FRCR Physics MCQs in Clinical Radiology

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Preface

The book is a collection of specimen multiple choice questions (MCQs) for the First FRCR Examination in Clinical Radiology (Physics Module). The content follows the updated Royal College of Radiology (RCR) UK syllabus (November 2016) on scientific basis of medical imaging that now covers topics in molecular imaging. This book will assist the candidate in preparing for the First FRCR Examination and other postgraduate examinations.

The questions are arranged in nine sets of 40 MCQs following the examination format. In addition, explanations to all the answers are provided to improve understanding of the topics.

In each practice set, the questions are arranged in the order of the syllabus from the basis of medical imaging and radiation physics to the principles of specific modalities and safety issues. The candidate can also attempt the questions according to the topics in the syllabus by referring to the table below.

	Content	Question number
4.1	Principles of medical diagnostic imaging	1, 2, 3
4.2	Common themes for all imaging modalities	
4.3	Matter and radiation	4, 5, 6, 7
4.4	Ionising radiation dose	8, 9
4.5	Radiography	10, 11
4.6	Fluoroscopy	12, 13
4.7	Safety in radiography and fluoroscopy	14, 15
4.8	Radioactivity	16
4.9	Planar radionuclide imaging	17
4.10	Safety in planar radionuclide imaging	18
4.11	UK framework for ionising radiation protection	19, 20, 21
4.12	Tomographic reconstruction	22, 23
4.13	Computed tomography	24, 25
4.14	Single-photon emission computed tomography	26, 27, 28
4.15	Positron emission tomography	
4.16	Nuclear magnetic resonance	29, 30
4.17	Magnetic resonance imaging	31, 32
4.18	Safety in magnetic resonance imaging	33

	Content	Question number
4.19	Physics of ultrasound	34, 35, 36
4.20	Ultrasound imaging	
4.21	Safety in ultrasound imaging	37
4.22	Optical imaging	38
4.23	Functional and molecular imaging	39
4.24	The principles of biological processes that can be probed with functional and molecular imaging	40

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Contents

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Part I

Questions

Examination One: Questions

1. Regarding digital radiographic image:

(A) A larger pixel size is required for a larger field of view if the number of pixels is the same.
(B) Increasing the pixel size increases the spatial resolution.
(C) The bit depth determines the number of greyscale range of a pixel.
(D) A 12-bit pixel stores up to 512 levels of grey.
(E) Lossless compression of an image causes degradation of the image quality.

2. The technique used to minimise scatter includes

(A) collimation of the beam.
(B) increasing the kVp.
(C) using an air gap between the patient and the detector.
(D) using compression on the patient.
(D) using anti-scatter grids.

3. Regarding gas-filled detectors used for quality assurance:

(A) Dose calibrator is a type of ionisation chamber.
(B) Proportional counter measures energy of the radiation.
(C) Methane gas is added to reduce gas multiplication effect in a proportional counter.
(D) Geiger-Muller counter discriminates energy of the radiation.
(E) Geiger-Muller counter is used as a dose rate monitor.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
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4. A nucleus is represented by the symbol, ${}^{A}_{Z}X$, where

(A) A is the atomic number.
(B) Z is the mass number.
(C) the atomic number is equal to the number of protons.
(D) the mass number is equal to the total number of protons and electrons.
(E) the number of neutrons is equal to $A-Z$.

5. Protons in an atom

(A) have no mass.
(B) have a positive charge.
(C) are equal to the number of electrons.
(D) are equal to the atomic number.
(E) increase in number, following gamma decay.

6. X-ray photon

(A) is an electromagnetic radiation.
(B) is deflected in a magnetic field.
(C) ionises an atom.
(D) travels at light velocity in a vacuum.
(E) is produced from gamma decay.

7. Rayleigh scatter

(A) is called coherent scatter.
(B) contributes to patient dose.
(C) causes the electrons to be dislodged from the atom.
(D) is a major type of interaction in diagnostic radiology.
(E) has higher probability to occur in high atomic number material.

8. Effective dose is

(A) dependent on the tissue weighting factor.
(B) dependent on the type of radiation.
(C) measured in Sieverts.
(D) equal to the equivalent dose.
(E) used to measure internal radiation exposure.

9. Regarding the differences between deterministic and stochastic effects:

(A) Ulceration of the skin is a stochastic effect.
(B) Stochastic effects have a threshold dose.
(C) Sterility is a deterministic effect.
(D) Deterministic effects have repair mechanism.
(E) Cataract is a stochastic effect.

10. Regarding filters:

(A) Combined filters are used in mammography.
(B) Rhodium filter is used in mammography.
(C) Lead is used as a filter in fluoroscopy.
(D) Using a filter will reduce the patient's skin dose.
(E) Aluminium is the filtering material of choice in general radiography.

11. Component of direct digital radiography includes

(A) image intensifier.
(B) image management system.
(C) digital image processing unit.
(D) communication interface to patient information system.
(E) film digitiser system.

12. Component of the fluoroscopic image intensifier tube includes

(A) input phosphor.
(B) photocathode.
(C) electrostatic focusing lens.
(D) charge couple device.
(E) thin-film transistor.

13. Cause of unsharpness in fluoroscopic image includes

(A) thin phosphor layer in output phosphor.
(B) thick caesium iodide layer in input phosphor.
(C) needle-shaped caesium iodide microcrystal at input phosphor.
(D) increased distance of the image intensifier from the patient.
(E) smaller pixel in flat panel detector.

14. Concept used in ALARP includes

(A) shielding.
(B) dose limit.
(C) distance.
(D) optimisation.
(E) time.

15. The protection to the patient from unnecessary radiation exposure includes

(A) use of collimator.
(B) high kV technique.
(C) increasing source to image distance.
(D) use of fast screen.
(E) use of grid.

16. Radionuclides

(A) are unstable nuclides.
(B) are heavy elements.
(C) undergo radiation decay.
(D) have a 1:1 ratio of neutrons to protons in heavy elements.
(E) are artificially produced.

17. Regarding planar radionuclide imaging:

(A) Gamma camera detector is made of a sodium iodide crystal.
(B) It involves the use of unsealed sources of radioactivity in the form of radiopharmaceuticals.
(C) Extrinsic resolution is the spatial resolution without a collimator in place.
(D) The collimator spatial resolution is improved by decreasing the diameter of collimator cylinders.
(E) The half-life of ^{99m}Tc is 8 h.

18. Concerning safety in planar radionuclide imaging:

(A) Radioactive materials are stored in designated storage location.
(B) Spills of radioactive materials that present no radiological hazard to persons are cleaned immediately.
(C) Occupational workers are trained to maximise the use of radiopharmaceuticals.
(D) Application of cosmetics is prohibited during radiopharmaceuticals preparation.
(E) Occupational internal exposures are infrequent.

19. Regarding UK radiation protection regulations:

(A) Machine maintenance is the responsibility of the operator.
(B) Every controlled area should be governed by a set of local rules.
(C) If in a certain area an employee is likely to receive more than 6 mSv per year, it is designated as a controlled area.
(D) It is the responsibility of the employee to utilise radiation protective clothing provided by the employer.
(E) The annual dose limit for a trainee aged under 18 years is 6 mSv.

20. Concerning the Ionising Radiations Regulations (IRR) 1999:

(A) A controlled area is for classified workers.
(B) Personal dosimeters are issued for periods no greater than 1 month.
(C) The annual effective dose limit is 20 mSv for employees aged over 18 years.
(D) A radiation protection adviser is responsible for managing staff radiation safety in a radiology department.
(E) Local rules are required for a controlled area.

21. According to the Ionising Radiation (Medical Exposure) Regulations 2000 (IRMER)

(A) all referrers must undergo training.
(B) a qualified chiropractor acts as a practitioner.
(C) a medical physics expert is to be present for all nuclear medicine exposures.
(D) anyone participating in the practical aspects of a medical exposure is an operator.
(E) the regulations do not apply to research exposures.

22. Concerning tomographic reconstruction:

(A) It allows visualisation of the internal structures of an object.
(B) The radon transform reconstructs tomographic images from measured projection data.
(C) X-ray CT measures the number of X-ray photons emitted through the patient along individual projection lines.
(D) Backprojection propagates the measured sinogram back into the image space.
(E) Direct Fourier is one of the techniques.

23. Reducing the number of projections is desirable for the purpose of

(A) increasing scanning time.
(B) reducing noise.
(C) reducing motion artefact.
(D) reducing patient dose.
(E) increasing number of measurement.

24. Reducing CT slice thickness results in

(A) increased partial volume effect.
(B) low subject contrast.
(C) fewer X-rays incident upon the detector.
(D) noisier images.
(E) changing the beam width.

25. Technique to reduce the CT dose includes

(A) limiting the coverage of the scan.
(B) increasing mA.
(C) utilisation of body mass index chart.
(D) proper patient positioning.
(E) using the 3D dose modulation.

26. Regarding SPECT:

(A) Spatial resolution is lower than planar gamma imaging.
(B) Multiple camera heads are used.
(C) Reconstructed resolution improves as the distance of the detector from the patient is increased.
(D) The detection sensitivity of SPECT system is less than the planar gamma imaging.
(E) Filtered backprojection technique is used to reconstruct the tomographic images.

27. Regarding SPECT:

(A) The computational time in SPECT reconstruction is longer than CT.
(B) SPECT imaging is less susceptible to motion artefacts than CT imaging.
(C) SPECT allows over- and underlying distribution of radioactivity with improved contrast.
(D) Radiopharmaceutical used in general planar imaging is used in SPECT procedures.
(E) Intrinsic uniformity for SPECT camera is a daily QA test.

28. Regarding radionuclides for positron emission tomography (PET):

(A) It is produced from Mo generator.
(B) It has significant physiologic potential.
(C) It replaces atoms in molecules for metabolism.
(D) It allows direct studies of metabolism of tissue.
(E) ^{16}O is one of the examples.

29. Regarding nuclear magnetic resonance (NMR):

(A) It uses electromagnetic radiation to promote transitions between electric signals.
(B) ^{1}H is one of the magnet nuclei.
(C) Different atoms within a molecule resonated at the same frequencies.
(D) It is expected to provide more specific pathophysiologic information than conventional imaging modalities.
(E) It is capable of producing high-quality images without the use of ionising radiation.

30. Factor which contributes to the decay of transverse magnetisation in NMR includes

(A) constant frequency.
(B) presence of two spin states.
(C) molecular interactions.
(D) variations in magnetic field.
(E) the spin aligns in one orientation.

31. Regarding magnetic resonance imaging (MRI):

(A) STIR is used for suppression of fatty tissues.
(B) Gadolinium reduces both T1 and T2 relaxation times.
(C) STEAM stands for stimulated echo acquisition mode.
(D) The TR used to obtain T1W images is long.
(E) T1 relaxation occurs, closely followed by the initiating of T2 relaxation.

32. In T2-weighted images

(A) the TE used is long.
(B) the flip angle used is 30°.
(C) tissue with long T2 decay time appears bright.
(D) cerebral spinal fluid appears dark.
(E) infectious regions produce low signal.

33. Concerning safety in MRI:

(A) The radiofrequency deposition is minimised in patients.
(B) A limited number of implants are assessed at field strengths of 3 Tesla.
(C) Patient's skin is insulated from the bore of the magnet.
(D) Subjecting the human body to time-varying electromagnetic fields leads to induced magnet fields.
(E) Immediate evacuation of the patient is necessary if a quench occurs.

34. Ultrasound used in medical diagnosis

(A) has an average speed in tissue of 1540 m/s.
(B) causes microcavitation of blood.
(C) has a frequency range of 1–20 Hz.
(D) measures blood velocity.
(E) generates large amount of heat in the imaged tissues.

35. Piezoelectric materials in ultrasound

(A) expand when direct current is applied.
(B) expand and contract when alternating current is applied.
(C) convert electric current to sound energy.
(D) act as transmitter and receiver material.
(E) convert sound energy to electric signal.

36. Factor affecting visibility of anatomical detail in ultrasound image includes

(A) frequency.
(B) transducer focusing.
(C) time gain compensation.
(D) pulse rate.
(E) acoustic impedance.

37. Regarding safety in ultrasound imaging:

(A) The output level is kept as low as reasonably achievable.
(B) The mechanical index (MI) greater than 0.7 generates the risk of cavitation.
(C) The maximum temperature of the probe in contact with the patient is limited to 43 °C.
(D) Pulsed Doppler technique produces lesser heating potential than Doppler power mapping.
(E) The use of Doppler ultrasound in the first trimester is restricted.

38. Fluorescent imaging

(A) is sensitive for protein detection.
(B) has lower stability compared to radioisotopes.
(C) requires radiation shielding during handling.
(D) involves an optical camera.
(E) detects photon of a wavelength longer than X-ray.

39. Concerning functional and molecular imaging (FMI):

(A) Optical imaging with fluorescent molecular probes produces images with high spatial resolution.
(B) Cadmium zinc telluride (CZT) semiconductor detectors used in SPECT/MR system are not susceptible to magnetism.
(C) Equal distance separation between both gantries during data acquisition leads to the misregistration of the PET/CT images.
(D) PET studies demonstrate higher sensitivities for detection of coronary artery disease than SPECT.
(E) The reconstructed slice of PET images is thicker than CT slice for a precise PET/CT image fusion.

40. Regarding FMI:

(A) MR spectroscopic imaging (MRSI) detects tumour in the brain based on changes in lactate concentration.
(B) Kinetic modelling is used to provide information about varying aspects of biological processes in dynamic studies.
(C) In diffusion weighted (DW)-MRI study, tissues with high cellularity display higher signal intensity than dense tissues.
(D) In fasting state, the level of muscle FDG uptake is higher than the tumour FDG uptake.
(E) Metabolic activity serves as an imaging biomarker in PET imaging.

Examination Two: Questions

1. The technique used to minimise motion blur includes

(A) increasing the mA.
(B) increasing the exposure time.
(C) using a fast film-screen combination.
(D) image magnification.
(E) using a breath-hold technique.

2. Geiger-Muller counter used for radiation survey

(A) has a thick window to detect alpha particle.
(B) has low efficiency in detecting gamma radiation.
(C) is a dosimeter-type detector.
(D) distinguishes beta particle from alpha particle.
(E) requires a multichannel analyser to read out the signal from radiation interaction.

3. Regarding quality assurance of a dose calibrator:

(A) Accuracy test is done on installation.
(B) Constancy test is done annually.
(C) Measurement of high-energy gamma emitters is affected by changes in the sample volume.
(D) Sealed ^{60}Co is used in quality assurance test.
(E) Linearity test result is accepted if the calculated activity exceeded 10%.

4. Carbon-12 and carbon-11 have the same

(A) chemical properties.
(B) physical properties.
(C) number of protons.

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(D) number of neutrons.
(E) half-life.

5. X-ray tube

(A) consists of a small coil of wire cathode.
(B) is a gas-filled tube.
(C) has 100% efficiency in producing X-rays.
(D) has a glass envelope.
(E) is located within a CT scanner.

6. Regarding bremsstrahlung X-rays produced in an X-ray tube:

(A) It is produced from the interaction of electrons with the nucleus of the target atom.
(B) The energy spectrum is discrete.
(C) The lower-energy photons are absorbed by the tube.
(D) The maximum energy of the photons is equal to the tube kVp.
(E) It is the major component of photons produced from a tungsten target.

7. Beam attenuation

(A) is caused by scatter.
(B) is caused by absorption.
(C) is caused by penetration.
(D) increases patient dose.
(E) is caused by photoelectric interaction.

8. The device used to measure radiation dose includes

(A) film badge.
(B) optically stimulated luminescence detector.
(C) TLD.
(D) lonisation chamber.
(E) geiger counter.

9. The radiation weighting factor

(A) for gamma is 5.
(B) for proton and X-ray is the same.
(C) for alpha is 20.
(D) for neutron is dependent on energy.
(E) affects the absorbed dose value.

10. Regarding X-ray production:

(A) A large focal spot produces sharper images.
(B) Tungsten is used in cathode filament.

(C) The cathode filament is heated to 200 °C for it to emit electrons.
(D) The quantity of X-ray produced increases linearly with mAs.
(E) The quantity of X-ray produced increases linearly with filtration thickness.

11. Regarding digital image receptor in direct digital radiography:

(A) It converts X-rays to electric signals.
(B) Thin-film transistor collects electrical charge.
(C) Charge-coupled device (CCD) is used to collect electrical charge in direct digital image receptor.
(D) The caesium iodide (CsI) crystal is use to convert X-rays to lights.
(E) Lights are produced following the interactions of X-rays with amorphous selenium.

12. Regarding resolution of an image intensifier:

(A) The output phosphor liberates light when bombarded by light photons.
(B) The input screen liberates visible lights when stimulated by X-rays.
(C) Resolution improves by using a thicker input phosphor.
(D) It is superior to conventional film.
(E) It is measured in pixels.

13. Regarding fluoroscopic image quality:

(A) Vignetting is a reduction in brightness of the fluoroscopic image at the periphery.
(B) Brightness gain is defined as the ability of the image intensifier to increase the illumination level of the image.
(C) S-distortion is due to maladjustment of the electron focusing system.
(D) Flux gain is defined as the ratio of the light photons at output phosphor to the number of X-rays at input phosphor.
(E) Low quantum detection efficiency in input phosphor causes pincushion distortion.

14. Regarding personal radiation monitoring device:

(A) It is used at waist level during pregnancy.
(B) Film badges contain various types of filters.
(C) Ring dosimeter is used on the hand closest to radiation source.
(D) It is placed at location that can represent whole-body exposure.
(E) It is used whenever working with radionuclide.

15. The purpose of using personal monitoring device is to

(A) protect the radiologist from radiation.
(B) calculate the total of radiation delivered to the patient.
(C) calculate the number of radiation procedures conducted by the radiologist.

(D) indicate an occupational exposure.
(E) recognise the type of radiation received by personnel.

16. Regarding radioactive decay:

(A) Alpha particle is identical to a helium nucleus.
(B) Positron decay occurs when a neutron is converted into a proton.
(C) Beta minus decay emits an electron.
(D) An antineutrino is emitted in a positron decay.
(E) Electron capture results in a production of Auger electron.

17. Regarding choice of collimators in planar radionuclide imaging:

(A) It is a trade-off between specificity and resolution.
(B) A collimator with small holes will provide better resolution but has lower sensitivity.
(C) The best spatial resolution is achieved with a collimator with long holes of a small diameter.
(D) Lung ventilation and perfusion scans are acquired using a low-energy general purpose collimator.
(E) Bone scans are best done with a low-energy high-resolution collimator.

18. Concerning ^{57}Co flood source:

(A) The half-life is 5.2 years.
(B) The photon energy is 122 keV.
(C) It is used for intrinsic uniformity.
(D) A ^{99m}Tc flood source is used to replace it for the same uniformity test.
(E) The uniformity test is performed on daily basis.

19. Regarding UK radiation legislation:

(A) A radiation protection supervisor is responsible for ensuring that patient doses are kept as low as reasonably practicable.
(B) Classified workers require an annual medical report by an appointed doctor to be certified fit.
(C) An area in which doses are greater than 30% of the annual dose limit is classified as controlled area.
(D) There are no dose limits for patients undergoing medical exposures under IRR 1999.
(E) A diagnostic dose reference level is the dose limit.

20. The Ionising Radiations Regulations (IRR) 1999 states the following dose limits

(A) the annual whole-body effective dose for a member of the public is 6 mSv.
(B) equivalent dose of 150 mSv to the lens of the eye of a radiologist.

(C) 10 mSv during any consecutive 3-month period to the abdomen of a woman of reproductive capacity.
(D) 50 mSv to the individual organs or tissues of a radiographer.
(E) radiation exposure resulting from medical exposure for a member of the public is limited to 5 mSv in any five consecutive calendar years.

21. The circumstance where the Health and Safety Executive (HSE) must be notified includes

(A) loss or theft of a radioactive source.
(B) dose exceeding investigation level.
(C) radioactive spillage leading to significant contamination.
(D) medical exposure much greater than intended.
(E) failure to follow local rules.

22. Regarding tomographic reconstruction:

(A) Filtered backprojection is referred to as the convolution method.
(B) The convolution method allows image to be reconstructed, while X-ray transmission data are being collected.
(C) A low-frequency convolution filter makes the image appear smoother.
(D) A low-frequency filter is referred to as a low-pass filter.
(E) Serial expansion is also known as iterative reconstruction technique.

23. Concerning simple backprojection:

(A) Each X-ray emission path through the body is divided into equally space elements.
(B) It is formed by smearing each view back through the image in the direction it was originally acquired.
(C) A final summed attenuation coefficient is determined by summing the attenuation for each element at different distances.
(D) A composite image of attenuation coefficients is obtained when the coefficient for all elements is combined in the anatomic section.
(E) It produces blurred images of sharp features in the object.

