose per cumulated activity, limitation of MIRD method; extremity dosimetry.
- Quality Assurance of Nuclear Medicine equipment's Flood check –

  Techniques and methods
- Record Keeping and Equipment maintenance.

  Radiopharmaceutical preparation and QC of

  given test:
- Lymphoscintigraphy, infection imaging, MUGA scan, brain SPECT and cardiac SPECT etc. Recent advances in SPECT and PET radiopharmaceuticals: DAT scan, newer cardiac SPECT and PET imaging procedures, 18 F FDG, 18 F Sodium fluoride in conventional and molecular imaging for oncology patients.
- Ultra short- and short-lived

  radionuclide. generators.

  RADIATION BIOLOGY: Principles
- RADIATION SAFETY: Radionuclide Therapy - Radiation Safety Aspects / Emergency Response Plans and Preparedness.
- Transport and Disposal of Radioactive Waste.

Planning of Nuclear Medicine (NM) Laboratories / Regulatory Aspects for Nuclear Medicine Laboratories.