Q.1  a) Enlist four major parameters to be selected by the technologist to perform a Stress Cardiac Gated SPECT imaging with $^{99m}$Tc MIBI on a dual head gamma camera.
   b) What is "Motion Correction" and what is its role in Cardiac SPECT imaging?
   c) Enlist three technical parameters which can change the split function values in dynamic renal studies?

Q.2  a) How the resultant products of pair-production loose their energy while their interaction with matter?
   b) Name the Alpha Emitter (and its chemical form) approved for use in bone metastatic lesions. What are the physical characteristics of this alpha emitter?
   c) What is the gamma ray dose-rate constant?

Q.3  a) What is a TL Dosimeter? How does it work with added impurities?
   b) Which mode of decay increases n:p ratio, which decreases and in which it remains same?
   c) What is neutrino? What is their importance in nuclear decay?

Q.4  a) What is the difference between useful field of view and Central Field of view of gamma camera? Why only Central Field of View is used in nuclear medicine imaging?
   b) Define the followings for a SPECT system,
      i- Multi head resolution
      ii- spatial resolution
      iii- Linearity
      iv- Calibration Factor
   c) Why iterative reconstruction technique is preferred over filtered back-projection in SPECT studies?
Q.5 a) How can you define the ability of a scintillation detector to separate photons of different energies? 
b) Are there any limits on the number of photons that can be counted by a gamma camera in a given time? 
c) Define the term Time Of Flight? 
d) Why Co-57 is used for quality control of gamma camera?

Q.6 a) Define the followings:  
i. Measurement Error 
ii. Precise Measurement and accurate Measurement 
iii. Standard Error and standard deviation  
b) On Thursday at 11 a.m $^{99m}$Tc has activity of 9mci (333 M bq). What was the activity at 8 a.m. and 4 p.m. on the same day?

Q.7 a) What is the clearance criteria for unsealed radioactive waste generated in Nuclear Medicine as per Pakistan Nuclear Regulatory Authority (PNRA) Regulations?  
b) What is the annual dose limits for a non-adult comfortor / visitors of a patient?  
c) What is minimum level of radiation absorbed dose which entitle a radiation worker to go for annual medical / health surveillance?  
d) A medical physicist record 7400 uSv/hr at the surface and 3800 uSv/hr exposure at one meter from a FDG (F- 18) package using a calibrated survey meter. What is the Transport Index of the package?
Q.8  a) A diagnostic test has got
   Sensitivity = 50%
   Specificity = 50%
   Calculate NPV and PPV.
   b) Comment how above mentioned test is helpful as screening test of an epidemic disease, endemic disease, fatal disease, a disease of which treatment has serious financial and health consequences.
   c) In the diagnosis of sarcoidosis angiotensin converting enzyme testing yields
      Sensitivity = 73%, specificity = 83%.
      Gallium scanning yields
      Sensitivity = 91%, specificity = 84%.
      Calculate combine sensitivity and specificity of both diagnostic tests run in parallel and in series.
   d) What do you mean by LD-50?

Q.9  a) How does $^{99}$Mo/ $^{99m}$Tc generator reach equilibrium? Provide graphical diagrams?
   b) What are the characteristics of an ideal therapeutic radiopharmaceutical?
   c) What is the threshold of $^{99}$Mo impurity in $^{99m}$Tc as per Nuclear Regulatory Commission (NRC)? How this impurity is measured?

Q.10 a) How $^{18}$F-FDG is synthesized by Nucleophilic Fluorination?
   b) What is a LAL test? What is its role in FDG quality assurance?
   c) An automated synthesis unit receives 5 Curie radioactive $^{18}$F from cyclotron. This unit provides 3.2 Curie radioactive $^{18}$FDG. What is the percentage yield of the synthesis unit?
   d) What is the dress code of a radio-pharmacist / radio-chemist while working in a radio-pharmacy?
Q.11 A 38 year old female with mitral valve prolapse syndrome presented with atypical chest pain. Her baseline ECG showed QRS complex 140 ms, tall R waves in leads I, V5 and V6 with deep S waves in V1-V3 leads. Patient has history of bronchial asthma, however she was not on any xanthine derivative and at presentation did not have an active wheeze on examination. She underwent pharmacological stress myocardial perfusion imaging on nuclear cardiology floor. She completed stress with 0.5 mm ST depression in leads II, III, and aVF. The myocardial perfusion scan showed fixed perfusion defect in anteroseptal region. Rest of the myocardium showed fairly normal perfusion.

a) What is the pharmacological agent most suitable for use in this patient? 
b) Give the protocol for the stress agent, mentioning its dosage, route of administration and possible complications. 
c) How will you deal with these complications with a prophylactic medication? 
d) Evaluate the post-test probability of coronary artery disease and probability of future cardiac events in this patient.

Q.12 a) A 33-year old female develops signs and symptoms of thyrotoxicosis with recent onset of upper respiratory tract infection. Her thyroid gland is exquisitely tender and finely nodular.