24. In CT imaging

(A) the images are presented as a greyscale display of linear attenuation coefficients of tissues.
(B) the linear attenuation coefficients are related to the physical density of tissues.
(C) rectilinear pencil-beam scanning is the second generation of CT scanners.
(D) the beam hardening artefact results in reduced attenuation coefficients in the centre compared with the periphery.
(E) higher CT numbers produce darker CT image.

25. Advantages of spiral compared with conventional CT include

(A) slower image acquisition.
(B) quicker response to contrast media.
(C) less partial volume artefact.
(D) more motion artefacts.
(E) improved two-axis resolution.

26. Regarding SPECT:

(A) The advantage of multiple heads in SPECT system is an improvement in count-rate sensitivity.
(B) The centre of rotation QC test for SPECT cameras is performed on monthly basis.
(C) A 180° acquisition arc is recommended for cardiac imaging.
(D) The bull's-eye artefact in SPECT images is due to field non-uniformity.
(E) The continuous data acquisition is better than "step-and-shoot" acquisition as it reduces blurred images due to camera head motion.

27. Concerning SPECT:

(A) The usual collimator used for ^{99m}Tc-pertechnetate thyroid imaging is pinhole collimator.
(B) ^{99m}Tc-labelled aerosol is preferable for use in pulmonary ventilation imaging as it provides better distribution of radioactivity in lungs.
(C) Cold area in SPECT images indicates the area of no activity.
(D) Any discontinuities in the sinogram indicate the patient motion.
(E) In filtered backprojection algorithm, selecting higher cut-off frequency yields a blurry reconstruction.

28. Regarding positron emission tomography (PET):

(A) Radionuclides are produced in a cyclotron.
(B) The distribution of radioactivity is estimated by Fourier transform method.
(C) The radiation detected is annihilation radiation released due to photon interaction with electron.
(D) The PET image reveals the number of decays occurring in each of the voxels.
(E) Collimators are needed in imaging.

29. Concerning nuclear magnetic resonance (NMR):

(A) The nuclei of many elemental isotopes have a characteristic spin.
(B) Nuclei of ^{12}C have an integral spin.
(C) Some nuclei have integral spin.
(D) A spinning charge generates a magnetic field.
(E) The resulting spin-magnet has a magnetic moment proportional to the spin.

30. Regarding NMR:

(A) A magnetic dipole moment in a magnetic field has a potential energy related to its orientation with respect to that field.
(B) The photon spin tends to precess around the magnetic field with a frequency called the Larmor frequency.
(C) It allows imaging of soft tissues of the body by distinguishing between hydrogen atoms in different environments.
(D) In vivo NMR provides a window to the metabolic states of different cells.
(E) The NMR allows the measurement of chemical shifts in the properties.

31. Regarding MRI:

(A) FLAIR stands for fluid-attenuated inversion recovery.
(B) The rephasing pulse is 180°.
(C) A narrow bandwidth allows for thinner slices.
(D) Positron is imaged using MRI.
(E) The longitudinal relaxation time is longer than the transverse relaxation time.

32. Regarding T1-weighted image in MRI:

(A) The TR used is long.
(B) Large flip angle is used in gradient echo pulse sequences.
(C) Cerebrospinal fluid is hypointense.
(D) Grey matter is hyperintense compared to white matter.
(E) It provides the contrast for paramagnetic contrast agents such as gadolinium.

33. Safety of MR imaging in patients with cardiovascular devices involves

(A) a careful initial patient screening.
(B) accurate determination of the permanent implanted cardiovascular device and its properties.
(C) a thoughtful analysis of the risks of performing the examination.
(D) physician management and supervision.
(E) clarification of safety issues in regard to the performance of MR examinations.

34. Regarding medical ultrasound:

(A) The velocity of ultrasound in fat is equal to that in muscle.
(B) High-frequency probes are used in endoscopic ultrasound.
(C) The absorption coefficient for fat is higher than water.
(D) A caesium iodide crystal is used to produce diagnostic range ultrasound waves.
(E) Setting the focus at the depth of interest improves the resolution at this level.

35. As an ultrasound pulse moves through tissue, it undergoes a change in

(A) frequency.
(B) amplitude.
(C) wavelength.
(D) intensity.
(E) velocity.

36. Determining blood flow velocity using Doppler function requires for the operator to adjust for

(A) transducer frequency.
(B) depth of vessel.
(C) direction of vessel.
(D) size of transducer.
(E) direction of blood flow.

37. Concerning safety in ultrasound imaging:

(A) For obstetric examination, the recommended maximum scanning time for thermal indices (TI) of 1.5 is less than 30 min.
(B) The thermal index for cranial bone (TIC) is used for any foetal scan more than 10 weeks after the last menstrual period.
(C) The raised tissue temperature due to probe self-heating is greater for endo-cavitary probes than for surface probes.
(D) The eye is particularly vulnerable to thermal hazard of the ultrasound.
(E) For neonatal cardiac imaging, the recommended exposure time for TI of 2.5 is less than 15 min.

38. The key element of a fluorescent imaging system includes

(A) helium neon laser.
(B) lenses.
(C) optical filters.
(D) light scintillator.
(E) photomultiplier tube.

39. Regarding functional and molecular imaging (FMI):

(A) Molecular imaging is defined as the ability to visualise the function of cellular processes in vivo.
(B) CT images provide an attenuation map for scatter correction in PET/CT.
(C) Molecularly targeted microbubbles in ultrasound imaging are used in FMI.
(D) Sodium iodide (NaI) crystals are preferred for PET imaging over bismuth germanate (BGO).
(E) The limitation of MRI as a molecular imaging tool is the size of the contrast agents.

40. Concerning FMI:

(A) Cellular MRI is based on tracking of migration of cells labelled with an MR contrast agent.
(B) Cerebral glucose metabolism is decreased during seizures.
(C) The clinical application of in vivo optical imaging is for imaging of atherosclerosis.
(D) ^{18}FDG is used to measure the local cerebral metabolic rate in SPECT imaging.
(E) Cervical carcinoma has low uptake of FDG in PET.

Examination Three: Questions

1. Overall detection efficiency of a detector in nuclear medicine department is affected by

(A) quantum detection efficiency.
(B) intrinsic efficiency.
(C) photopeak efficiency.
(D) geometric design of the detector.
(E) distance of the source from the detector.

2. Regarding scintillation detector in an imaging detector:

(A) It emits visible light after the interaction with ionising radiation.
(B) The two bands of the scintillator material are the valence and conduction bands.
(C) Dopants are introduced in the scintillator material to create the electron traps.
(D) Phosphorescence occurs without the electron trap.
(C) It exists in liquid form.

3. Regarding dead time of a detector system:

(A) It is determined by the electronic component of the systems.
(B) Geiger-Muller counter has the shortest dead time.
(C) Paralysable system causes longer dead time compared to a non-paralysable system.
(D) It affects sensor running in current mode.
(E) It causes loss of signal.

4. Gamma ray

(A) is emitted from a nuclide in a metastable state.
(B) has a lifetime of several years.

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(C) results in an increase of the mass number of the daughter nuclide.
(D) is emitted after alpha decay.
(E) is produced from an X-ray tube.

5. Interaction of electrons with the anode in an X-ray tube results in

(A) production of thermal energy.
(B) emission of bremsstrahlung X-ray.
(C) increase kinetic energy of the electron.
(D) production of discrete energy X-rays.
(E) generation of a spectrum of X-rays.

6. Regarding characteristic X-ray produced in an X-ray tube:

(A) It is the maximum energy photon from a tungsten target.
(B) It results in a ramp-shaped spectrum.
(C) It has several discrete energies.
(D) It is produced from interaction of electrons with the nucleus of the target atom.
(E) The energy of the incoming electron is higher than the K-shell binding energy of the anode.

7. Beam attenuation

(A) is the attenuation of photons due to scatter and absorption.
(B) affects the image contrast.
(C) is contributed from photoelectric interaction.
(D) is contributed from Compton interaction.
(E) is contributed from coherent scatter.

8. Regarding radiation measurement and its unit:

(A) Absorbed dose is measured in J/kg.
(B) Equivalent dose is measured in Gy.
(C) Dose limits are given in Gy.
(D) Effective dose is measured in Sv.
(E) Dose area product is measured in Gy/cm^2.

9. Regarding the tissue weighting factor:

(A) The gonads have the highest weighting factor.
(B) The stomach and colon have the same weighting factor.
(C) The skin has a lower weighting factor than bone surface.
(D) The factor indicates the radiosensitivity of various tissues.
(E) The values are derived from atomic bomb survivors in Japan in 1945.

10. Increasing the kVp of the beam

(A) makes photon less penetrating.
(B) decreases exposure latitude.
(C) increases the amount of scatter reaching the receptor.
(D) necessitates the use of a grid.
(E) results an increase in the patient's skin dose.

11. The advantage of digital radiography includes

(A) real-time dose measurement.
(B) ability to transfer images faster over network systems.
(C) effective image storing and retrieving method.
(D) image contrast is improved using image post-processing technique.
(E) low initial cost compared to other system.

12. Part of fluoroscopic imaging chain includes

(A) charge-coupled device (CCD) camera.
(B) kerma air product (KAP) metre.
(C) flat panel image receptor.
(D) molybdenum filter.
(E) intensifying tube.

13. Regarding the image intensifier in fluoroscopy:

(A) It is filled with ionised gas.
(B) The potential difference between photocathode and anode is used to accelerate electrons to output phosphor.
(C) Modern fluoroscopy unit replaces image intensifier with flat panel detector.
(D) The diameter of the input screen is twice the diameter of the output screen.
(E) A thin lead foil shielding the inner side of the chamber is used to prevent light from reaching the tube.

14. Exposure to radiation worker is reduced by

(A) applying an inverse square law concept.
(B) decreasing the amount of time near the source.
(C) providing shielding between personnel and the source.
(D) applying an ALARP concept.
(E) using the radiation monitoring device appropriately.

15. Radiation protection action practised in the department of radiology by

(A) wearing a personnel radiation protective equipment.
(B) reducing time spend in supervised area while X-ray machine is operational.

(C) applying dose limit concept to patient.
(D) using personal dosimeter in supervised area.
(E) applying an inverse square law theory.

16. Regarding radioactive decay:

(A) Gamma decay occurs in a metastable nuclide.
(B) Beta minus decay emits a positively charged electron.
(C) Positron emitted will annihilate with an electron.
(D) The parent nuclide is a radionuclide.
(E) The decay rate is characterised by the half-life.

17. Concerning radiopharmaceuticals selection in planar radionuclide imaging:

(A) ^{99m}Tc produces a monoenergetic gamma emission at 150 keV.
(B) ^{201}Tl leads to an increase in the radiation dose even for smaller injected dosages.
(C) The selection of radionuclides that have energy close to 200 keV results in better quality images for less radiation dose.
(D) ^{99m}Tc radiopharmaceuticals used for the same purpose have different uptake and clearance characteristics.
(E) Encouraging patients to drink liquids and void frequently helps to reduce the radiation dose.

18. Regarding safety in planar radionuclide imaging:

(A) Drying causes airborne ^{99m}Tc dust contamination.
(B) Expelling ^{99m}Tc solutions through syringe needle generates airborne aerosols.
(C) A lab coat and disposable gloves are required when handling ^{99m}Tc.
(D) Rapid boiling causes airborne ^{99m}Tc aerosol contamination.
(E) Indirect counting using a liquid scintillation counter is used to detect removable ^{99m}Tc contamination on smears.

19. According to the Ionising Radiations (Medical Exposure) Regulations 2000 (IRMER)

(A) the practitioner is the person entitled to authorise an X-ray exposure.
(B) dentists are permitted to request for a medical exposure.
(C) the enforcing authority is the Health and Safety Executive.
(D) the medical physics expert is involved in consultation on dose optimisation.
(E) the employer shall establish a quality assurance programme for standard operating procedures.

20. According to Ionising Radiations Regulations (IRR) 1999, the information in local rules contains

(A) summary of working instruction in an area.
(B) contingency plans for any potential radiation accident.
(C) dose limit for each staff and member in each area covered.
(D) procedures for contamination monitoring.
(E) arrangements for breastfeeding staff.

21. Regarding radiation dose to patients and members of the public:

(A) The equivalent dose for 1 cm^2 area of the skin for members of the public is limited to 50 mSv.
(B) Radiation dose to the patient resulting from medical exposure is limited to 5 mSv in any five consecutive calendar years.
(C) Patient doses in interventional radiology are amongst the highest received from medical exposures.
(D) The dose limit is not applicable for any biomedical and medical research programmes.
(E) The effective dose limit to the public is 6 mSv per annum.

22. Regarding tomographic image reconstruction:

(A) Each tomographic modality measures a different physical quantity.
(B) It measures the number of X-ray photons transmitted through the patient along individual reconstructed lines in CT.
(C) It measures the number of photons emitted from the patient along individual projection lines in nuclear medicine imaging.
(D) It measures the amplitude and phase of scattered waves along a particular line in ultrasound diffraction tomography.
(E) The radon transform provides basis for reconstructing tomographic images from measured projection data.

23. The iterative image reconstruction

(A) requires high computation.
(B) demands the same computing power as two full reconstructions in filtered backprojection.
(C) approach is based on expectation-maximisation.
(D) provides noisy images compared to filtered backprojection.
(E) is advantageous when the number of projection data is low.

24. Regarding CT number:

(A) Tissues with high attenuation coefficient have negative CT number.
(B) CT number for grey matter is similar with white matter.

(C) CT numbers vary depending on beam filtration.
(D) CT number of blood is similar to that of soft tissue.
(E) Changing the window width will change the CT number values.

25. Concerning CT image:

(A) Lower CT numbers produce darker image.
(B) The amount of X-rays absorbed contributes to the radiation dose of the patient.
(C) The window used for display is matched to the X-ray density of the object of interest to optimise the visible detail.
(D) Sinogram is a visual representation of CT raw data.
(E) Noise occurs when power supplied to the X-ray tube is insufficient to penetrate the anatomy.

26. Regarding SPECT system:

(A) The camera heads are arrayed parallel (180°) to each other for body imaging.
(B) The ability of the camera to separate events of different energies is known as energy resolution.
(C) Decreasing the septal thickness allows the use of higher-energy gamma emitters.
(D) The pinhole collimator is used when imaging small organs that lie close to the skin.
(E) The geometric sensitivity of a parallel-hole collimator depends on the distance between the source and collimator.

27. Regarding SPECT:

(A) High-sensitivity collimator provides better image quality compared to high-resolution collimator.
(B) For dedicated cardiac imaging, the dual heads are arrayed in the 90° position.
(C) ^{99m}Tc-tetrofosmin is used in myocardial perfusion imaging.
(D) SPECT imaging has more uniform resolution than PET imaging.
(E) The centre of rotation calibration test is not required for SPECT quality control.

28. Regarding positron emission tomography (PET):

(A) Attenuation corrections are inherently more accurate in SPECT than in PET.
(B) Detector sensitivity is a major design consideration in PET.
(C) Bismuth germanate crystals have greater intrinsic efficiency for higher-energy photons.
(D) PET resolution is greater than CT.
(E) Positron emitters are produced in a cyclotron.

29. In nuclear magnetic resonance (NMR)

(A) the resonance frequency of a particular substance is directly proportional to the strength of the applied magnetic field.
(B) resolution of the imaging technique depends on the uniformity of magnetic field.
(C) superconductors are used to increase the magnetic field strength.
(D) the sensitivity is improved by using hyperpolarisation.
(E) ^{13}C is one of the nuclei.

30. Regarding NMR:

(A) It uses a combination of static and radio frequency magnetic fields.
(B) The intensities of NMR signal depend on the differences of the magnetic strength.
(C) The NMR spectroscopy uses electromagnetic radiation to cause transitions between the energy levels.
(D) ^{1}H NMR relaxation time images are useful for the detection of a wide spectrum of disorders.
(E) ^{31}P NMR chemical shift spectra measure directly the metabolic status of living tissue.

31. Regarding MRI:

(A) Combining a low flip and long TR results in saturation.
(B) T2* is typically shorter than T1.
(C) Substances with negative magnetic susceptibility are termed paramagnetic.
(D) Fast STIR sequences use an initial 180° inversion pulse.
(E) Free induction decay is the raw MR signal.

32. Concerning the proton density (PD)-weighted image in MRI:

(A) A short TE and a long TR are used to produce a PD image.
(B) Tissue with low proton density appears bright.
(C) Long TR is used to reduce the effect of T2 on contrast.
(D) PD weighting is used for high-resolution imaging.
(E) Fat appears bright.

33. Concerning MRI safety:

(A) Electrical potentials during physical movements within static magnetic field gradients induce sensations of nausea.
(B) Short-bore magnets require the patient's height to be recorded.
(C) Poor positioning of the patient is the cause of skin burns.
(D) Patient's skin is insulated from the bore of the magnet.
(E) Superconducting magnets offer a potential cryogen hazard.

34. Regarding ultrasonic waves:

(A) Sound travels faster in a vacuum.
(B) Focusing transducer improves the axial resolution at the depth of interest.
(C) The velocity in different tissue densities is constant.
(D) The velocity of sound through the bone is slowest.
(E) In constructive interference, the amplitude of the resulting wave is higher than the interfering waves.

35. Changing from a 2 MHz to a 5 MHz ultrasound transducer produces

(A) better resolution image for superficial structures.
(B) deeper penetration.
(C) shorter wavelength.
(D) shorter ultrasound pulses.
(E) increased attenuation in tissue.

36. Regarding acoustic impedance in ultrasound:

(A) It is a product of the tissue's density and the sound velocity within the tissue.
(B) The amplitude of returning echo is proportional to the difference in acoustic impedance between the two tissues.
(C) It is a physical property of tissue in ultrasound imaging.
(D) The highest reflection in acoustic impedance occurs at the interfaces of different materials.
(E) The SI unit for acoustic impedance is kg/m^3.

37. Safety in ultrasound imaging

(A) the thermal index for bone (TIB) assumes the bone is present at the depth where temporal intensity is greatest.
(B) according to the guidelines by the UK Association of Sonographers, informed consent should be obtained before proceeding with the examination.
(C) for thermal index (TI) more than 0.7, the overall exposure time of the neonatal central nervous system should be restricted.
(D) in obstetrics imaging, the soft-tissue thermal index (TIS) should be used in the first trimester.
(E) mechanical effect of ultrasound leads to cavitation injury.

38. Bioluminescent imaging

(A) requires external light excitation.
(B) involves process inside the organism that emits light.
(C) is useful for molecular imaging.

(D) cannot provide real-time cell tracking.
(E) utilises a reaction called 'luciferase-luciferin' reaction.

39. Regarding functional and molecular imaging (FMI):

(A) The disadvantage of magnetic resonance spectroscopy (MRS) is long acquisition time.
(B) Dynamic contrast-enhanced MRI (DCE-MRI) is used to assess tissue vascularity.
(C) Attenuation correction is more accurate for SPECT than PET imaging.
(D) The use of contrast-enhanced ultrasound imaging in characterisation of liver lesions is based on vascular enhancement using non-targeted microbubbles.
(E) As compared to SPECT, CT underestimates the extent of cerebral infarction.

40. Concerning functional and molecular imaging (FMI):

(A) In PET, the uptake of FDG is inversely proportional to the tumour grade.
(B) CT imaging is more sensitive than FDG-PET in detecting renal cell carcinoma.
(C) Diffusion-weighted images (DWI) are used to differentiate benign from malignant lesions.
(D) Proton magnetic resonance spectroscopic imaging (H-MRSI) is able to examine the biochemistry of tissue.
(E) Lactation results in decreased female breast uptake of ^{67}Ga.

Examination Four: Questions

1. Regarding image receptor in digital radiography:

(A) The image receptor is divided into a matrix of pixels.
(B) Increasing the number of pixels reduces the spatial resolution.
(C) Fill factor is the percentage of pixel area that is sensitive to radiation.
(D) Signal in pixel array is read out using the associated electronic circuitry.
(E) Each pixel contains a photoconductor.

2. Radiographic contrast

(A) is affected by the subject contrast.
(B) is affected by the detector contrast.
(C) is affected by the linear attenuation coefficients of the structures.
(D) is enhanced using digital image processing.
(E) improves with the use of contrast media.

3. Regarding scintillation detectors in a dose calibrator:

(A) Thallium-doped sodium iodide is an example.
(B) The type of the scintillating material affects the energy gap.
(C) It emits visible light upon absorption of ionising radiation.
(D) Photomultiplier tubes are used to amplify the signal.
(E) Inorganic scintillator is used.

4. Electrons in an atom

(A) have a higher mass compared to proton.
(B) have a positive charge.
(C) are equal to the number of protons in a non-ionised atom.
(D) are equal to the mass number.
(E) orbit the nucleus in specific shells.

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5. Regarding X-rays produced in an X-ray tube:

(A) The spectrum of the X-rays produced is characteristic of a given target material.
(B) Bremsstrahlung X-ray is produced from filament electron dislodging orbital electrons in the target.
(C) An increase in the tube voltage (kV) leads to an increase in X-ray energy.
(D) Filament electrons with 90 keV dislodge K-shell electrons in a tungsten target.
(E) Characteristic X-rays are the main component of X-rays produced from a tungsten target.

6. Regarding Compton interaction:

(A) It involves an outer shell electron.
(B) The probability of interaction is dependent on the number of the atomic number in the absorbing material.
(C) The probability of Compton attenuation decreases as photon energy is increased.
(D) It causes scattered radiation in the material.
(E) It causes ejection of a recoil electron.

7. The heel effect is

(A) due to attenuation of X-rays in the target material.
(B) greater on the cathode side of the X-ray field.
(C) bigger for a smaller anode angle.
(D) more pronounced at lower kVp.
(E) useful in spine radiographs.

8. Regarding radiation units:

(A) Equivalent dose is a product of absorbed dose multiplied by the radiation weighting factor and tissue weighting factor.
(B) Effective dose is a product of absorbed dose multiplied by the radiation weighting factor.
(C) Dose limit is the limit of radiation dose for each individual.
(D) Dose area product is the absorbed dose divided by the unit area.
(E) The tissue weighting factors are the same for certain organs.

9. Regarding effects of ionising radiation on tissue:

(A) Production of photoelectrons causes the effect.
(B) It depends on the mitotic rates of a cell.
(C) Gamma rays cause direct damage.
(D) It is caused by damage of DNA by free radicals.
(E) Younger person has a greater risk of radiation damage compared to adult.

10. Amount of transmission radiation detected by imaging device is decreased by

(A) increasing the air gap distance.
(B) reducing the field area.
(C) using the compression technique.
(D) using an anti-scatter grid.
(E) reducing kVp of X-rays.

11. Regarding intensifying screens in screen film radiography:

(A) The traditional phosphor used in intensifying screen is lanthanum oxybromide.
(B) Rare earth screen is efficient in converting X-rays to lights.
(C) Use of intensifying screens reduces radiation dose to the patient.
(D) The spectral emission of the screen should match the spectral sensitivity of the film.
(E) Screen material is chosen from a phosphorescence crystal.

12. Part of fluoroscopic image intensifier includes

(A) focusing electrodes.
(B) zinc cadmium sulphide screen.
(C) vacuum housing.
(D) rotating anode.
(E) polyester base.

13. Adjustment of brightness in fluoroscopy is made by

(A) controlling kVp.
(B) changing mA.
(C) using CCD camera.
(D) adjusting sensitivity of TV system.
(E) using automatic brightness control.

14. Practical methods in protecting the patients from radiation include

(A) collimation should always be to the region of interest.
(B) magnified field of views is used in fluoroscopy procedure.
(C) supplementary shielding is used to protect sensitive structures within field of view.
(D) image intensifier is kept as far as possible to the patient in fluoroscopy.
(E) removal of anti-scatter grids for extremity X-ray procedure.

15. The risk of deterministic effect includes

(A) sterility.
(B) leukaemia.

(C) formation of cataract.
(D) hair loss.
(E) skin erythema.

16. In radioactive decay

(A) transition energy is the energy released in a decay event.
(B) the source of energy released is a conversion of mass into energy.
(C) it results in the transformation of one nuclear species into another.
(D) activity is an average number of radioactive decays per unit time.
(E) decay constant is a fraction of nuclei that will decay per unit time.

17. Concerning gamma camera:

(A) It is also known as scintillation camera.
(B) The thickness of the NaI(Tl) crystal determines its detection efficiency.
(C) A collimator is used to selectively absorb unwanted radiation.
(D) Pinhole collimators are best suited for magnification imaging of the thyroid.
(E) Septal materials with low atomic numbers provide best results.

18. Regarding rules for avoiding internal radiation dose:

(A) Work should be performed on absorbent pads to catch spills.
(B) Containers with sharp edges should not be used for radioactive materials.
(C) Lab coats should be worn when handling radioactive sources.
(D) Work with radioactive gases should be performed in ventilated fume hood.
(E) No foodstuff should be stored in the laboratory refrigerators.

19. According to the Ionising Radiations (Medical Exposure) Regulations 2000 (IRMER)

(A) the practitioner is required to establish local DRLs for dose audit.
(B) a registered healthcare professional can act as a referrer.
(C) the employer is required to provide referrer recommendations on referral criteria.
(D) no restriction on requested examination is stated for healthcare professionals as a referrer.
(E) medical physics expert is involved in patient dosimetry.

20. The content of local rules includes

(A) contingency plans.
(B) description of controlled and supervised areas.
(C) requirements for the use of personal dosimeters.
(D) description of dose limits for employees.
(E) arrangements for pregnant patient.

21. Concerning the practical aspects of radiation protection for staff:

(A) A 120 mm thickness of solid brick provides protection equivalent to 1 mm of lead.
(B) Under-couch tube is recommended during fluoroscopy examination.
(C) A thinner lead apron is recommended for interventional radiology.
(D) The primary beam is collimated less than 15% of the FOV on the fluoroscopy monitor.
(E) A glove of at least 0.25 mm lead equivalence should be worn when palpating a patient.

22. Concerning tomographic reconstruction:

(A) It measures the number of X-ray transmitted through the patient along individual projection lines in CT.
(B) Radon transform is a basis for reconstructing tomographic images from measured projection data.
(C) Filtered backprojection is referred to as the convolution method.
(D) Backprojection propagates the measured sinogram back into the image space.
(E) It is a technique that allows visualisation of internal structure.

23. In CT windowing

(A) the CT image brightness is adjusted via the window level.
(B) the CT image contrast is adjusted via the window width.
(C) a wide window displays all the CT numbers.
(D) when the window level is decreased, the CT image will be brighter.
(E) wide window is best used in lung examination.

24. In computed tomography (CT) imaging

(A) the CT number of fat is higher than water.
(B) high level of scatter reaches the CT detectors.
(C) windowing is a technique to adjust the greyscale.
(D) CT values increase when the atomic number of the material is higher than water.
(E) air corresponds to a CT value of 0 HU.

25. Concerning CT development:

(A) First-generation scanner used a single detector.
(B) First-generation scanner utilised a 360° spiral motion for imaging.
(C) Second-generation scanner used fan-beam system.
(D) Third-generation scanner utilised a static detector arc.
(E) Fourth-generation scanner used a complete stationary detector rings.

26. Regarding single-photon emission computed tomography (SPECT) system:

(A) It is a multidetector gamma camera approach.
(B) Bismuth germanate oxide is the detector element.
(C) Spatial resolution is characterised by the line spread function.
(D) Bar phantom is used to test spatial resolution of the system.
(E) Image contrast refers to differences in density in the image that corresponds to different concentrations of activity in the patient.

27. Concerning type of noise in SPECT:

(A) Random noise caused by random statistical variations in counting rate.
(B) Random noise refers to the mottled appearance of images.
(C) Random noise is caused by imaging system artefacts.
(D) Structured noise refers to non-random variations in counting rate superimposed on the object structures of interest.
(E) Respiratory motion contributes to structured noise.

28. Correctly match difference between positron emission tomography (PET) and single-photon emission computed tomography (SPECT) includes

	PET	SPECT
(A)	It involves annihilation coincidence detection	It involves gamma rays detection
(B)	It uses ^{99m}Tc as a tracer	It uses ^{18}F as a tracer
(C)	Tracers have a long half-life	Tracers have a short half-life
(D)	The energy of annihilation photons is higher than the photon energy of radionuclides used in SPECT	The photon energy of radionuclides is lesser than the energy of annihilation photons
(E)	It provides higher sensitivity in detection of emitted events	It provides less sensitivity in detection of emitted events

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) The spin-up nuclei have low energy.
(B) The precession frequency of the nuclei is inversely proportional to field strength.
(C) The magnetic moments of high-energy nuclei are in the antiparallel direction of the external field.
(D) Resonance occurs when applied RF has the same frequency with nucleus precession frequency.
(E) The align direction depends on the thermal energy level of the nuclei.

30. The nuclei that routinely used in NMR includes

(A) ^{31}P
(B) ^{23}Na
(C) ^{19}F
(D) ^{1}H
(E) ^{13}C

31. Regarding contrast media used in MRI:

(A) Iron in deoxyhaemoglobin acts as paramagnetic contrast agent in functional MRI.
(B) Gadolinium agent causes a shortening of T2.
(C) Positive contrast agents appear dark on MRI images.
(D) Air is a negative contrast agent in the rectum.
(E) Blood pool contrast agents have superparamagnetic properties.

32. Regarding MR image quality:

(A) Random thermal movement in the tissue produces white noise.
(B) Spin echo produces greater signal strength compared to gradient echo.
(C) Noise is higher in the areas of low proton density.
(D) SNR is reduced when the number of excitation is increased.
(E) The spatial resolution is increased when the phase matrix is increased.

33. Regarding safety in MR scan room:

(A) The exclusion zone is defined at the boundary of the 5 gauss line.
(B) The area with magnetic fields less than 0.51 mT is accessible to the public.
(C) The passive shielding is used to block the incoming radiofrequency signals into the MR scan room.
(D) The security zone is an area which potentially can cause projectile injuries.
(E) The MR scan room must have only one point of access.

34. Regarding ultrasound waves:

(A) It has frequency above 20 kHz.
(B) It is not an electromagnetic radiation.
(C) It undergoes reflection at medium interfaces.
(D) It requires a medium to travel.
(E) It is produced by a transducer that converts electric signal into an ultrasound beam.

35. Regarding piezoelectric crystal:

(A) It loses its properties when heated above 350 °C.
(B) An alternating voltage is produced when it is subjected to alternating pressures.
(C) It produces a wave with propagation speed approximately 330 ms^{-1} in air.
(D) The thickness of the crystal is inversely proportional to the ultrasound frequency produced.
(E) It produces a longitudinal wave.

36. Amplitude mode echo ranging in ultrasound

(A) is used to examine the eye.
(B) is the most complex form of ultrasound imaging.
(C) shows the position of tissue interfaces.
(D) is used for identification of cyst in the breast.
(E) uses time gain compensation to compensate attenuation in tissue.

37. The risk of ultrasound imaging includes

(A) mechanical damage to cell membranes.
(B) acoustic streaming of cellular contents in the direction of the beam.
(C) cavitation.
(D) local heating.
(E) stochastic effects.

38. Optical imaging technique include:

(A) optical coherence tomography.
(B) photoacoustic microscopy.
(C) bioluminescent imaging.
(D) positron emission tomography.
(E) tissue spectroscopy.

39. Concerning functional and molecular imaging (FMI) using MRI:

(A) Diffusion-weighted imaging is based upon thermal movement of molecules in extracellular space.
(B) In MR spectroscopy (MRS), a nuclide must have a high gyromagnetic ratio.
(C) In functional MRI (fMRI), different magnetic properties of oxy- and deoxyhaemoglobin produce magnetic field inhomogeneities.
(D) fMRI compares the brain functional images during stimulus and rest phase.
(E) MRS provides a frequency spectrum based on chemical composition of the tissue.

40. Regarding the principles of FMI:

(A) For diffusion-weighted (DW) MRI, a low diffusion coefficient is found in hypercellular tissues.
(B) The FDG-PET scan is based on glucose metabolism of tumour tissue.
(C) Tissues with high cellularity display higher signal intensity than dense tissues.
(D) Microbubbles of less than 10 μm are used as targeted molecular imaging agents in ultrasound.
(E) Biomarker imaging is the detection of molecular parameters that relate with disease.

Examination Five: Questions

1. Regarding display and post-processing of digital radiographic images:

(A) Liquid crystal display (LCD) monitor utilises variation in light polarisation within the crystal for image visualisation.
(B) The LCD monitor has to be calibrated to the DICOM standard to display images for primary diagnostic clinical interpretation.
(C) The size of a good quality digital image is over 10 megabytes of data.
(D) Windowing improves spatial resolution.
(E) Averaging a few images reduces the noise.

2. The technique used to minimise motion unsharpness includes

(A) immobilisation of the patient.
(B) shortening the exposure time.
(C) reducing object-to-film distance.
(D) using digital detector with faster imaging speed.
(E) suspension of patient respiration.

3. Regarding a multichannel analyser (MCA):

(A) Acquisition of energy spectrum is faster with a single-channel analyser (SCA).
(B) It consists of an analogue to digital converter (ADC).
(C) Number of channels ranges up to a few thousands.
(D) It is interfaced to a computer.
(E) Calibration is needed to convert the readout into energy.

4. Regarding electromagnetic radiation:

(A) Gamma rays are a form of electromagnetic radiation.
(B) It is composed of transverse wave of electric and magnetic fields.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
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(C) The wavelength is proportional to frequency.
(D) The frequency is inversely proportional to photon energy.
(E) The velocity of the electromagnetic radiation in a vacuum differs depending on their individual properties.

5. Regarding X-ray tube:

(A) Electrons are generated by heating the anode.
(B) The tube voltage determines the maximum kinetic energy of electrons.
(C) The tube current is controlled using the filament voltage.
(D) The electrons collide with the target to produce X-ray.
(E) The amount of heat produced during X-ray production is negligible.

6. Regarding photoelectric effect:

(A) It involves the collision of X-ray photons with a K-shell electron.
(B) Characteristic X-rays are produced during the process.
(C) It results in the production of scattered photons.
(D) The energy of the X-ray photons is greater than the binding energy of the inner shell electron.
(E) The probability of photoelectric effect is dependent on the atomic number.

7. Concerning X-ray beam filtration:

(A) The glass window of an X-ray tube provides an inherent filter.
(B) It is measured in terms of mm of aluminium.
(C) A filter stops low-energy photons and reduces dose to the patient.
(D) A filter stops high-energy photons and improves contrast.
(E) Molybdenum is used as a filter in mammography.

8. Regarding the deterministic effects of radiation:

(A) Deterministic effects have a threshold dose.
(B) Skin reddening is a deterministic effect.
(C) Deterministic effect resulted in loss of organ function.
(D) Deterministic effect has repair mechanism.
(E) Opacity of the eye is a deterministic effect.

9. Regarding radiation dose:

(A) Kerma takes into account the type of tissue being irradiated.
(B) The absorbed dose is measured in Sievert.
(C) Linear energy transfer (LET) is the sum of energy deposited per unit mass.
(D) An electron particle has a higher LET than an alpha.
(E) High-LET particles are more hazardous than low-LET particles.

10. Regarding radiographic grid:

(A) It is constructed using barium strips.
(B) Grid ratio is the ratio of the height of the interspace channel divided by its width.
(C) The larger the grid ratio, the greater the contrast of the image.
(D) It is usually used in extremities imaging.
(E) It is required in air gap technique procedure.

11. Regarding characteristic curve in film-screen radiography:

(A) It consists of four distinctive regions.
(B) It is a graph of optical density as a function of exposure.
(C) At higher optical density region, the slope of the curve is insignificant.
(D) The straight-line portion contains information on film-density range.
(E) The lowest value of *y*-axis in characteristic curve is base plus fog value.

12. Regarding gain in image intensifier of fluoroscopy:

(A) Flux gain is due to the acceleration of electrons in image intensifier.
(B) Minification gain is due to reducing the image size at output phosphor.
(C) It is used to describe the performance of image intensifier.
(D) It is a ratio of brightness of the output phosphor to input phosphor.
(E) The unit of minification gain is mm^2.

13. Regarding digital subtraction angiography (DSA):

(A) Liquid-type contrast media is used in DSA.
(B) It is important to avoid movement of patient during DSA procedure.
(C) Misregistration of image is minimised using pixel-shifting technique.
(D) The mask image is taken after patient is administered with contrast media.
(E) The subtraction image is stored as a third frame.

14. Regarding deterministic effects:

(A) It is also known as non-stochastic effects.
(B) The effect will not occur if the threshold value does not exceed.
(C) The risk of the effect increases with dose.
(D) The effect can only be observed to their descendants.
(E) Most deterministic effects have a repair mechanism.

15. Basic principles of radiation protection proposed by ICRP include

(A) dose limitation.
(B) effective dose.
(C) optimisation.
(D) threshold doses.
(E) justification.

16. Radionuclides in metastable state

(A) emit gamma rays.
(B) are produced from a generator.
(C) decay by isomeric transition.
(D) decay to a daughter nuclide that has the same atomic number and mass number of the parent.
(E) are useful for PET imaging.

17. Regarding collimator design parameters in planar radionuclide imaging:

(A) The collimator localises radioactive sources in patients.
(B) The photons are absorbed immediately if they strike the absorbing material in the septa.
(C) The collimator imposes a weak correlation between the position in the image and the point of origin of the photon within the patient.
(D) Improvement in collimator performance affects the statistical noise in the images.
(E) Intrinsic resolution of the gamma camera affects the collimator imaging.

18. Regarding patient dose in planar radionuclide imaging:

(A) Smaller injected dosages of ^{201}Tl lead to an increase in the radiation dose.
(B) The selection of radionuclides that have energy close to 140 keV results in better quality images for less radiation dose.
(C) Encouraging patients to drink liquids and void frequently helps to reduce the radiation dose.
(D) The amount of radioactivity injected into the patient is directly proportional to the radiation dose delivered.
(E) The choice of collimators affects the patient dose in imaging.

19. Regarding the controlled area:

(A) The controlled area for mobile X-ray is within 3 m of the X-ray tube and patient.
(B) A person working in that area is likely to receive radiation dose greater than 3/10 of any dose limit.
(C) It is for classified workers.
(D) The external dose rate could exceed 7.5 $\mu Sv h^{-1}$ averaged over the working day.
(E) Local rules are required for a controlled area.

20. According to the Ionising Radiations Regulations 1999 (IRR 1999)

(A) a radiation protection supervisor is required to identify the potential risks before installation of new X-ray equipment.
(B) an employer is required to set a dose constraint for comforters.
(C) the designation of controlled areas is the duty of the employer.

(D) the classified persons must be aged 18 years or above.
(E) a radiation protection advisor is required to ensure that personal protective equipment is properly used.

21. The employer has to notify the Health and Safety Executive (HSE) if the following incident occurs

(A) a major contamination due to radioactive spill.
(B) loss of ^{99m}Tc source involved more than 50 MBq.
(C) loss of dose record of the workers.
(D) a patient received higher radiation doses than intended.
(E) a public member received a dose greater than the annual dose limit.

22. Regarding CT analytical reconstruction methods:

(A) The common method is in the form of filtered backprojection.
(B) The reconstruction kernel is also referred to as filter.
(C) Smooth kernels are usually used in bony structure.
(D) Sharp kernels are used in liver tumour assessment.
(E) There is a trade-off between spatial resolution and noise for each kernel.

23. Iterative reconstruction techniques

(A) reduce noise throughout the body.
(B) increase radiation dose to patient.
(C) enhance artefact suppression.
(D) enhance diagnostic performance.
(E) increase low-contrast resolution.

24. Regarding computed tomography (CT) filter:

(A) Copper is used as a filter.
(B) It shifts the spectrum to higher energies.
(C) Bow-tie filter attenuates radiation strongly in the periphery.
(D) High atomic number material is used as a bow-tie filter.
(E) Patient dose is reduced with the use of filter.

25. CT effective dose

(A) is expressed in the unit of mGy.
(B) is a risk indicator for any individual.
(C) is the tissue-weighted sum of the equivalent doses in all specified tissues.
(D) facilitates the comparison of biologic effect in diagnostic exams.
(E) reflects the stochastic risk from an exposure to ionising radiation.

26. Regarding SPECT:

(A) Isotopes are generator produced.
(B) It uses rotating detector.

(C) Isotopes have short half-lives.
(D) It requires collimator to detect gamma emission.
(E) It suffers from low detection efficiency.

27. Regarding image reconstruction in SPECT:

(A) A sinogram represents a full set of projection data in the form of a 2D matrix.
(B) Each row in sinogram across the matrix represents an intensity displayed across a single projection.
(C) Simple backprojection produces high image quality.
(D) The counts recorded are divided uniformly amongst the pixels that fall within its projection path in the backprojection.
(E) The distribution of radioactivity is obtained when the backprojections for all profiles are added together.

28. The property of a scintillator in a PET includes

(A) maximum efficiency in stopping the 511 keV photons.
(B) short decay time.
(C) long attenuation length.
(D) good intrinsic energy resolution.
(E) a high light output.