What is the possible work up that can be performed on the patient at nuclear medicine floor? How can the findings in these investigations be interpreted, leading to most probable diagnosis and ruling out other causes? Suggest the needed management after the most likely diagnosis is reached. What is the role of radionuclide therapy in this case?

b) A 15 year old female with history of recurrent episodes of hypertension was referred to Nuclear Medicine department for the Radionuclide Imaging. There is no clinical evidence of renovascular pathology.

1. Which is the most specific Scintigraphic study helpful in evaluation of this case? 
2. What specific radiation protection related instructions should be delivered to this patient prior and after the study? 
3. What are the interpreting criteria in case of a negative and a positive study?
Q.13 a) A 52 year old male presented with progressive memory loss. On recent brain CT, no space occupying lesion was found. Tc99m-HMPAO study is indicated.

1. What are the steps of Tc-99m-HMPAO kit preparation and its QC procedures?
2. What are the expected findings of HMPAO study in this patient?

b) A 32 year old male presented with history of CSF rhinorrhea. Patient was referred for evaluation to Nuclear Medicine department. Give the technique and protocol of Scintigraphic study (Imaging as well as non-imaging) in this case?

Q.14 a) 40 year old female presented with pain Right hypochondrium, radiating to right shoulder associated with vomiting. What scintigraphic imaging is needed for evaluation of GIT pathology? Mention the detailed technique, precautions and interpretation in this clinical scenario. Enumerate four reasons of a positive study.

b) 3 months old boy presented with congenital hyperbilirubinemia at Nuclear Medicine department. HIDA scan is planned. Give the preparation, technique, possible scan findings and their interpretation in this case.

Q.15 a) A 58 year old male with recent H/O CABG presented with persistent fever and discharging sternal sinus. Enumerate 8 radionuclide imaging techniques that may be helpful in localizing source of infection.

b) A patient with diabetic foot showed increase uptake on delayed MDP bone imaging.

1. What are the two possible differential diagnoses in this case?
2. What radiologic imaging is used as gold standard before planning amputation
Q.16 a) A 45 year old male, known case of Hodgkin’s lymphoma, is referred for baseline FDG PET-CT Imaging.

1. What are the patient’s instructions for the study?
2. Metabolically active lesions were discernible in cervical, mediastinal nodes and left upper lung. What is the stage of the disease?

b) PET and routine gamma imaging are available in your department, a patient is referred for Bone Imaging. MDP kit is not available at present.

1. What other radionuclide imaging can you use to ascertain bony metastases?
2. How do you compare sensitivity and specificity of this alternative technique with routine MDP bone scan?
3. These two techniques help in visualizing bony metastasis. What is the rationale of radiopharmaceutical localization in these two techniques?

Q.17 A 2 year old boy considered at high risk for non-accidental injuries all over the body. An initial X-ray skeletal survey is performed and subsequently a bone scan is requested for additional evaluation.

a) What is the dose and the technique of radiopharmaceutical in the study?
b) Do you consider thyroid blocking before bone scanning in pediatric population?
c) What additional information bone scan (X-ray films already done) may impart?
d) Comment on accuracy of bone scan for diagnosing fractures of ribs, long bones and skull.
e) Can age of fracture can be determined on bone scan?
Q.18 A 53 years old male patient, recently operated case of Papillary Carcinoma thyroid (pT3 N1a M1); I-131-Diagnostic whole body scan 1 month after surgery showed significant residual tissue in neck. First dose of 150 mCi of I-131 was administered. Three months after the dose, patient developed Pleural effusion which was tapped multiple times (No malignant cell could be traced in the fluid tapped). Pleural effusion was recurrent, while cardiac performance status was normal.

a) How is the significant residual thyroid tissue defined in such a case?
b) What should be done for Pleural effusion?
c) When is External Beam therapy considered in differentiated thyroid cancer?
d) What is the role of targeted therapy in differentiated thyroid cancer? How does the therapy help in controlling the disease?

Q.19 A 26 years old male presented to his doctor with intractable headaches. His blood pressure was 180/110 mm Hg. His Urea and Creatinine is within normal limits.

a) How nuclear medicine imaging can help managing this patient?
b) What pharmaceutical(s) can be used in this patient, as per present day practice?
c) Mention the technique including monitoring before imaging. Draw the renograms showing the difference in these radiopharmaceuticals in case of a positive study.
Q.20 a) A 9 years old boy presents with recurrent abdominal pain and occasional hematochezia. He is in continuous distress during examination, but the bowel sounds are normal. X-ray film of abdomen is normal. Patient is sent to nuclear medicine department for further work up.

1. Which scintigraphic investigation would you advise that may help in reaching a diagnosis? Tailor your study acquisition keeping in mind that you have only Gamma Camera in your department and cardiac studies are already planned on that day.
2. Describe reason for false positive and false negative study.

b) If the first investigation turns out to be negative and patient is still suffering from fresh hematochezia.

1. What additional nuclear medicine investigation is recommended?
2. Enumerate two radiopharmaceuticals with their acquisition protocol you may perform in this case.

The End