29. Regarding resonance in nuclear magnetic resonance (NMR):

(A) It occurs when nuclei absorb the energy from external magnetic field.
(B) It produces phase coherence of the magnetic moments.
(C) The applied RF pulse is similar with the resonant frequency of the dipole nuclei.
(D) Spin-up nuclei have higher energy than spin down nuclei.
(E) The nuclei move to transverse plane at an applied flip angle.

30. Factors that reduce the sensitivity of NMR signals

(A) increasing the temperature of the environment.
(B) small number of nuclei.
(C) presence of magnetically susceptible nuclides.
(D) increase magnetic field strength.
(E) increase density of spin.

31. Regarding proton density (PD)-weighted images in MRI:

(A) Image contrast is due to differences in the number of hydrogen protons.
(B) Cortical bone appears dark.
(C) A long TR of more than 1000 ms is used.
(D) White matter appears brighter than grey matter.
(E) It produces more noise compared to T1-weighted image.

32. Regarding artefacts in MRI:

(A) The truncation artefacts appear at high-contrast interfaces.
(B) Chemical shift artefact occurs due to displacement in the frequency-encoding direction.
(C) The ghost images are apparent only in the frequency-encoding direction.
(D) Using a surface coil that matches the FOV can reduce the aliasing artefacts.
(E) 'Zipper' artefact appears when there is an interference with RF from outside.

33. Regarding bioeffects from MRI:

(A) Changes in the magnetic field cause an induced current that affect blood vessels.
(B) RF energy dissipation is expressed in terms of skin absorption rate.
(C) Heating of tissue depends on the frequency of the RF.
(D) Time-varying magnetic fields can induce peripheral nerve stimulation.
(E) Radiofrequency fields can induce burn hazards due to induced electrical current.

34. Parameter describing the sound waves includes

(A) amplitude.
(B) wavelength.
(C) frequency.
(D) period.
(E) density.

35. When ultrasound travels through material

(A) energy is absorbed by frictional forces of material.
(B) it is attenuated linearly with depth.
(C) energy is deposited by the forward travelling beam.
(D) it is attenuated due to viscous forces of material.
(E) absorbed energy is converted into heat.

36. Contrast agent used in ultrasound imaging includes

(A) gold-bound colloidal microtubes.
(B) gadolinium-containing liquid.
(C) perfluorocarbon nanoparticles.
(D) low-solubility gas encapsulated in a lipid.
(E) air-filled microsphere encapsulated in a thin shell of albumin.

37. Regarding safety consideration in ultrasound:

(A) Thermal index gives an indication of temperature in tissue.
(B) Heat deposition is determined by the average ultrasound intensity in the focal zone of the tissue.

(C) The mechanical index is a value that estimates the probability of cavitation by ultrasound beam.
(D) Cavitation is a consequence of the negative pressures that induce bubble formation.
(E) Thermal effect is dependent on heat dissipation removed by blood.

38. Regarding fluorescence process:

(A) It emits visible light.
(B) It does not require fluorescent dyes.
(C) The fluorescent dye has a half-life time of several minutes.
(D) The excitation and emission spectrum are different.
(E) The intensity of the emitted fluorescence is linear with the number of fluorophore.

39. Regarding molecular imaging (MI):

(A) It is defined as in vivo characterisation of biological process at cellular level.
(B) The spatial scale of MI techniques is approximately 1 μm–10 mm resolution.
(C) MI technique involves imaging the proteins.
(D) The MI agent includes exogenous probes.
(E) MI quantification determines the regional concentrations of MI agents.

40. FMI techniques used for evaluating hypoxia in clinical setting includes

(A) SPECT imaging with ^{99m}Tc-HL91.
(B) CT perfusion imaging.
(C) blood oxygen level-dependent (BOLD) MRI.
(D) FDG-PET imaging.
(E) optical spectroscopy.

Examination Six: Questions

1. Picture archiving and communications system (PACS)

(A) stores digital radiographic images in DICOM format.
(B) removes the need for film storage.
(C) is not accessible from different locations simultaneously.
(D) compresses the stored images to help reduce the storage requirement.
(E) use Health Level Seven (HL7) standard.

2. Regarding quality assurance in radiography:

(A) The tube kV is measured using a dosimeter.
(B) The tube output is measured using an ionisation chamber.
(C) The tube output is proportional to the peak kV at a fixed mAs.
(D) The half-value layer (HVL) provides the tube filtration.
(E) The quality assurance programme is managed by the radiation protection supervisor (RPS).

3. Detection efficiency of a thallium-doped sodium iodide detector is affected by the

(A) source to the detector distance.
(B) thickness of the detector.
(C) intrinsic efficiency.
(D) quantum detection efficiency.
(E) photopeak efficiency.

4. Regarding the nucleus of an atom:

(A) It is made up of protons and neutrons.
(B) The nucleons are held by a strong nuclear force.
(C) The nucleus has zero charge.

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(D) The number of nucleons represents the atomic number.
(E) The size is smaller than the atom.

5. Regarding characteristics X-ray produced in an X-ray tube:

(A) The energy of the characteristic X-ray produced from a molybdenum target is 59.3 keV.
(B) It is produced from filament electrons dislodging orbital electrons in the target.
(C) An increase in the tube voltage (kV) resulting in an increase in the number of X-ray photon produced.
(D) Filament electrons with 75 keV dislodge K-shell electrons in a tungsten target.
(E) It is the main component of X-rays produced from a tungsten target.

6. The radiation interaction occurs in medical imaging includes

(A) photoelectric interactions.
(B) compton interactions.
(C) pair production.
(D) photodisintegration.
(E) coherent scatter.

7. Regarding the focal spot:

(A) It is the area of the anode over which electrons are targeted.
(B) The dimension of the effective focal spot is bigger than the actual focal spot.
(C) A typical size of focal spot in general radiography is 0.3 mm.
(D) Increasing the anode angle increases the actual focal spot size.
(E) Its size is estimated using a slit camera.

8. The stochastic effects of radiation

(A) are hereditary.
(B) arise as a result of chance.
(C) have severity that increases with the dose.
(D) have a lower-dose threshold compared to the deterministic effects.
(E) cause cancer.

9. Regarding measurement of radiation quantity in air:

(A) The detector used is an ionisation chamber.
(B) The effects of changes in temperature are ignored in diagnostic radiology dosimetry.
(C) The charge is measured with a simple ammeter.
(D) The charge measured is inversely proportional to dose.
(E) This is stipulated in the Ionising Radiations Regulations (IRR) 1999.

10. Unsharpness in radiographic imaging is worsen due to:

(A) Decreased object-film distance.
(B) Moving structures.
(C) Longer focal spot to film distance.
(D) Small focal spot size.
(E) Anode heel effects.

11. Regarding amorphous selenium detector:

(A) It is a photoconductor material.
(B) It converts X-ray to lights.
(C) It is used in CR imaging plates.
(D) The detection quantum efficiency is higher compared to barium fluorohalide doped with europium.
(C) An X-ray photon interacting in amorphous selenium causes ionisation.

12. Regarding veiling glare in fluoroscopic image quality:

(A) It is due to lights scattering in the output window of the image intensifier.
(B) It is due to electron scattering in image intensifier tube.
(C) The larger the image intensifier, the greater is the veiling glare.
(D) It is due to maladjustment of the electron focusing system.
(E) It reduces the image contrast.

13. Concerning dual-energy subtraction:

(A) It is rapid series of image acquisition at low and high kVp.
(B) At low kVp, high contrast between the bone and soft tissue is displayed.
(C) Visualisation of the bone is minimised in low kV image subtraction from high kVp image.
(D) High kVp image contrast is influenced by tissue density.
(E) It is a method of choice in modern fluoroscopic equipment.

14. Concerning equivalent dose:

(A) It is derived from absorbed dose multiplied by radiation weighting factor.
(B) The SI unit is Sievert.
(C) It is independent on radiation type.
(D) It is equal to absorbed dose in gamma ray interaction.
(E) Radiation weighting factor for X-rays and beta particles is 1.

15. Dosimeter used in personal dosimetry system includes

(A) gel dosimeter.
(B) thermoluminescent dosimeters.
(C) optical stimulated luminescent dosimeters.
(D) film dosimeters.
(E) semiconductor dosimeters.

16. In radioactivity

(A) alpha decay emits ^{4}He nuclei.
(B) beta decay emits positron.
(C) gamma decay emits high-energy protons.
(D) half-life of radioactive substance is a time interval that is half of a given number of radioactive nuclei decay.
(E) 1 Bq is equal to 3.7×10^{10} Ci.

17. Regarding planar radionuclide imaging:

(A) It involves the use of unsealed sources of radioactivity in the form of radiopharmaceuticals.
(B) Extrinsic resolution is the spatial resolution without a collimator in place.
(C) The choice of a collimator is dependent on the amount of radiation absorption.
(D) The half-life of ^{99m}Tc is 8 h.
(E) The energy of gamma ray is over 180 keV.

18. The use of dose calibrator in radionuclide imaging includes

(A) verifying the activity of generator eluates.
(B) measuring radioactivity received from supplier.
(C) measuring radioactivity prepared for patients.
(D) monitor activity for specific radionuclides.
(E) verifying background radiation exposure.

19. Regarding the dose limits:

(A) The annual effective dose limit for whole body of staff aged over 18 years is 20 mSv.
(B) There is no dose limit applied for student aged 16 years working with radiation.
(C) The annual whole-body dose limit for a patient undergoing treatment is 500 mSv.
(D) The equivalent dose limit to the abdomen of a female of reproductive capacity is 13 mSv in any consecutive 3-month period.
(E) The whole-body dose limit for comforters is 100 mSv in any consecutive 5-year period.

20. Regarding radiation protection:

(A) For chest radiography, the focal spot to skin distance should not be less than 30 cm.
(B) In mammography, the total permanent filtration should never be less than 0.3 mm molybdenum.
(C) 12 mm of barium plaster is approximately equal to 1 mm lead equivalent.
(D) Lead apron should be thoroughly examined at least once a year to ensure that no cracks have developed.
(E) Lead aprons should be worn when involved in nuclear medicine.

21. According to the Medicines (Administration of Radioactive Substances) Regulations 1978

(A) employers are responsible for the patients treated under the Act.
(B) the certificates are issued by the Department of Health.
(C) a doctor should be the chairman of the advisory committee.
(D) the application of the certificate must be signed by the radiation protection supervisor.
(E) any procedures that are no longer required can be removed during certificate renewal.

22. Concerning simple backprojection:

(A) Each X-ray emission path through the body is divided into equally spaced elements.
(B) Each element is assumed to contribute equally to the total attenuation coefficient along the X-ray path.
(C) A final summed attenuation coefficient is determined by summing the attenuation for each element at different distance.
(D) A composite image of attenuation coefficients is obtained when the coefficient for all elements is combined in the anatomic section.
(E) It produces blurred images of sharp features in the object.

23. X-ray attenuation

(A) describes the attenuation of the incident X-ray intensity when passing through an object.
(B) depends on the energy of the X-ray.
(C) is calculated based on the Lambert-Beer law.
(D) is defined as the natural logarithm of the ratio of attenuated intensity to primary intensity.
(E) falls off exponentially with absorber thickness.

24. A computed tomography (CT) detector system

(A) transforms the incident X-ray intensity into a corresponding electric signal.
(B) amplifies the signal.
(C) converts the signal from analogue to digital form.
(D) cas high quantum absorption efficiency.
(E) has high radiation drift.

25. Regarding CT image noise:

(A) It is caused by the variation in attenuation coefficients between voxels.
(B) Blur affects the ability to visualise the anatomical structure.
(C) It is reduced by increasing the quantity of X-ray photons absorbed by each tissue voxel.
(D) Large voxel decreases the image noise.
(E) Increasing the mAs will increase the image noise.

26. The radioisotope used in SPECT includes

(A) ^{18}F.
(B) ^{13}N.
(C) ^{99m}Tc.
(D) ^{111}In.
(E) ^{201}Tl.

27. The similarity between SPECT and PET includes

(A) both are based on tracer principle.
(B) the radioactive emissions are recorded by the sensitive radiation detectors surrounding the patient.
(C) the recorded emissions form line integrals representing the accumulated activity along lines passing through the subject.
(D) the line integrals are reconstructed into tomographic images using filtered backprojection technique.
(E) both are transmission imaging.

28. The level of radiation exposure to the PET patient depends on the:

(A) Activity administered.
(B) Physical half-life of radioactive decay.
(C) Age of patient.
(D) Mass of respective organ.
(E) Biokinetics of the radiopharmaceutical used.

29. Regarding nuclear magnetic resonance (NMR):

(A) Bulk magnetic vector is produced at the same direction of magnetic field.
(B) The precession frequency in 1 T field is 42.6 MHz.

(C) At equilibrium, the magnetic moments of nuclei are in phase.
(D) The recovery of longitudinal magnetisation is termed as spin-lattice relaxation.
(E) Magnetic field fluctuation induces electric current in receiver coils.

30. During the free induction decay (FID) in NMR

(A) longitudinal magnetisation (M_z) regrows.
(B) transverse magnetisation (M_{xy}) decays.
(C) the induced signal in receiver coil decays.
(D) nuclei lose their absorbed energy.
(E) the sum magnetic vector turns back to transverse plane.

31. Concerning image formation in MRI:

(A) Spatial frequency in k-space is Fourier transformed to produce image.
(B) The central k-space contains data with low signal amplitude.
(C) Unit of k-space is radians per cm.
(D) Received bandwidth contains encoded frequencies across the FOV.
(E) 128 phase matrix consists of +128 to −128 k-space lines.

32. Regarding MR angiography (MRA) principles:

(A) Vessels containing slow-flowing blood appear bright.
(B) Bright blood imaging uses gradient moment rephasing.
(C) Blood flowing in transverse direction of FOV appears dark in time-of-flight MRA.
(D) Bipolar gradient is used to shift the phase in phase contrast MRA.
(E) Fast-flowing blood in aorta appears as void.

33. Regarding terms used in defining devices in MRI:

(A) MR unsafe is a device that is known to pose hazards in all MRI environments.
(B) MR incompatible is the device that is not safe for exposure to MRI.
(C) An item that poses no known hazards in a specified MRI environment is known as MR conditional.
(D) An item that poses no known hazards in all MRI environments is known as MR friendly.
(E) A device that poses minor magnetic field interactions is defined as MR unsafe type 2.

34. The velocity of ultrasound is changed greatly when it travels from the muscle to:

(A) Liver.
(B) Lung.
(C) Kidney.

(D) Air.
(E) Bone.

35. Fresnel zone in ultrasound

(A) is longer with higher transducer frequency.
(B) is also known as far field.
(C) has converging beam profile.
(D) is dependent on the transducer diameter.
(E) is adjacent to the transducer face.

36. Common artefact in ultrasound imaging includes

(A) refraction.
(B) ring-down.
(C) reverberation.
(D) acoustic shadowing.
(E) speckle.

37. Regarding the risk of ultrasound:

(A) Mechanical damage to cell membranes is caused by violent acceleration of particles.
(B) Acoustic streaming of cellular content affects cell membrane permeability.
(C) Time-average intensity limit from safety guideline is below 100 mW cm^{-2}.
(D) Mechanical index gives information regarding the power deposition to the patient.
(E) Local heating due to frictional process leads to chemical damage.

38. Bioluminescent imaging

(A) has limited depth information.
(B) lacks tissue penetration.
(C) is invasive.
(D) has higher spatial resolution than fluorescent imaging.
(C) uses fluorescent dye.

39. Regarding modalities for functional and molecular imaging (FMI):

(A) MRI gives the highest spatial resolution compared to other modalities.
(B) PET has higher molecular sensitivity compared to CT imaging.
(C) CT imaging is more sensitive than FDG-PET in detecting renal cell carcinoma.
(D) The advantage of SPECT for FMI is unlimited depth penetration.
(E) SPECT imaging produces better spatial resolution compared to ultrasound imaging.

40. Regarding application of FMI in clinical setting:

(A) Contrast-enhanced ultrasound is used for characterisation of focal lesion in the liver.
(B) ^{123}I-SPECT is used for neurodegenerative imaging.
(C) Dynamic contrast-enhanced (DCE) MRI is used to demonstrate tumour responses to therapeutic agents.
(D) FDG-PET is used for inflammation imaging based on the metabolic level.
(E) Diffusion-weighted (DW) MRI is used to differentiate benign from malignant lesions.

Examination Seven; Questions

1. Regarding modulation transfer function (MTF):

(A) It describes the image contrast of an imaging system.
(B) It is based on Fourier analysis.
(C) The MTF value increases with better visibility of small structures.
(D) The MTF curve is specific to an imaging system.
(E) The MTF value is not applicable for a digital system.

2. DICOM

(A) is an abbreviation for Digital Imaging and Communications in Medicine.
(B) is a digital radiographic image format.
(C) image contains the metadata of patient identity.
(D) is best viewed on a calibrated computer display.
(E) standards have regional variation.

3. Regarding ionisation chamber:

(A) A Geiger-Muller tube is an example.
(B) It is used as a phototimer in automatic exposure control unit.
(C) It contains gas as the detection material.
(D) It has electrodes to collect charge from ionisation.
(E) It is used as a dosimeter.

4. Regarding an atom:

(A) Neutrons have no mass.
(B) Neutrons have no charge.
(C) It consists of a nucleus.
(D) The mass number depends on the number of neutrons.
(E) The atomic number is equal to the number of protons.

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5. Regarding electrons in an atom:

(A) Electrons have a positive charge.
(B) The electrons orbit the nucleus in the Bohr model of atomic structure.
(C) The binding energy of the L-shell is higher than the K-shell.
(D) The mass of electrons is greater than protons.
(E) The K-shells can hold four electrons.

6. Regarding x-ray:

(A) It is produced from the interaction of electrons with the nucleus of the target atom.
(B) The energy spectrum is continuous.
(C) The x-ray production process does not result in any heat.
(D) The maximum energy of the photons is equal to the tube kVp.
(E) It is emitted from a metastable radioisotope.

7. Rotating anodes:

(A) Are used in fluoroscopy x-ray tubes due to superior heat dispersal.
(B) Have a rotation speed proportional to the effective length of the focal spot track.
(C) Use induction motor.
(D) Increase the area for heat dissipation.
(E) Have a smaller effective focal spot size compared to a stationary anode.

8. Regarding absorbed dose:

(A) It is the energy deposited by the radiation in the materials it passes.
(B) The SI unit in Sievert.
(C) It is measured using an ionisation chamber.
(D) 100 rad is equal to 1 J/kg.
(E) It takes into account the type of tissue.

9. Equivalent dose is:

(A) Measured in Gy.
(B) Dependent on the tissue weighting factor.
(C) Dependent on the type of radiation.
(D) Equal to the effective dose.
(E) Absorbed dose multiplied by radiation weighting factor.

10. Concerning base plus fog of radiographic film:

(A) It is affected by moving grids.
(B) It is influenced by background radiation.
(C) The value is increased by storing in moist condition.
(D) It is measured from exposed film.
(E) Radiochromic film type is independent of base plus fog value.

11. Regarding digital mammography system:

(A) It is superior over film-screen mammography in terms of resolution.
(B) Digital mammography offers wider dynamic range over film-screen mammography.
(C) The breast dose in digital mammography is significantly higher compared to film-screen mammography.
(D) The spatial resolution of digital mammography is limited by the pixel size.
(E) Digital mammography technique uses high kVp technique in comparison with conventional system.

12. Concerning the image intensifier:

(A) Minification gain is the increment of brightness due to reduced size at input phosphor.
(B) The brightness gain is the amplification of the image by image intensifier.
(C) Vignetting is a reduction in brightness of the fluoroscopic image at the periphery.
(D) Low quantum detection efficiency at input phosphor causes pincushion distortion.
(E) Minification gain is independent of output phosphor diameter size.

13. Image sensor used in fluoroscopy includes

(A) vidicon.
(B) plumbicon.
(C) dynodes.
(D) thin-film transistor.
(E) charge-coupled device.

14. Method of reducing dose to patient undergoing barium enema procedure includes

(A) use of carbon fibre patient table.
(B) application of last image hold.
(C) use of magnification technique.
(D) practising an over-couch x-ray tube.
(E) use of low pulse rate digital fluoroscopy.

15. In radiography, dose of patient is reduced by

(A) using a low ratio grid.
(B) increasing the object distance from image receptor.
(C) increasing thickness of filter.
(D) protecting radiosensitive organs in field of view using lead apron.
(E) using shortest exposure time.

16. Alpha decay

(A) occurs in heavy nuclei of atomic number greater than 82.
(B) does not occur in nature.
(C) produces helium nuclei.
(D) travels up to 1 m in air.
(E) causes the atomic number of the parent nuclide to reduce by two.

17. Regarding the scintillation crystal in gamma camera:

(A) The scintillation crystal is made of sodium iodide.
(B) It is hygroscopic.
(C) It converts gamma rays to electrons.
(D) The thickness of the crystal affects the spatial resolution.
(E) A photomultiplier tube is attached to the crystal.

18. Absorbed dose delivered to an organ by the activity within it increases in proportion to the

(A) total scanning time.
(B) fraction taken up by the organ.
(C) activity administered to patient.
(D) effective half-life of the activity in the organ.
(E) energy of beta radiation emitted in each disintegration.

19. Regarding supervised area:

(A) It is clearly marked with warning sign.
(B) It is an area that received an effective dose more than 1 mSv per year.
(C) It is required when the worker is likely to receive dose larger than one-tenths of any relevant dose limit.
(D) Injection room of radionuclide imaging is one of the supervised areas.
(E) Average dose rate value at supervised area is two times higher compared to controlled area.

20. According to IRMER 2000

(A) referrer is the person who carries out the practical aspect of the exposure.
(B) practitioner should justify the examination requested to authorise the examination to proceed.
(C) operator must have had an adequate training.
(D) referrer is a registered healthcare professional.
(E) employer is responsible to ensure patient doses are as low as reasonably practicable (ALARP).

21. Concerning dose constrain for comforters and carers in IRR 99:

(A) TLD is worn by comforter to provide direct reading of dose.
(B) Lead apron is used to protect comforters from primary beam.
(C) Immobilisation device is used to hold a child in position during radiographic procedure.
(D) The comforter is positioned outside of the primary beam.
(E) Effective dose limit for comforters is 15 mSv/year.

22. The advantage of iterative reconstruction (IR) technique against filtered backprojection (FBP) includes

(A) a faster reconstruction.
(B) possible for quantitative imaging.
(C) less sensitive to noise.
(D) requires more filtering processes.
(E) results in higher spatial resolution.

23. Reducing the number of projection views for image reconstruction results in:

(A) Higher spatial resolution.
(B) Lower patient dose.
(C) Aliasing artefacts.
(D) Incomplete projection data.
(E) Faster scanning time.

24. Regarding the principles of computed tomography (CT):

(A) A bow-tie filter is used to reduce the scattered radiation.
(B) CT raw data is stored as sinogram.
(C) The pixel value represents the linear attenuation coefficient in a voxel.
(D) The most predominant interaction in CT is Compton scatter.
(E) Only detectors rotate in the fourth-generation CT scanner.

25. Regarding dose in CT imaging:

(A) Doubling the tube current doubles the dose.
(B) A high-resolution CT chest delivers greater dose per slice than a routine CT chest.
(C) The dose is reduced with narrow beam collimation.
(D) The dose is greater in obese patient than smaller patient.
(E) The dose in multi-slice CT is lower than single slice CT for similar image quality.

26. Regarding the ^{99m}Tc generator:

(A) ^{99}Mo has a half-life of 6 h.
(B) The generator is replaced every year.
(C) ^{99m}Tc produces gamma rays.
(D) Sterile saline is used as an eluting agent.
(E) It undergoes secular equilibrium.

27. Regarding single-photon emission computed tomography (SPECT):

(A) Noise in SPECT is higher compared to gamma camera imaging.
(B) Fusion of images is a problem in SPECT imaging.
(C) Rotating detectors are used in acquiring image in SPECT.
(D) Spatial resolution in SPECT is better compared to CT image.
(E) Three-dimensional images are produced in SPECT imaging.

28. Regarding positron emission tomography (PET):

(A) The positron emitters used in PET have long half-life.
(B) Any pulses that do not coincide in time are ignored.
(C) Positrons tend to be emitted from nuclides with an excess of neutrons.
(D) The scintillation detector used is bismuth germanate.
(E) Random coincidence is due to scattering of annihilation photons.

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) A proton has both magnetic moment and angular momentum.
(B) The frequency at which resonance occurs is inversely proportional to the applied magnetic field.
(C) The stronger the magnetic field, the faster a proton precesses.
(D) Spin-down dipoles are slightly more than spin-up inside a magnetic field.
(E) The magnetic moment of protons is not affected by temperature of sample.

30. Regarding relaxation in MRI:

(A) The faster the molecular motion, the slower the substance decays.
(B) The recovery of transverse magnetisation is termed spin-lattice relaxation.
(C) T2 decay is due to energy exchange in nuclei with neighbouring nuclei.
(D) Water signal recovers quicker than fat signal.
(E) Typical T1 relaxation time of CSF in 1 T field is 150 ms.

31. Regarding magnetic resonance imaging (MRI) instrumentation:

(A) Permanent magnets produce less field homogeneity than superconducting magnets.
(B) The spatial localisation of MR signal is controlled by the gradient coils.
(C) The closer the RF coils to body parts, the greater the signal received.

(D) Shim coils are used to adjust magnetic field inhomogeneities.
(E) Surface coils have wider field of views than the body coils.

32. Concerning image quality in MRI:

(A) Thinner slice produces better anatomical details.
(B) White noise is due to the random thermal movement of protons.
(C) Noise is reduced by increasing the receive bandwidth.
(D) Steep gradient slope results in better spatial resolution.
(E) Signal-to-noise ratio (SNR) is increased with short TR.

33. Regarding MRI safety guidelines by UK Medicines and Healthcare products Regulatory Agency (MHRA):

(A) Limited exposure for whole body of staff is not more than 2 T.
(B) Pregnant patients should not be exposed above 1.5 T.
(C) Ethics committee approval is needed for scanning with magnetic strength above 4 T.
(D) The whole-body exposure time for staff to 2 T MRI is restricted to 2 h.
(E) The normal mode for whole-body exposure of patients is less than 2.5 T.

34. Concerning ultrasound:

(A) Lateral resolution is improved by using focused transducers.
(B) The amount of attenuation of an ultrasound beam is inversely proportional to its frequency.
(C) The decibel is a measure of the relative intensity of an ultrasound beam.
(D) The velocity of ultrasound is increased in higher density material.
(E) In destructive interference, the amplitude of the resulting wave is higher than the interfering waves.

35. Phase array in ultrasound is used to alter the:

(A) Pulse repetition frequency.
(B) The focal length.
(C) Lateral resolution.
(D) Axial resolution.
(E) Direction of the beam.

36. In diagnostic ultrasound:

(A) High-frequency probes are used to explore deep structures.
(B) Bowel gas acts as a good acoustic window, through which the operator visualises the retroperitoneal structures.
(C) Curvilinear array probes provide a wider field of view ‘sector width’ when compared to linear probes.
(D) The interaction of ultrasound with contrast agents causes changes in bubble size.
(E) Doppler ultrasound provides information regarding the direction of flow.

37. Regarding biological effect of ultrasound:

(A) Acoustic steaming of ultrasound is potentially causing cellular damage.
(B) The risk of neonatal intestine damage increases as the mechanical index reaches 0.3 value.
(C) Transient cavitation is one of the biological effects of ultrasound imaging.
(D) Tissue heating occurred in diagnostic range.
(E) Ultrasound causes more biological damage to tissue compared to ionising radiation.

38. Fluorescence microscope:

(A) Consists of helium neon laser.
(B) Is attached to an optical camera.
(C) Detects gamma rays.
(D) Has low sensitivity to DNA detection.
(E) Requires a light filter for detection.

39. Regarding the principles of functional and molecular imaging (FMI):

(A) Molecular probes that bind biochemical markers are used to increase image contrast.
(B) Signal from integrated multimodalities is related to the same event of interest.
(C) Cross-validation of two independent measurements is performed for multimodality imaging.
(D) Spatial co-registration of single modality data is more complicated than integration from multimodality data.
(E) Doppler ultrasound measures temporal variations of the successive backscattered signals from red blood cells.

40. Regarding FMI technique for assessment of the biological process:

(A) ^{18}F-FDG PET/CT in infection and inflammation.
(B) Blood oxygenation level-dependent (BOLD) MRI in assessment of hypoxia.
(C) Diffusion-weighted MRI in differentiation of acute from chronic stroke.
(D) Optical coherence tomography (OCT) in imaging of atherosclerosis.
(E) ^{18}F-FDG PET in tumour cell proliferation.

Examination Eight: Questions

1. Regarding the photographic emulsion of radiographic film:

(A) It is made of silver halide crystals.
(B) The emulsion layer is coated onto a base material.
(C) The thickness of the emulsion is 1 mm.
(D) It is sensitive to radiation.
(E) It is sensitive to visible light.

2. Regarding amorphous silicon detector in digital radiography:

(A) Direct conversion system uses amorphous silicon detector.
(B) Indirect conversion system uses gadolinium oxysulphide.
(C) It uses image phosphor (IP) plate.
(D) The quantum efficiency of the detector is less than 50%.
(E) The images are stored in DICOM format.

3. Regarding artefacts in computed radiography (CR):

(A) A ghost image is resulted from insufficient x-ray exposure.
(B) Improper handling of the phosphor screen causes artefacts.
(C) Electromagnetic interference resulted in venetian blind effect.
(D) Dust trapped inside the phosphor plate does not result in artefact.
(E) The artefacts do not affect the quality of the digitised image.

4. Regarding the tungsten atom:

(A) The atomic number of tungsten is 74.
(B) The mass number of tungsten is 284.
(C) It is represented by the symbol W in the periodic table.
(D) The binding energy of K-shell electrons is 20 keV.
(E) It is the anode material in an x-ray tube.

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5. Type of electromagnetic radiation includes

(A) visible light.
(B) x-rays.
(C) sound waves.
(D) microwaves.
(E) infrared.

6. The x-ray tube component includes a

(A) vacuum tube.
(B) heated filament.
(C) tungsten target.
(D) parent radionuclide.
(E) dynode.

7. Regarding the quality and quantity of the x-ray beam:

(A) The quantity determines the intensity of photons in the x-ray beam.
(B) The quality determines the penetrability of the x-ray beam.
(C) The tube voltage does not affect the quantity of the x-ray beam.
(D) The quantity is directly proportional to tube current.
(E) The quality of the x-ray beam increases with filtration.

8. Linear energy transfer (LET)

(A) is the total energy deposited by a particle along its entire path.
(B) of alpha particle is lower compared to electron.
(C) of gamma is lower compared to neutron.
(D) for heavier particles are higher compared to x-rays.
(E) value affects the severity of damage to biological tissue.

9. The threshold dose

(A) for skin erythema is 5 Gy.
(B) for thyroid cancer is 25 Gy.
(C) for cataract is 15 Gy.
(D) for hair loss is higher than skin erythema.
(E) for foetal abnormality is higher than sterility.

10. Subject contrast is decreased when

(A) contrast media is used.
(B) mAs is decreased.
(C) density between tissues is comparable.
(D) film with high fog value is used.
(E) moving grid is used.

11. A factor that leads to loss of sharpness in film-screen system includes

(A) shorter exposure time.
(B) larger focal spot.
(C) increased magnification.
(D) use of intensifying screen.
(E) application of air gap technique.

12. Regarding digital flat panel detector in fluoroscopy:

(A) It provides undistorted images compared to image produced by image intensifier.
(B) It displays a better contrast than image intensifier.
(C) The image is produced in rectangular shape.
(D) It uses caesium iodide detector.
(E) Flat panel detector offers better image resolution compared to image intensifier.

13. Concerning digital subtraction angiography:

(A) Exposure factor is maintained in temporal subtraction technique.
(B) Carbon dioxide is used to improve contrast in the image.
(C) Mask image is taken in digital subtraction angiography.
(D) Misregistration of mask image is reduced using double-contrast technique.
(E) Energy subtraction technique utilises identical mAs.

14. Collimation in fluoroscopy

(A) increases scatter production in image.
(B) limits the exposed tissue volume.
(C) increases image contrast.
(D) reduces glare at peripheral image.
(E) is important for reduction of patient dose.

15. Method of reducing dose to patient in fluoroscopy includes

(A) last image hold.
(B) collimation.
(C) use of under-couch x-ray tube.
(D) application of low pulse rate digital fluoroscopy.
(E) use of digital image.

16. Regarding positron decay:

(A) It is called beta minus decay.
(B) It occurs in neutron poor nucleus.
(C) It has a charge of −1.

(D) It is useful for PET.
(E) The atomic number of the parent decreases by 1.

17. Regarding the pulse height analyser (PHA) **in a scintillation detector system:**

(A) It processes the signal detected by the detector.
(B) The range of the radiation energy to be detected is selected using PHA.
(C) A wider window on the PHA improves the image quality.
(D) It detects multiple photopeaks.
(E) The photopeak is resulted from photoelectric interaction.

18. Regarding dose received during radionuclide imaging:

(A) Patients should empty the bladder frequently to reduce dose to the gonads.
(B) Breastfeeding patient should continue breastfeeding her baby following administration of radionuclides.
(C) Examination that delivers foetal dose greater than 10 mSv should be restricted to pregnant patient.
(D) The activity is checked before administration using the dose calibrator.
(E) The organ of excretion receives similar dose with other remaining tissues after an intravenous injection.

19. Concerning controlled area:

(A) It is required in areas with risk of radioactive contamination.
(B) It is required where the person working is likely to receive an equivalent dose of 6 mSv per year.
(C) It is monitored by radiation protection supervisor.
(D) It is needed during radiography using portable x-ray units.
(E) Waiting room for injected patients is classified as controlled area.

20. According to IRR 99, local rules must contain

(A) an appropriate summary of the working instructions.
(B) name(s) of the appointed radiation protection supervisor(s).
(C) details of significant findings of any risk assessments.
(D) arrangements for pregnant and breastfeeding staff.
(E) the identification and description of the area covered, with details of its designation.

21. According to IRMER 2000, practitioners and operators shall have successfully completed training, including theoretical knowledge and practical experience in

(A) biological effects of radiation.
(B) use of radiation protection devices.
(C) attenuation of ionising radiation.

(D) medical and biomedical research.
(E) health screening.

22. Regarding tomographic reconstruction:

(A) It is a summation of line integrals through object.
(B) A sinogram depicts the histogram of detected events for each angle.
(C) Convolution on the attenuation profiles increases the blurring.
(D) The backprojected image is a blurred version of the original image.
(E) Emission reconstruction measures the activity for each line of response.

23. Regarding filtering in filtered backprojection (FBP):

(A) Changing filter results in trade-off between noise and image resolution.
(B) Filtering is performed on frequency-sampled projections.
(C) Bow-tie filter cuts off the high-frequency signals.
(D) Filtering converts attenuation data to Hounsfield units.
(E) Filtering compensates the blurring effect inherent to backprojection.

24. Concerning detectors used in CT scanner:

(A) Xenon gas is used for ionisation chamber detectors.
(B) Adaptive array detector comprises different sizes of detector rows.
(C) The detection efficiency in gas-filled detector is higher than solid-state detector.
(D) Ceramic material has better scintillation efficiency than cadmium tungstate.
(E) Gas-filled detector is better than solid-state detector because of no after-glow effects.

25. The dose reduction strategy in CT includes

(A) increasing pitch.
(B) centring the patient in the gantry.
(C) limiting the number of contrast phase.
(D) increasing kVp.
(E) using multiphase exams for adult patients.

26. Resolution in SPECT image is increased by

(A) using low-resolution collimator.
(B) enabling the mathematical filter during reconstruction of the image.
(C) increasing the image bit.
(D) using smooth reconstruction filters.
(E) increasing activity of the radiopharmaceuticals.

27. Advantage of PET over SPECT includes

(A) better spatial resolution.
(B) reduced radiation dose to patient.

(C) lesser image noise.
(D) collimators are not required.
(E) the use of shorter half-life radionuclides.

28. Radionuclide produced in a cyclotron includes

(A) ^{11}1In.
(B) ^{123}I.
(C) ^{122}Xe.
(D) ^{11}C.
(E) ^{99m}Tc.

29. Concerning Larmor frequency of a nucleus:

(A) It is proportional to magnetic field strength.
(B) It is a fixed frequency of protons precession.
(C) At 1.5 T, the Larmor frequency of hydrogen is 21.3 MHz.
(D) It is unique for each nucleus.
(E) The frequency of spin-up protons is similar with spin-down protons.

30. Regarding free induction decay (FID) in NMR:

(A) The reduction of transverse magnetisation is termed as decay.
(B) The amplitude of induced voltage in receiver coils is decreased.
(C) FID occurs due to absence of the applied RF pulse.
(D) Magnetic moments of nuclei are back into phase with each other.
(E) The magnetisation in longitudinal plane gradually increases.

31. Regarding MR signal:

(A) Localisation of the MR signal is attained by applying a gradient.
(B) Gradient echo produces greater signal strength compared to spin echo.
(C) Air in sinuses produces no signal.
(D) Signal along the short axis is localised using frequency encoding.
(D) The peak signal is proportional to spin density.

32. Technique to improve image acquisition speed in MRI includes

(A) gradient echo imaging.
(B) turbo spin-echo imaging.
(C) inversion recovery imaging.
(D) echo-planar imaging.
(E) parallel imaging.

33. Regarding safety precautions in MRI:

(A) Any electrically conductive material should be avoided near surface coils.
(B) Prosthetic heart valve should be removed before MR screening.

(C) When quenching occurs, the room ventilation should be turned off.
(D) A cool wet cloth should be placed over tattoos to dissipate heat during screening.
(E) It is not recommended for pregnant patients to be screened during the first trimester of pregnancy.

34. Regarding ultrasound transducer:

(A) The frequency of transducer increases as the thickness of transducer decreases.
(B) It operates based on the piezoelectric principle.
(C) Ultrasound transducer converts mechanical energy to ultrasound wave.
(D) It is made of lithium fluoride (LiF) crystal.
(E) A backing layer is used to ensure rapid damping of the transducer vibration.

35. Regarding lateral resolution of ultrasound imaging:

(A) Distance of structure affects lateral resolution of ultrasound beam.
(B) It is improved by increasing the frequency of the ultrasound beam.
(C) Lateral resolution of near field is increased using small transducer.
(D) It is dependent to the thickness of ultrasound probe.
(E) It is improved by using B-mode scan.

36. Advantage of tissue harmonic imaging includes

(A) liquid-filled cavities are better visualised.
(B) reverberation artefacts are reduced.
(C) shorter imaging time.
(D) scattering from fatty tissues is reduced.
(E) acoustic noise is reduced.

37. The potential bio-effect of ultrasound to human includes

(A) tissue heating.
(B) cavitation.
(C) local heating.
(D) stochastic effects.
(E) acoustic streaming of cellular contents in the direction of the beam.

38. Regarding optical imaging techniques:

(A) Fluorescent imaging is adapted for in vivo imaging.
(B) Radioisotope-labelled antibody is used for fluorescent labelling.
(C) The imaging technique includes non-fluorescent-based imaging technique.
(D) Radiation shielding is required during imaging.
(E) Multiple fluorescent labels are detected using different light filters.

39. The multimodality integration used for functional neuroimaging includes

(A) Diffusion tensor imaging (DTI) and related MR techniques.
(B) Near-infrared optical spectroscopy (NIRS) and EEG.
(C) EEG and PET imaging.
(D) Blood oxygenation level-dependent (BOLD) contrast fMRI.
(E) PET and MRI techniques.

40. Regarding imaging agents used in functional and molecular imaging (FMI):

(A) 1^{8}F-FDG is a non-specific biomarker of glycolytic metabolism in PET.
(B) Magnetic resonance spectroscopy (MRS) measures the concentration of marker molecules such as lipids.
(C) Iron in deoxyhaemoglobin acts as paramagnetic contrast agent in functional MRI.
(D) Perfluorocarbon nanodroplets are used as agent in contrast-enhanced ultrasound (CEUS).
(E) Apparent diffusion coefficient (ADC) is used as marker in MR angiography.

Examination Nine: Questions

1. Optical density is

(A) The ratio of incident light to transmitted light in logarithmic form.
(B) Measured using densitometer.
(C) A measure of the degree of film darkening.
(D) Referred as radiographic density.
(E) 1.0 if 100% of the incident light is transmitted.

2. Regarding photostimulable phosphor used in computed radiography (CR):

(A) The phosphor emits light.
(B) Barium fluorohalide is a type of phosphor used.
(C) It is in a form of plate contained within a cassette.
(D) It requires heat stimulation for readout.
(E) It is not reusable.

3. Regarding image quality in radiography:

(A) Increasing the mA decreases the image quality.
(B) Compression of the patient improves contrast.
(C) The use of grid reduces scatter radiation.
(D) Latitude describes the dynamic range of a film.
(E) Beam collimation reduces the amount of scattered radiation.

4. Isotopes of an element

(A) Have the same number of protons.
(B) Have the same physical properties.
(C) Have the same chemical properties.
(D) Are stable.
(E) Have different number of neutrons.

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5. Regarding the intensity of x-ray produced in an x-ray tube:

(A) The intensity refers to the energy fluence rate.
(B) It is not a factor of x-ray energy.
(C) It is directly related to tube current.
(D) It is affected by the distance from the source.
(E) It is proportional to tube voltage.

6. The mass attenuation coefficient is:

(A) Equal to the linear attenuation coefficient.
(B) Independent of the material density.
(C) Measured in cm−1.
(D) Multiplied with the mass thickness of the material to obtain the beam attenuation.
(E) Used to calculate Hounsfield unit.

7. Regarding anode angle:

(A) It is between 6° and 20°.
(B) It is an angle between the target surface and the central electron beam.
(C) Smaller angle increases the field coverage.
(D) Bigger angle improves geometrical unsharpness.
(E) The heel effect varies with the target angle.

8. Regarding the deterministic and stochastic effects of radiation:

(A) Stochastic effect has a lower dose threshold compared to the deterministic effect.
(B) Sterility is a deterministic effect.
(C) Deterministic effect has repair mechanism.
(D) Stochastic effect is hereditary.
(E) Cataract is a stochastic effect.

9. Regarding radiation damage to DNA:

(A) The DNA damage is caused by free radicals produced from x-ray interaction.
(B) The damage leads to cell death.
(C) The process is beneficial for radiotherapy.
(D) The x-ray causes a direct damage to DNA.
(E) The damage is irreparable.

10. Regarding digital radiography (DR) detectors:

(A) Indirect conversion system uses scintillating material.
(B) The active matrix array is made up of rare earth materials.
(C) DR latent image is read out one line at a time.

(D) The photoconductor in direct conversion DR system is amorphous selenium.
(E) Indirect conversion detector in DR offers lower patient dose for the same image quality over direct conversion detector.

11. Cause of misregistration in digital subtraction angiography includes

(A) peristalsis.
(B) patient breathing.
(C) contrast concentration.
(D) cardiac motion.
(E) metal implant in patient body.

12. Concerning the input screen in image intensifier:

(A) It converts the electron beam to light.
(B) The input phosphor is made of caesium iodide.
(C) It is coated with photocathode layer on the inner side screen.
(D) It is larger in size compared to output screen.
(E) It is coated with zinc cadmium sulphide.

13. Artefact in fluoroscopy imaging includes

(A) lag.
(B) ring artefact.
(C) pincushion distortion.
(D) veiling glare.
(E) vignetting.

14. Concerning dose in fluoroscopic procedure:

(A) Zoom option in fluoroscopy increases patient entrance skin dose.
(B) Automatic brightness control output display is independent of image intensifier entrance dose rate.
(C) Reducing the fluoroscopy pulse rate results in reduction of patient entrance dose rate.
(D) It is safer for the operator to use under-couch x-ray tube position in comparison with over-couch tube position.
(E) Increasing the thickness of copper filter results in reduction of patient surface dose.

15. Technique for reducing dose to patient in fluoroscopy imaging includes

(A) filtration of low-energy photon using grid.
(B) iso-centric imaging.
(C) last image hold.
(D) image magnification.
(E) pulsed fluoroscopy.

16. The half-life of a radionuclide:

(A) Varies according to the radionuclide.
(B) Is based on probabilistic events.
(C) Is the time taken for 25% of the radionuclides to decay.
(D) Is dependent on the physical state of the nuclide.
(E) Is proportional to decay constant.

17. Regarding collimators used in planar imaging:

(A) Convergent hole collimator is useful for imaging larger organs.
(B) A larger field of view (FOV) is obtained by a divergent hole collimator.
(C) Medium-energy collimator is used for imaging with ^{99mTc} radionuclide.
(D) High-sensitivity collimator has larger holes compared to high-resolution collimator.
(E) A pinhole collimator is preferable for imaging the superficial small organ.

18. Regarding image quality in gamma camera:

(A) Resolution test is tested using bar test pattern.
(B) Sensitivity is reduced with increased crystal thickness.
(C) The resolution increases as the distance between gamma camera head and patient is reduced.
(D) Scattered gamma rays detected by gamma camera reduce image contrast.
(E) Resolution is increased as crystal thickness is increased.

19. Regarding radiation protection in radiographic procedure:

(A) Lead protective barrier used in x-ray rooms is 2 mm thick.
(B) Under-couch x-ray tube provides more scatter shielding to staff compared to over-couch in fluoroscopy examination.
(C) Thyroid shield used in radiology is 0.25 mm lead equivalent thickness.
(D) Accurate collimation is practiced to reduce unnecessary radiation to patient in diagnostic imaging procedure.
(E) X-ray tube is positioned to be as far as possible to patient in fluoroscopy examination.

20. Regarding dose records in IRMER 2000:

(A) Classified persons must have an assessment of their dose of ionising radiation made by an approved dosimetry service.
(B) The person engaged in the endoscopy using x-rays is a classified worker.
(C) Health records for classified staff are kept for at least 20 years.

(D) Investigation reports for doses received by employees that exceed the investigation level must be kept for at least 2 years.
(E) Persons who are likely to receive an effective dose more than 3 mSv per year must be classified.

21. According to IRR 99, an incident should be reported if a patient received

(A) 5 times the intended dose for a mammogram.
(B) 1.2 times the intended dose during radionuclide therapy.
(C) 15 times the intended dose for a skull x-ray.
(D) 1.5 times the intended dose for an interventional radiology.
(E) 10 times the intended dose for an abdominal x-ray.

22. Concerning reconstruction kernel:

(A) Smooth kernel is usually used in brain examinations.
(B) High-pass filter reduces the blurring effects.
(C) Bone algorithm is known as edge-enhancement kernel.
(D) Sharper kernel is used to assess bony structures.
(E) Smooth kernel produces smoother images with higher noise.

23. The iterative reconstruction (IR) technique

(A) is capable of reconstructing optimal image with incomplete projection data.
(B) is based on repetitive correction by estimation.
(C) works better for metal artefact reduction.
(D) results in lower spatial resolution than FBP technique.
(E) is capable of reducing dose.

24. Regarding high-pitch technique in helical CT:

(A) It reduces scan time.
(B) It is useful for retrospective gated cardiac CT.
(C) It reduces patient dose.
(D) Image reconstructed is blurred.
(E) It produces more respiratory motion artefact.

25. Regarding image quality in CT:

(A) As slice thickness increases, the partial volume effects tend to decrease.
(B) CT noise is reduced by reducing the voxel size.
(C) Spatial resolution is improved by reducing the field of view.
(D) Soft reconstruction kernel improves the visibility of low-contrast lesions.
(E) A narrower window width decreases the image contrast.

26. Regarding the principles of single-photon emission computed tomography (SPECT):

(A) It consists of gamma cameras that rotate continuously around patient.
(B) The system sensitivity is decreased as triple-headed camera is used.
(C) Iterative reconstruction offers more accurate attenuation correction than filtered back projection.
(D) It has potential to correct the gamma attenuation.
(E) An elliptical orbit is used to minimise the gap between patient and collimator.

27. Concerning image quality of SPECT imaging:

(A) Noise is higher due to limited number of counts.
(B) It has spatial resolution greater than planar imaging.
(C) An area of very high activity causes streaking artefacts.
(D) Noise is reduced by using thicker reconstructed slice.
(E) Image resolution is improved by using a high-sensitivity collimator.

28. The positron emitter used in PET imaging includes

(A) ^{18}F.
(B) ^{133}Xe.
(C) ^{68}Ga.
(D) ^{82}Rb.
(E) ^{123}I.

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) An MR active nucleus spins at its own precessional frequency.
(B) The magnetic moments of the nuclei move out of phase of each other.
(C) Nuclei with an odd number of protons are MR active.
(D) More nuclei are aligned antiparallel to the magnetic field than the parallel nuclei.
(E) Net magnetisation vector (NMV) is larger at high field strength than lower field strength.

30. Regarding resonance induced by RF pulses in MRI:

(A) Net magnetisation vector (NMV) moves out of alignment from magnetic field.
(B) All magnetic moments move at the same precessional path.
(C) Excitation of nuclei due to energy absorption from RF pulse.
(D) 90° flip angle rotates the NMV completely from transverse to longitudinal plane.
(E) The applied RF pulse is exactly at Larmor frequency.

31. Concerning magnetic resonance imaging (MRI):

(A) The k-space stores the signal spatial frequencies.
(B) Higher proton density tissue appears dark in MR image.
(C) A steeper phase-encoding gradient results in smaller FOV.
(D) The time taken for 63% of longitudinal magnetisation to recover is known as T1 relaxation time.
(E) Bone does not produce any artefacts in MRI.

32. Regarding pulse sequences in MRI:

(A) The pulse sequences involve RF pulses and gradients.
(B) Repetition time (TR) controls the amount of T2 weighting in image.
(C) 180° rephasing pulse is used to generate echoes.
(D) Inversion recovery sequence begins by 180° pulse followed by 90° pulse.
(E) Spin-echo sequence is preferable as it produces good image quality.

33. Regarding safety in MRI:

(A) Specific absorption rate (SAR) is used to measure body temperature increment due to RF absorption.
(B) Patients with cardiac pacemaker should be excluded from areas where stray fields are greater than 0.5 mT.
(C) Anaesthetised patients do not require hearing protection.
(D) The SAR limits are similar for the whole body and extremities.
(E) There must be two physical barriers between the 5 G line and public access area.

34. Parameter that affects ultrasound velocity includes

(A) tissue density.
(B) maximum voltage of the transducer.
(C) wavelength of ultrasound.
(D) diameter of transducer.
(E) frequency of ultrasound.

35. Regarding Doppler effect:

(A) It causes an increase in frequency when object is moving towards the transducer.
(B) The reflected sound velocity is decreased when the object is moving away from transducer.
(C) The greatest change in frequency takes place when the direction of ultrasound beams parallel to the object movement.
(D) The reflected frequency is same to the incident frequency if the reflector is static.
(E) Negative Doppler shift happens when the angle between Doppler beam and moving object is less than 90o.

36. Regarding ultrasound equipment:

(A) Cardiac transducer is a specialised transducer.
(B) A-mode measures the depth of object along a single ultrasound ray.
(C) A Doppler mode measures blood flow.
(D) Annular array is a series of concentric circular transducers that can shape the beam to different focal depth.
(E) A linear array is a series of individual transducers along a line to produce rectangular image.

37. Method of quantifying biological effects of ultrasounds includes

(A) internal dosimetry.
(B) tissue weighting factor.
(C) mechanical index.
(D) thermal index.
(E) spatial peak-temporal average intensity.

38. Regarding bioluminescent imaging:

(A) Bioluminescence is the process of light emission in living organisms.
(B) It involves detection of a luminescent signal from within a tissue sample.
(C) It is useful for molecular imaging.
(D) It does not provide real-time cell tracking.
(E) It utilises sensitive charged-coupled device (CCD) camera for imaging.

39. Technical requirement for functional imaging includes

(A) larger field of view (FOV).
(B) high temporal resolution.
(C) rigid image registration.
(D) low dose to patients.
(E) capable for quantitative analysis.

40. Comparison of imaging modalities for functional and molecular imaging (FMI)

(A) ultrasound offers better quantitative information compared to optical imaging.
(B) both ultrasound and optical imaging can be applied externally and internally.
(C) ultrasound has shorter acquisition time than optical imaging.
(D) MRI has better soft tissue contrast than CT.
(E) both PET and SPECT have unlimited depth penetration.

Part II

Answers

Examination One: Answers

1. Regarding digital radiographic image:

(A) True. Detector size is a function of the pixel size times the number of pixels.
(B) False. Increasing the pixel size decreases the spatial resolution. Smaller pixel will allow detection of finer details.
(C) True. Bit depth determines the number of bits used to indicate the grey level of a single pixel.
(D) False. The number of grey level is equivalent to 2 to the power of bit size. For example, $2^{12} = 4096$ levels of grey, $2^9 = 512$ levels of grey and $2^8 = 256$ levels of grey.
(E) False. Lossless compression uses image compression algorithm that allows the original image to be perfectly reconstructed from the compressed data.

2. The technique used to minimise scatter includes

(A) True. Collimating the beam decreases the total tissue area irradiated and the amount of radiation interaction that produces scatter.
(B) False. Increasing the kVp lowers photoelectric interaction but increases the Compton scatter interaction. Compton scatter resulted in production of scatter radiation.
(C) True. Air gap reduces scatter radiation reaching the detector.
(D) True. Compression decreases the total tissue area irradiated; therefore, there is less scatter from the interactions.
(E) True. The grid reduces the number of scatter radiation reaching the detector.

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3. Regarding gas-filled detectors used for quality assurance:

(A) True. Dose calibrator is a well-type ion chamber used in nuclear medicine to assay the activities of dosages of radiopharmaceuticals to be administered to patients.
(B) True. Proportional counter operates at an intermediate voltage between ionisation chamber and Geiger-Muller counter which produces detector output proportional to the radiation energy.
(C) True. Due to the high voltage in the proportional region, the accelerated electrons have high kinetic energy that causes spread of additional ionisation along the anode and therefore requires quench gas such as methane to prevent this from happening.
(D) False. Geiger-Muller counter operates at a voltage range higher than proportional counter and causes gas multiplication effect. The amount of charge collected from each event is independent of the energy deposited in the detector.
(E) False. The generated signal from a Geiger-Muller counter is the same, regardless of the amount of energy deposited by the interaction. Therefore, it cannot be used as a dose rate monitor.

4. A nucleus is represented by the symbol ${}^{A}_{Z}X$, where

(A) False. A is the mass number.
(B) False. Z is the atomic number.
(C) True. Atomic number is the number of protons found in the nucleus of an atom. It is identical to the charge number of the nucleus.
(D) False. The mass number is equal to the total number of protons and neutrons.
(E) True. Neutron is an uncharged elementary particle that has a mass nearly equal to that of the proton. It is present in all known atomic nuclei except hydrogen atom.

5. Protons in an atom

(A) False. Protons have a mass of 1.67×10^{-27} kg.
(B) True. Protons have a positive charge of +1.
(C) True. Number of proton matches number of electron in a non-ionised atom.
(D) True. Number of proton represents the atomic number.
(E) False. There is no change in the number of proton following gamma decay.

6. X-ray photon

(A) True. X-ray is a type of electromagnetic radiation produced from an X-ray tube.
(B) False. X-ray has no charge and cannot be deflected in a magnetic field.

(C) True. X-ray is an ionising radiation.
(D) True. X-ray is a type of electromagnetic radiation; therefore, it travels with the velocity of light in a vacuum.
(E) False. X-ray photon is produced from an X-ray tube. Gamma decay produces gamma photon from a radioactive nucleus.

7. Rayleigh scatter

(A) True. Coherent scatter occurs when a photon excites an atom but passes straight through; the photon causes the electrons to vibrate only.
(B) False. Coherent scatter does not contribute to patient's dose because no energy is deposited during the interaction.
(C) False. The electrons only vibrate, not dislodged from the atom.
(D) False. Coherent scatter accounts for only a few percent of total interaction in diagnostic radiology.
(E) True. Coherent scatter is proportional to the square of atomic number.

8. Effective dose is

(A) True. Effective dose is equal to absorbed dose multiplied by radiation weighting factor and tissue weighting factor.
(B) True. The radiation weighting factors are dependent on the types of radiation.
(C) True. Effective dose is measured in Sievert (Sv).
(D) False. Equivalent dose is equal to absorbed dose multiplied by radiation weighting factor.
(E) True. Tissue weighting factor incorporates internal radiation exposure.

9. Regarding the differences between deterministic and stochastic effects:

(A) False. Ulceration is a deterministic effect and has a threshold dose.
(B) False. Stochastic effects have no threshold dose.
(C) True. Sterility is a deterministic effect and has a threshold dose.
(D) True. Deterministic effects have repair mechanism below the threshold dose.
(E) False. Cataract is a deterministic effect and has a threshold dose.

10. Regarding filters:

(A) False. Combined filters are the second filter used in CT unit. It is used to absorb the characteristic radiation from the first higher atomic number filter.
(B) True. Rhodium filters are commonly used in mammography. Other material used for mammography filters is molybdenum.
(C) False. Lead is used as radiation shielding material, not for filtration.

(D) True. The filter increases the average energy of the beam by removing the lower-energy rays which mainly contribute to the patient's skin dose and almost does not affect the final image contrast.
(E) True. Aluminium is a suitable filtering material in general radiography due to its physical characteristics (Z = 13 and density = 2.70 g/cm^3), to filter unnecessary low-energy photons from the beam.

11. Component of direct digital radiography includes

(A) False. Image intensifier is a component of fluoroscopy.
(B) True. Image management system is used to store, organise and archive all images in direct digital radiography.
(C) True. Digital image processing is the use of computer algorithms to perform image processing on digital images.
(D) True. A method of communication is needed to archive the patient information system.
(E) False. Film digitiser system is not a component of direct digital radiography.

12. Component of the fluoroscopic image intensifier tube includes

(A) True. Input phosphor is a caesium iodide crystal layer in image intensifier used to convert X-rays to visible lights.
(B) True. Photocathode is an immediate layer after input phosphor made up of caesium antimony used to convert visible lights to electrons.
(C) True. Electrostatic focusing lens directs and accelerates electrons from photocathodes to output phosphor.
(D) False. Charge-coupled device is not a component of image intensifier. It is a component of flat panel system.
(E) False. Thin-film transistor is not a component of image intensifier. It is a component of flat panel system.

13. Cause of unsharpness in fluoroscopic image includes

(A) False. Thin phosphor layer of output phosphor does not cause unsharpness, but thick phosphor layer causes unsharpness in fluoroscopic image.
(B) True. Thick caesium iodide layer in input phosphor is a cause of geometric unsharpness in fluoroscopic image.
(C) False. Needle-shaped CsI microcrystal makes fluoroscopic images sharper.
(D) True. Magnification due to distance causes an unsharpness to the fluoroscopic image.
(E) False. Smaller pixel gives better resolution and image sharpness.

14. Concept used in ALARP includes

(A) True. Radiation dose to personnel can be reduced using proper shielding materials, for example, lead.
(B) False. Dose limit is not a concept of ALARP, but it is a principle of radiation protection.
(C) True. Dose to person will be reduced by the power of two with doubling the distance.
(D) False. Optimisation is not a concept of ALARP, but it is a principle of radiation protection.
(E) True. Dose to personnel will be reduced with reduced time spent with radiation.

15. The protection to the patient from unnecessary radiation exposure includes

(A) True. Collimator is made up of plumbum material able to limit unnecessary radiation field to patient.
(B) True. With high kV technique, lower-energy photon that contributes unnecessary dose to the patient is filtered before it reaches the patient's skin.
(C) True. With doubling the distance, the dose will be decreased significantly by the power of two.
(D) True. Fast screen has higher conversion efficiency factor. It is able to provide image with high output signal using lesser photon quantity.
(E) False. Grid is only used to reduce scatter to image receptor. With the use of grid, exposure factors should be increased, therefore increasing dose to patients.

16. Radionuclides

(A) True. Radionuclides will decay to become stable nuclides.
(B) True. Most radionuclides are heavy elements.
(C) True. Radionuclides will emit radiation during decay process.
(D) False. Stable state nuclei have an optimal ratio of neutrons to protons. For the lighter elements, this ratio is approximately 1:1, but for heavy elements, the number of neutrons exceeds the number of protons.
(E) True. Most radionuclides are artificially produced and don't exist naturally.

17. Regarding planar radionuclide imaging:

(A) True. Gamma cameras are made of a sodium iodide crystal that produces a burst of light when gamma rays hit it.
(B) True. Planar radionuclide imaging uses unsealed sources of radiation, either liquids or gases for diagnosis and therapy. These unsealed sources are known as radiopharmaceuticals that emit radiation.

(C) False. Extrinsic resolution is the spatial resolution with a collimator in place. It is evaluated by using a flood-field image obtained by presenting the collimator-crystal combination with a uniform planar source of activity.

(D) True. The collimator spatial resolution is stated as $R_c = d(1 + b/h)$, where
d is hole diameter
b = distance from radiation source to collimator
h = hole length
From this equation, resolution is improved by using a collimator with long holes of small diameter positioned as close to the patient as possible.

(E) False. The half-life of ^{99m}Tc is 6 h. It is a short-lived metastable nuclear isomer produced from ^{99}Mo. It is used in imaging of the thyroid, colon, bladder and stomach.

18. Concerning safety in planar radionuclide imaging:

(A) True. Radioisotopes must be stored in lockable metal cabinets or refrigerators at designated locations within a laboratory. Proper storage of radioisotopes in the laboratory includes providing sufficient shielding to reduce emitted radiation level to the lowest possible and certainly to below the legally prescribed limit of 1 μSv/h and preventing the release or spillage of radioactive materials.

(B) True. Small spills that present no radiological hazard to persons should be cleaned up immediately. More serious spills may require evacuation of the area before clean-up is undertaken.

(C) False. Occupational workers are trained to minimise the use of radiopharmaceuticals. The goal is to reduce occupational exposure to radiation.

(D) True. The major objective of radiation safety is to reduce public and occupational exposure to a minimum, keeping in mind the as low as reasonably practicable principle. Thus, the time spent near radioactive material should be minimised.

(E) True. A worker's occupational dose may be caused by exposure to radiation from radioactive material that has been taken into the body, called internal exposure. Most activities involve little, if any, internal exposure. The intake of radioactive materials by workers is generally due to breathing contaminated air.

19. Regarding UK radiation protection regulations:

(A) False. It is the responsibility of the employer to ensure the machine is properly maintained, subject to Regulation 10(1) in IRR 99.

(B) True. All controlled area and supervised area should be governed by local rules that appropriate with the radiation risks and nature of works carried out in that area, subject to Regulations 17 and 18.

(C) True. Controlled area is an area in which any person working in that area is likely to receive an effective dose greater than 6 mSv per year or an equivalent dose greater than three-tenths of any related dose limit.

(D) True. The employee should fully utilise the personal protective equipment, subject to Regulation 34(2) in IRR 99.
(E) True. The dose limit for effective dose for trainee aged below 18 years is 6 mSv in any calendar year.

20. Concerning the Ionising Radiations Regulations (IRR) 1999:

(A) True. The controlled area is only permitted for classified persons.
(B) False. Personal dosimeters are issued for periods greater than 1 month (monthly basis and not more than 3-month period).
(C) True. The dose limit on effective dose for employee aged 18 years or above is 20 mSv in any calendar year.
(D) False. Employer should be responsible for managing the staff radiation safety. Radiation protection adviser (RPA) is responsible for anything related to installation, maintenance, monitoring and engineering controls of the radiation tools.
(E) True. Local rules are written instructions that describe the safe methods of working in various situations involving ionising radiations.

21. According to the Ionising Radiations (Medical Exposure) Regulations 2000 (IRMER)

(A) False. Training and continuous education are compulsory for employer, practitioner and operator who are responsible for medical exposures, subject to Regulation 11(1–5) in IRMER 2000.
(B) True. A practitioner is entitled to take responsibility for an individual medical exposure in accordance with employer's procedures. It can be a registered medical practitioner, dental practitioner or other health professional (e.g. chiropractor).
(C) True. A medical physics expert shall be involved in every medical exposure such as radiotherapeutic procedures and therapeutic and diagnostic nuclear medicine procedures, as well as in dose optimisation, quality assurance and radiation protection.
(D) True. An operator is any person who is entitled to carry out the practical aspects, including handling of radiological equipment, assessment of technical and physical parameters including radiation doses, calibration and maintenance of equipment, preparation and administration of radioactive materials and development of films.
(E) False. These regulations shall be applied to the radiation exposure involving patients or volunteers participating in research programmes, subject to Regulation 3 in IRMER 2000.

22. Concerning tomographic reconstruction:

(A) True. Tomography is a non-invasive imaging technique allowing for the visualisation of the internal structures of an object without the superposition of over- and underlying structures.
(B) True. Radon transform provides mathematical basis for reconstructing tomographic images from measured projection or scattering data.

(C) False. X-ray CT measures the number of X-ray photons transmitted through the patient along individual projection lines.
(D) True. Backprojection involves smearing back the projection across the image at the angle it was acquired. By smearing back all of the projections, an image will be reconstructed. This image looks similar to the real picture but is blurry—some bright pixels are smeared across the entire image instead of putting them exactly where they belonged.
(E) True. Direct Fourier reconstruction is based on the Fourier slice theorem. Other tomographic reconstruction techniques are backproject-filter method based on the laminogram (the blurred version of the object) and the convolve-backproject method, also called the filter-backproject method.

23. Reducing the number of projections is desirable for the purpose of:

(A) False. Decreasing scanning time because less number of projections is required in a scan.
(B) True. Reducing the number of projections would not sacrifice the image quality because the iterative reconstruction can handle incomplete data sets better than the filtered backprojection algorithms.
(C) True. Less scan time is required for less number of projections. Thus, it reduces motion artefact during the scan.
(D) True. Patient is exposed to minimum radiation dose with less number of projections.
(E) False. The number of measurement decreases as the number of projection increases.

24. Reducing CT slices results in:

(A) False. Reducing CT slice thickness results in reduced partial volume effect. Partial volume effect yields a CT number representative of the average attenuation of the materials within a voxel. It can be avoided by using thinner slices.
(B) False. Subject contrast is determined by the number of X-rays penetrating the patient and reaching the detectors. CT slice thickness does not affect the subject contrast.
(C) True. The height of the collimator defines the thickness of the CT slice. Narrowing the collimator yields thinner slices. With thinner CT slices, fewer X-rays are interacting in the detector during a scan.
(D) True. Thinner slices have fewer X-rays interacting in the detector; the resulting signals are subject to greater statistical fluctuation and yield a noisier image in the final display.
(E) True. Changing the slice thickness changes the beam width entering each detector and the number of detected X-rays.

25. Technique to reduce the CT dose includes

(A) True. Limiting the anatomic scan coverage to the specific organs of clinical concern will minimise the scan length and radiation to other tissues.
(B) False. Increasing mA increases the X-ray flux through the patient with the consequence of increased dose and decreased noise.
(C) True. Technologists can reduce dose without image degradation by observing the patient's body habitus (weight and size or body mass index). For example, some radiologists suggest that if a patient's BMI is less than 30, a lower kVp and mA can be used.
(D) True. Patients that are properly centred will have their centre of mass properly aligned with the centre of the bow-tie filter which affects the attenuation of the X-ray beam and image noise. Thus, dose optimisation efforts to reduce radiation dose while maintaining image noise can be done in proper patient positioning.
(E) True. 3D dose modulation is the most comprehensive approach to CT dose reduction because the X-ray dose is adjusted according to the patient attenuation in all three dimensions.

26. Regarding SPECT:

(A) True. Spatial resolution is worse in SPECT compared to planar gamma imaging because the distance between the camera and patient is further in SPECT. Camera head is closer to the patient in planar gamma imaging.
(B) True. In SPECT imaging, two or more (multiple) gamma cameras are used.
(C) False. Reconstructed resolution improves as the distance of the detector from the patient is decreased. The detector should be placed as close as possible to the patient to allow more photons to be detected and increase the detection efficiency.
(D) False. The detection sensitivity of SPECT system is more than the planar gamma imaging because SPECT detects photons in multiple directions, as the detector rotates. However, planar imaging detects photons in one direction only.
(E) True. In SPECT, tomographic reconstruction with filtered backprojection (FBP) or iterative technique is employed.

27. Regarding SPECT:

(A) True. The computational time for image reconstruction in SPECT is longer compared to CT because it involves reconstructing an attenuation map from emission data for attenuation correction.
(B) False. SPECT imaging is more susceptible to motion artefacts than in CT imaging because the acquisition time is longer.

(C) True. SPECT produces 3D images that eliminate the superimpositions of radioactivity distribution underlying and overlying the regions of interest with improved contrast and image details.
(D) True. Both planar and SPECT imaging used radioisotopes that emit gamma rays such as ^{99m}Tc.
(E) True. The intrinsic and extrinsic flood uniformity test for SPECT camera should be performed daily using two to four million counts.

28. Regarding radionuclide for PET:

(A) False. It is produced from cyclotron.
(B) True. The radionuclide possesses chemical properties that render them particularly useful in the study of physiological process. Thus, it is referred to as physiological radionuclides, for example, ^{11}C, ^{13}N and ^{15}O.
(C) True. This includes the measurement of the pharmacokinetics of labelled drugs and the measurement of the effects of drugs on metabolism.
(D) True. Radionuclide for PET measures biochemical and physiological processes in vivo in a quantitative way by using radiopharmaceuticals labelled with positron-emitting radionuclides and by measuring the annihilation radiation using a coincidence technique.
(E) False. Radionuclide for PET includes ^{15}O. ^{16}O is a stable isotope of oxygen.

29. Regarding nuclear magnetic resonance (NMR):

(A) False. It uses electromagnetic radiation to promote transitions between nuclear energy levels (resonance).
(B) True. Nuclei are positively charged and spin on an axis; they create a tiny magnetic field. Not all nuclei are suitable for NMR. ^{1}H and ^{13}C are the most important NMR active nuclei in organic chemistry.
(C) False. Different atoms within a molecule resonated at different frequencies.
(D) True. Each chemically distinct hydrogen nucleus in each metabolite in a biological sample, such as biofluid, will exhibit an NMR signal at a characteristic resonance frequency, which is measured as a chemical shift relative to a standard compound. Thus, NMR allows metabolite identification in biological fluids.
(E) True. The nucleus of the hydrogen atom (which is the most prevalent in the body and has a single unpaired proton) has been most commonly exploited to produce high-quality NMR images.

30. Factor that contributes to the decay of transverse magnetisation in NMR includes

(A) False. Transverse magnetisation is an unstable or excited condition and quickly decays after the termination of the excitation pulse. The decay of transverse magnetisation is a relaxation process, which can be characterised by specific relaxation times or T2 values. Constant frequency is not a factor that contributes to the decay of transverse magnetisation in NMR.
(B) False. Energies cause transitions between the nuclear spin states which result in nuclear spin relaxation. The presence of two spin states is not a factor that contributes to the decay of transverse magnetisation in NMR.
(C) True. Molecular interactions lead to a pure T2 molecular effect.
(D) True. Variations in magnetic field lead to an inhomogeneous T2 effect.
(E) False. The spin aligns in two orientations (up and down).

31. Regarding MRI:

(A) True. Short tau inversion recovery (STIR) is a useful sequence for suppressing fat. STIR uses sequence that consists of short TI (tau) known as null point to suppress the signal from fat (no longitudinal and transverse components of fat).
(B) True. Gadolinium has paramagnetic properties and improves both longitudinal and transverse relaxations; thereby, it shortens both T1 and T2 relaxation times of tissues in which it accumulates.
(C) True. STEAM is one of the single-voxel techniques used to locate the spectrum of measured proton in MR spectroscopy.
(D) False. Short TR and TE are used to obtain T1W images.
(E) False. T1 and T2 relaxations happen simultaneously. Both relaxations happen at the same time but independently and contribute to image contrast.

32. In T2-weighted images

(A) True. Echo time (TE) is the time between the application of the radiofrequency pulse and the peak of the induced signal, corresponding to maximum of echo (collection of signal). TE determines the transverse magnetisation decay and thus controls the amount of T2 weighting.
(B) False. A flip angle of 90° is used to obtain T2-weighted images.
(C) True. Long TE used in T2 sequence allows tissues with long T2 to fully decay (relaxation), and higher signal is received. Tissues with higher signal will appear bright.

(D) False. Cerebral spinal fluid (CSF) has a long T2 time (300 ms). Long TE used in T2 weighting allows CSF to produce stronger signal compared to other tissues with short T2. Thus, CSF appears bright on T2-weighted images.

(E) False. Pathological processes, such as demyelination or inflammation, often increase water content in tissues. Thus, infectious regions produce higher signal in T2-weighted images.
The properties of T2-weighted image:
T2W images are characterised by dark fat and bright water.
Fat has low signal and appears dark.
Water has high signal and appears bright.
Long TE is used (~90–140 ms).
Long TR is used (~1000–2000 ms).
Tissue with long T2 will appear brighter (Allisy-Roberts & Williams (2008)).

33. Concerning safety in MRI:

(A) True. Radiofrequency (RF) power transmitted for MR imaging is transformed into heat within the patient's tissue as a result of resistive losses. The dosimetric term used to describe the absorption of RF radiation is the specific absorption rate (SAR). Measurements or estimates of SAR are not trivial, particularly in human subjects.

(B) True. The FDA restricts the amount of heat that can be induced in a given human tissue. The accepted levels are reached more quickly in 3-T scanning, which results in longer scan times to enable the tissue to have enough time to cool to an allowable level.

(C) True. Insulating material (minimum recommended thickness, 1 cm) should be placed between the patient's skin and RF transmitter coil that is used for the MR procedure (alternatively, the RF transmitter coil itself should be padded). There should be no direct contact between the patient's skin and the RF transmitter body coil of the MR system. This may be accomplished by having the patient place his arms over his head or by using elbow pads or foam padding between the patient's tissue and the RF transmitter body coil of the MR system.

(D) False. Subjecting the human body to time-varying electromagnetic fields leads to induced electric fields. At frequencies above 1 MHz, a reactive element begins to be significant, and at frequencies above 30 MHz, the wavelength begins to influence the electric field and current distribution. Induced electric currents can be sufficiently large to interfere with normal function of nerve cells and muscle fibres.

(E) True. Quenching is the process whereby there is a sudden loss of absolute zero of temperature in the magnet coils, so that they cease to be superconducting and become resistive, thus eliminating the magnetic field. This results in helium escaping from the cryogen bath extremely rapidly. It may happen accidentally or can be manually instigated in the case of an emergency.

34. Ultrasound used in medical diagnosis

(A) True. Average speed of ultrasound in air is 330 m s^{-1}, in tissue 1540 m $s^{-1}$and in bone 3200 m s^{-1}.
(B) True. Ultrasound can cause tissue damage via cavitation and acoustic steaming.
(C) False. The frequency range of diagnostic ultrasound is in MHz and not in Hz.
(D) True. The Doppler principle is utilised to measure blood velocity. It utilises the information of frequency change of ultrasound wave to calculate blood velocity.
(E) False. Medical ultrasound generates negligible amounts of heat in the tissue.

35. Piezoelectric materials in ultrasound

(A) True. When direct current is applied, piezoelectric material of ultrasound will expand or contract.
(B) True. When alternating current is applied, piezoelectric material of ultrasound will alternately expand and contract with the same frequency of alternating current.
(C) True. The contraction and expansion of piezoelectric materials due to electric current produce ultrasound wave.
(D) True. Its ability to convert electric current to sound and vice versa makes it a suitable material for transmitter and receiver.
(E) True. It will convert sound energy to electric signal when it acts as a receiver.

36. Factor affecting visibility of anatomical detail in ultrasound image includes

(A) True. The frequency effect on wavelength and pulse length determines blurring and visibility of detail in the axial direction.
(B) True. The transducer's focusing characteristics which determine the lateral size of the pulse affect visibility in the lateral direction.
(C) False. TGC does not affect visibility of anatomical detail in ultrasound image.
(D) False. Pulse rate does not affect visibility of anatomical detail in ultrasound image.
(E) True. Higher acoustic impedance of structure improves the image detail.

37. Regarding safety in ultrasound imaging:

(A) True. The basic principles in ultrasound safety are to keep the power output as low as reasonably practicable (ALARP) while producing the useful diagnostic results.
(B) True. The mechanical index (MI) gives an estimation of the risk of the nonthermal effects such as cavitation and streaming. The MI greater than 0.7 generates the risk of cavitation.

(C) True. According to International Standards (IEC 2007), the recommended maximum temperature of the probe in contact with the patient is limited to 43 °C, either internally or externally, and 50 °C when operated in air.
(D) False. Pulsed Doppler technique produces more heating potential than Doppler power mapping because it is usually associated with a high pulse repetition frequency.
(E) False. The Doppler examinations should only be used in the first trimester of pregnancy.

38. Fluorescent imaging

(A) True. Fluorescent dyes are the most sensitive for detection of total DNA, RNA and protein compared with traditional colourimetric methods.
(B) False. Fluorescent antibodies such as PCR primers can be stored for several months; however, radioisotope-labelled antibodies, for example, phosphorus-32-labelled nucleotides, decay in about a week.
(C) False. Fluorescent dye is not an ionising radiation.
(D) True. Optical camera is required to image the fluorescent light.
(E) True. Fluorescent imaging detects visible light which has longer wavelength than x-ray.

39. Concerning functional and molecular imaging (FMI):

(A) True. Optical imaging with fluorescent molecular probes is capable of producing higher spatial resolution images, which are less than 3 mm.
(B) True. There was negligible effect on magnetic field homogeneity when high or low voltage power was supplied to the CZT detector. Due to its compatibility with MR fields, CZT has been used as the detector for multimodality imaging such as SPECT/MRI.
(C) False. Equal distance separation between both gantries should be obtained during data acquisition to avoid misregistration of the PET/CT images.
(D) True. PET studies demonstrate higher sensitivity, specificity and accuracy for detection of coronary artery disease (CAD) than SPECT and PET/CT.
(E) False. The reconstructed slice of PET images should be similar with CT slice for a precise PET/CT image fusion.

40. Regarding FMI:

(A) True. MR spectroscopic imaging (MRSI) detects tumour in the brain based on the changes in lactate and choline concentration.
(B) True. The combination of dynamic imaging with computational approaches, particularly kinetic modelling method, is useful for the quantitation of biophysical properties of molecules and processes such as protein interaction in cells.

(C) True. In DW imaging (DWI), tissues with high cellularity have low apparent diffusion coefficient (ADC), and thus they will have high signal.

(D) False. In fasting state, the level of tumour FDG uptake is higher than the muscle FDG uptake.

(E) True. The typical imaging biomarkers used to measure the molecular characteristics in PET imaging are metabolic activity, receptor expression and enzymatic activity.

Examination Two: Answers

1. The technique used to minimise motion blur includes

(A) True. Increasing the tube current will shorten the exposure time and reduces the motion captured.
(B) False. Increasing the exposure time will prolong the imaging time and increases the motion captured.
(C) True. Using fast film-screen reduces exposure time required and reduces the motion captured.
(D) False. Image magnification will magnify any motion blur.
(E) True. Breath hold minimises organ motion captured and reduces blurring in the image.

2. Geiger-Muller counter used for radiation survey

(A) False. Thicker window will absorb alpha particle and resulted in the alpha particle being undetected in the gas.
(B) True. Detection efficiency for gamma radiation is lower than alpha or beta particles as the radiation is more penetrating.
(C) False. The detector is a counter-type detector.
(D) True. Different window thickness can be used to distinguish alpha and beta particles. Beta detection requires thicker window to absorb alpha particle.
(E) False. The counter cannot distinguish energy and doesn't require multi-channel analyser to differentiate the energy.

3. Regarding quality assurance of a dose calibrator:

(A) True. The device must be tested for accuracy on installation and annually thereafter.
(B) False. The device must be tested for constancy before its first use each day.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
https://doi.org/10.1007/978-981-13-0911-3_11

(C) False. Most dose calibrators have large wells to reduce the effect of position on the measurement and changes in the sample volume or container for most radionuclides except for weak gamma emitters.
(D) True. Sealed $^{6}0$Co source with known activity is used.
(E) False. The device is tested for linearity on installation and quarterly thereafter to be within 10%.

4. Carbon-12 and carbon-11 have the same

(A) True. Both are isotopes and have the same atomic number and chemical properties.
(B) False. Isotopes have different physical properties and the same chemical properties.
(C) True. Both have the same number of protons but different numbers of neutrons.
(D) False. Both have different numbers of neutrons but the same number of protons.
(E) False. Carbon-11 has a half-life of 20 min. Carbon-12 is a stable nuclide.

5. X-ray tube

(A) True. The wire cathode produces electrons.
(B) False. It is a vacuum tube.
(C) False. The detection efficiency is only several percent. Most of the energy is converted to heat.
(D) True. The glass envelope maintains a vacuum inside the tube.
(E) True. CT scanner has X-ray tube to produce X-rays during CT imaging.

6. Regarding bremsstrahlung X-rays produced in an X-ray tube:

(A) True. The interaction resulted in the electrons to produce bremsstrahlung X-rays.
(B) False. The energy spectrum is continuous.
(C) True. The glass envelope absorbs the low-energy photons.
(D) True. The maximum energy of X-rays produced is limited by the maximum energy of tube voltage supplied to the tube.
(E) True. Most photons produced from a tungsten target are bremsstrahlung X-rays.

7. Beam attenuation

(A) True. Attenuation is the reduction of the intensity of the X-ray beam as it transverses through the matter. The reduction may be caused by deflection or scatter of the X-ray photon.
(B) True. The reduction may be caused by absorption of the X-ray photon.
(C) False. Penetration is the passing of X-ray photons through the matter without any attenuation.

(D) True. Absorption causes energy deposition inside the patient and contributes to dose.
(E) True. Photoelectric interaction resulted in production of photoelectron and absorption of the X-ray photon.

8. The device used to measure radiation dose includes

(A) True. Film badge is a photographic film for personal dosimetry.
(B) True. Optically stimulated luminescence detector is a luminescence detector that is stimulated with light for readout.
(C) True. TLD is a luminescence detector that is stimulated with thermal heat for readout.
(D) True. Ionisation chamber is a gas-filled detector that is used for absorbed dose measurement.
(E) True. Geiger counter is a survey metre for radiation dose monitoring.

9. The radiation weighting factor

(A) False. The radiation weighting factor for gamma is 1.
(B) True. The radiation weighting factor for proton and X-ray is 1.
(C) True. The radiation weighting factor for alpha is 20.
(D) True. The radiation weighting factor for neutron varies between 5 and 22 depending on the neutron energy.
(E) False. Absorbed dose is not a factor of radiation weighting factor.

10. Regarding X-ray production:

(A) False. Large focal spot size causes geometrical unsharpness.
(B) True. Tungsten is used in cathode filament due to high melting point of approximately 3422 °C.
(C) False. The filament is heated to temperatures of 2000 °C not 200 °C.
(D) True. As mAs increases, the quantity of X-ray produced increases.
(E) False. As filtration thickness increase, quantity of X-ray produced decrease.

11. Regarding digital image receptor in direct digital radiography:

(A) True. Amorphous selenium used in direct digital radiography will convert X-ray to electric signal.
(B) True. Thin film transistor is used to collect electrical charge in direct digital image receptor.
(C) False. CCD detector is light-sensitive detector suitable for indirect digital radiography where visible lights are produced in the scintillation layer.
(D) False. Caesium iodide (CsI) crystal is a scintillation layer used to convert X-rays to visible lights in indirect digital radiography.
(E) False. Positive and negative charges are produced following interactions of X-rays with amorphous selenium.

12. Regarding resolution of an image intensifier:

(A) False. The output phosphor liberates light in response to bombardment by accelerated electrons from photocathodes, not light photons.
(B) True. Input screen made up of scintillating material liberates visible lights when simulated by X-rays.
(C) False. The thinner the phosphor, the better is the spatial resolution. This parameter limits and controls the light spread at input phosphor.
(D) False. Spatial resolution of conventional film is much superior to the best achieved by image intensifiers.
(E) False. Resolution of an image intensifier is measured in line pairs/mm.

13. Regarding fluoroscopic image quality:

(A) True. Vignetting is a distortion caused by image intensifier tube design.
(B) True. Brightness gain is a ratio of brightness at output phosphor to input phosphor.
(C) True. Maladjustment of electron focusing system due to strays of electric fields causes S-distortion.
(D) True. Flux gain is only applied to image intensifier-based system fluoroscopy.
(E) False. Low quantum detection efficiency causes lower signal-to-noise ratio.

14. Regarding personal radiation monitoring device:

(A) True. It is used at waist level during pregnancy to observe radiation level to foetus.
(B) True. Copper, cadmium, aluminium and lead are filters used in film badges to distinguish photon energy.
(C) True. Ring dosimeter is used to observe maximum exposure received by related hand of the operator.
(D) True. Personal dosimeter measurement should represent whole-body exposure of the radiation worker.
(E) True. It is used to monitor radiation exposures by radionuclide, X-rays and any ionising radiation involved.

15. The purpose of using personal monitoring device includes

(A) False. It is used to monitor the amount of radiation exposed to personnel and not to protect the radiation worker from radiation.
(B) False. Personal monitoring device is not used to calculate radiation delivered to the patient. It is used to estimate total doses received by the radiation worker monthly.
(C) False. It is unable to calculate the number of procedures conducted by radiologist. It can only calculate total dose received.
(D) True. Personal monitoring device should be worn by radiation workers in every procedure related to radiation exposure.
(E) True. Filters in personal dosimeters help in identifying the type of radiation received.

16. Regarding radioactive decay:

(A) True. Helium consists of a nucleus containing two protons and two neutrons with two electrons in orbit. An alpha particle has the same nucleus components.
(B) False. Positron decay occurs when a proton is converted into a neutron.
(C) True. Beta minus is an electron.
(D) False. A neutrino is emitted in a positron decay.
(E) True. Electron capture resulted in a production of Auger electron when the photon released during the process causes ejection of another orbital electron.

17. Regarding choice of collimators in planar radionuclide imaging:

(A) False. It is a trade-off between sensitivity and resolution. Sensitivity and spatial resolution are inversely related; the higher the sensitivity, the poorer the spatial resolution and vice versa.
(B) True. A collimator with small holes will provide better resolution but has lower sensitivity as it absorbs more emitted gamma rays.
(C) True. This is because the angle of acceptance is smaller and more scatter is rejected.
(D) True. LEGP collimator has holes with a large diameter. Larger diameter holes allow more scattered photon, so the sensitivity is relatively high where the resolution is moderate.
(E) True. LEHR collimators have higher-resolution images than the LEGP. They have more holes that are both smaller and deeper.

18. Concerning ^{57}Co flood source:

(A) False. The half-life is 271.8 days.
(B) True. Energy spectra of a ^{57}Co source are obtained with an external channel analyser connected to the camera. It shows a broad tail of high-energy photons above the 122 keV photopeak, due to Compton scatter and collimator penetration.
(C) False. It used for extrinsic uniformity. It is used for system flood-field uniformity to check the scintillation camera performance.
(D) True. ^{99m}Tc flood source of the same activity can be used for uniformity test to replace ^{57}Co.
(E) True. A daily flood image should be placed in a logbook to assess any changes in uniformity and for accreditation inspections.

19. Regarding UK radiation legislation:

(A) False. In IRMER 2000, the practitioner and operator shall ensure that doses arising from all medical exposure (except radiotherapeutic procedures) are kept as low as reasonably practicable that are consistent with the intended purpose. RPS is primarily responsible for ensuring compliance with the local rules in authorised areas.

(B) True. Classified workers should have an annual medical record for health review by an appointed doctor or employment medical adviser to determine his/her fitness to carry out the work with ionising radiation, subject to Regulation 24 (IRR 1999). That medical record or a copy should be kept until the person attained the age of 75 years or for at least 50 years from the date of the last entry.

(C) True. Controlled area is an area in which any person working in this area is likely to receive effective dose greater than 6 mSv per year or an equivalent dose greater than three-tenths (30%) of any relevant dose limit.

(D) True. The dose limit shall not apply to patients undergoing medical exposures or any person being a comforter or carer.

(E) False. A diagnostic dose reference level (DRL) is not a dose limit, but it is an investigation level.

20. The Ionising Radiations Regulations (IRR) 1999 states the following dose limits

(A) False. Annual dose limit for body effective dose for public is 1 mSv.

(B) True. The dose limit to the lens of the eye of an individual is related directly to the threshold dose that induce cataracts in the lens, which is approximately 5 mSv.

(C) False. Dose limit to the abdomen of a woman of reproductive capacity is 13 mSv during any consecutive 3-month period.

(D) False. Dose limit to the individual organs or tissues of staff is 500 mSv.

(E) True. The limit on effective dose shall be 5 mSv in any period of five consecutive calendar years for any person (not being a comforter or carer) who may be exposed to ionising radiation resulting from the medical exposure of others.

According to IRR 1999, the annual dose limits are as follows:

	Employees (mSv)	Trainees (mSv)	Public (mSv)
	≥18 years	≤18 years	
Effective dose	20	6	1
Equivalent dose			
Lens of the eye	150	50	15
Skin (any area of 1 cm^2 regardless of exposed area)	500	150	50
Skin, hands, forearms, feet and ankles	500	150	50
Abdomen of women of reproductive capacity	13	–	–
Foetus of pregnant employee	1	–	–

Adapted from the Ionising Radiations Regulations (IRR), 1999

21. The circumstance where the Health and Safety Executive (HSE) must be notified includes:

(A) True. The employer has to notify the HSE if there is radioactive substance under his control that is lost or has been stolen (depending on quantity and concentration of the radioactive as specified in IRR 1999).
(B) False. An investigation level is imposed when the effective dose received by any employee for the first time in any calendar year exceeds 15 mSv or such other lower effective dose as specified in local rules. Investigation dose level is lower than the dose limit; thus, the employer is not required to notify the HSE. The employer should only notify the HSE if an employee receives dose greater than any relevant dose limit.
(C) True. The employer should notify the HSE if radioactive source is spilt, causing significant contamination.
(D) True. The HSE must be notified if a patient received dose greater than intended due to equipment fault (based on HSE guidelines).
(E) False. The employer is not required to notify the HSE on failure to follow local rules by any employee.

22. Regarding tomographic reconstruction:

(A) True. The convolution method uses a one-dimensional integral equation for the reconstruction of a two-dimensional image.
(B) True. In the convolution method of using integral equations, a deblurring function is combined (convolved) with the X-ray transmission data to remove most of the blurring before the data are backprojected. The most common deblurring function is a filter that removes the frequency components of the X-ray transmission data that are responsible for most of the blurring in the composite image.
(C) False. A high-frequency convolution filter reduces noise and makes the image appear smoother.
(D) False. A low-frequency filter is referred to as a high-pass filter because it suppresses low frequencies and allows high frequencies to pass.
(E) True. Serial expansion technique requires all X-ray attenuation data to be available before reconstruction commences. It involves solving large systems of linear equation based on the observed attenuations from each ray. The linear system represents the target image for reconstruction.

23. Concerning simple backprojection:

(A) False. Each X-ray transmission path through the body is divided into equally spaced elements.
(B) True. An individual sample is backprojected by setting all the image pixels along the ray pointing to the sample to the same value.
(C) False. A final summed attenuation coefficient is determined by summing the attenuation for each element at different angular orientations.

(D) True. When this coefficient is combined with the summed coefficients for all other elements in the anatomical section scanned by the X-ray beam, a composite image of attenuation coefficients is obtained.

(E) True. Simple backprojection produces a blurred image because of the oversampling at the centre and less sampling at the edge.

24. In CT imaging:

(A) True. The computer assigns greyscale numbers (Hounsfield units) to the tissues that the X-ray beam passed through, based on their linear attenuation coefficients. The resultant image reflects the different greyscale numbers of different tissue types and therefore the tissues' respective abilities to attenuate X-rays.

(B) True. Attenuation of the X-ray beam in CT depends on the thickness of the anatomy traversed and the composition (physical density and atomic number) of the tissues in the path of the traversed beam.

(C) False. Rectilinear pencil-beam scanning is the first generation of CT scanners.

(D) True. Beam hardening refers to a gradual increase in the effective energy of polychromatic X-ray beams as they penetrate deeper into attenuating materials. It is caused by preferential attenuation of the lower-energy (and thus less penetrating) photons in the beam by each successive layer of attenuating material.

(E) False. The value of the CT number is calculated from the X-ray attenuation properties of the corresponding tissue voxel. Tissues with density greater than water have positive CT numbers. Those that are less dense have negative CT numbers. Higher CT numbers produce brighter CT image.

25. Advantages of spiral compared with conventional CT include:

(A) False. Technology of 'slip ring' electrical coupling allows X-ray tube and detectors to rotate continuously, and it allows faster image acquisition.

(B) True. Contrast enhancement is optimised because of volumetric acquisition of the region of interest in 20–60 s.

(C) True. Partial volume artefact occurs when tissues of widely different absorption are encompassed on the same CT voxel producing a beam attenuation proportional to the average value of these tissues. Its reduction in the volume of a voxel in spiral CT has substantially reduced the occurrence of this artefact.

(D) False. Spiral CT allows fast and continuous acquisition of data from a complete volume. Thus, it helps in avoiding misregistration of lesions and minimises respiratory and other motion artefact. Thus, it has less motion artefacts.

(E) True. The two-axis resolutions are axial and longitudinal spatial resolution. The axial spatial resolution is determined by the distances between the X-ray tube, the centre of rotation and the detector, as well as by the width of the focus and the detector elements and the number of measurements made per rotation. These factors are determined by the construction of the scanner. The longitudinal spatial resolution is determined by the selected protocol. It is described by the slice-sensitivity profile. This curve shows the relative contribution of the anatomy along the *z*-axis to the reconstructed image.

26. Regarding SPECT:

(A) True. The advantages of multiple heads in SPECT system are an improvement in count-rate sensitivity and decrease in imaging time.
(B) False. The centre of rotation (COR) measurement should be performed on weekly basis, and the purpose of this measurement is to test the COR offset that can degrade image resolution.
(C) True. Because of the anatomical location of the heart, which is the left anterior side of the thorax, photons coming from the right posterior side will be attenuated more and degraded the image quality. The 180° arc acquisition from the left posterior to the right anterior is suggested as an alternative to 360° circular acquisition for cardiac imaging.
(D) True. The bull's-eye or concentric ring artefacts are due to flood non-uniformities or collimator defects.
(E) False. 'Step-and-shoot' data acquisition is more preferable because continuous data acquisition has disadvantage of blurred data due to motion artefact of the moving camera head.

27. Concerning SPECT:

(A) True. The usual collimator used for ^{99m}Tc-pertechnetate thyroid imaging is a pinhole or high-resolution parallel collimator.
(B) False. In pulmonary ventilation imaging, ^{133}Xe is more preferable over ^{99m}Tc-labelled aerosols because it provides better distribution of radioactivity in the lungs.
(C) True. The areas where there is greater accumulation of radionuclide are called hot spots. The areas that do not absorb the radionuclide are referred to as cold spots.
(D) True. Motion-related artefact is best detected by viewing the raw projection data (sinogram). Sinogram discontinuities indicate patient motion related to respiration or cardiac motion.
(E) False. In filtered backprojection, selecting too low cut-off frequency yields a blurry reconstruction, and higher cut-off frequency yields a noisy reconstruction.

28. Regarding positron emission tomography (PET):

(A) True. Radionuclides such as ^{11}C, ^{13}N, ^{18}F and ^{15}O are produced in a cyclotron.
(B) False. The distribution of radioactivity is estimated by backprojection method.
(C) False. Annihilation radiation is produced when a particle and its antiparticle collide and annihilate. This refers to 511 keV gamma rays produced by electron colliding with a positron.
(D) True. Time-of-flight PET reconstruction is to obtain the best possible information about the PET tracer distribution.
(E) False. The collimators are not needed because the directionality of annihilation photons provides information about the origin of the photons.

29. Concerning nuclear magnetic resonance (NMR):

(A) True. Protons and neutrons that make up a nucleus have an intrinsic angular momentum or spin.
(B) False. Nuclei of ^{12}C have no spin because the atomic number is an even number.
(C) True. All nuclei have a spin quantum number, I, which may be integral (including zero) or half-integral, but never negative.
(D) True. Spin creates a magnetic field, even when charges are not in motion.
(E) True. A spinning charge generates a magnetic field. The nuclei of many elemental isotopes have a characteristic spin (I). Some nuclei have integral spins (e.g. $I = 1, 2, 3 \ldots$), some have fractional spins (e.g. $I = 1/2, 3/2, 5/2 \ldots$) and a few have no spin, $I = 0$ (e.g. ^{12}C, ^{16}O, ^{32}S). The resulting spin magnet has a magnetic moment proportional to the spin.

30. Regarding NMR:

(A) True. The magnetic moment of a magnet is a quantity that determines the torque it will experience in an external magnetic field. A loop of electric current, a bar magnet, an electron, a molecule and a planet all have magnetic moments. The magnetic moment may be considered to be a vector having a magnitude and direction.
(B) True. In Larmor frequency, these photons should precess around the direction of the applied magnetic field.
(C) True. Two single protons in hydrogen atoms in biological tissues gave an NMR signal that relates to its distribution and environment.
(D) True. NMR spectroscopy allows identification and quantification of metabolites in cells, tissues and organs.
(E) True. In NMR, the chemical shift is the resonant frequency of a nucleus relative to a standard in a magnetic field. Often the position and number of chemical shifts are diagnostic of the structure of a molecule. The NMR phenomenon is based on the fact that nuclei of atoms have magnetic properties that can be utilised to yield chemical information.

31. Regarding MRI:

(A) False. FLAIR stands for fluid-attenuated inversion recovery. FLAIR is an inversion recovery sequence that nulls the signal from CSF. FLAIR is useful to visualise more clearly periventricular lesions, cord lesions, multiple sclerosis plaque, haemorrhage and meningitis in brain and spine imaging.

(B) True. The 180° RF pulse is used to flip the NMV through 180° after dephasing occurs. After the application of 180° pulse, the magnetic moments are momentarily in phase (rephasing), and a maximum signal known as spin echo is induced in the coil.

(C) True. The transmitted bandwidth is the frequency range of RF pulse to match the frequency differences within the two points on the gradient. A steep slice select slope and/or narrow transmit bandwidth is used to obtain thin slices.

(D) False. Proton is imaged using MRI, not positron. MR-active nuclei are used in MRI because they contain positively charged protons and have magnetic moment that can align with external magnetic field.

(E) True. The longitudinal relaxation (T1 recovery) time is usually longer than the transverse relaxation (T2 decay) time, depending on the characteristics of tissue such as inherent energy of the tissue, space between molecules and molecular tumbling rate (Westbrook (2005)).

32. Regarding T1-weighted image in MRI:

(A) False. TR controls the amount of T1 weighting. A short TR is used to obtain T1W image because both fat and water have not fully recover their longitudinal magnetisation, and the differences in T1 (large contrast difference) can be demonstrated on the image.

(B) True. In gradient-echo pulse sequence, large flip angle (70–110°) and short TR are used to obtain T1W images. It will avoid a full recovery of longitudinal magnetisation of water and fat before the next RF is applied.

(C) True. Water and cerebrospinal fluid are hypointense (darker) in T1W image.

(D) False. Grey matter (T1 of 800 ms) is more hypointense (darker) compared to white matter (T1 of 650 ms). Tissue with shorter T1 produces stronger signal and appears as brighter pixel (hyperintense).

(E) True. Gadolinium (Gd) is a paramagnetic contrast agent that has positive magnetic susceptibilities. In the presence of Gd, it will reduce the T1 relaxation of nearby protons and increased the signal intensity.

The properties of T1-weighted image are as follows:

- T2W images are described by bright fat and dark water.
- Fat has short T1 and high signal and thus appears bright.
- Water has long T1 and low signal and thus appears dark.
- Short TE is used (~15 ms).
- Short TR is used (~300–800 ms).
- Tissues with short T1 will appear brighter (Westbrook (2002)).

33. Safety of MR imaging in patients with cardiovascular devices involves

(A) True. It is important to clarify safety issue and the safe performance of MR examination in patients with cardiovascular devices, as well as to ascertain caveats and contraindications regarding MR examination for such patients.
(B) True. With an increasing number of patients being treated with permanently or temporarily implanted cardiovascular devices, it is important to do a safe examination of patients with certain devices.
(C) True. To identify which patients with cardiovascular devices can safely undergo MR examination.
(D) True. This is intended to clarify issues regarding the safety of MR imaging in patients with cardiovascular devices.
(E) True. To avoid MR-related injuries.

34. Regarding medical ultrasound:

(A) False. There is a variation in the speed of sound in different tissue types in the human body. This is mainly related to the density and compressibility of the tissue. The velocity of ultrasound is slower in fat compared to muscle.
(B) True. Penetration is sacrificed for higher resolution which allows depiction of mucosal layers.
(C) True. Absorption coefficients of ultrasound in fat and water are 0.63 and 0.002, respectively.
(D) False. Piezoelectric crystal is used (lead zirconate titanate), and caesium iodide is an X-ray-sensitive phosphor used in image intensifier.
(E) True. The acoustic focus is where the beam width is narrowest which improves lateral resolution.

35. As an ultrasound pulse moves through tissue, it undergoes a change in

(A) True. As ultrasound pulse moves through tissue, the frequency is reduced.
(B) True. Velocity of ultrasound is reduced as it travels through tissue.
(C) True. Wavelength of ultrasound is reduced as it travels through tissue.
(D) True. Intensity of ultrasound is reduced as it travels through tissue.
(E) True. Velocity of ultrasound is reduced as it travels through tissue.

36. Determining blood flow velocity using Doppler function requires for the operator to adjust for:

(A) False. Transducer frequency adjustment does not influence the determination of blood flow velocity.
(B) False. Depth of vessel adjustment does not influence the determination of blood flow velocity.
(C) True. The angle between the ultrasound beams is needed to receive the reflected ultrasound wave.

(D) False. Size of transducer does not influence the determination of blood flow velocity.
(E) True. The direction of blood flow is needed to receive the reflected ultrasound wave.

37. Concerning safety in ultrasound imaging:

(A) True. Thermal index (TI) provides an onscreen indication of the relative potential for a tissue temperature rise. For obstetric examination, the recommended maximum scanning time is restricted to 30 min or less for TI of 1.5.
(B) False. The term thermal index for bone (TIB) is used for any foetal scan more than 10 weeks after LMP. Thermal index for cranial bone (TIC) is used when the ultrasound transducer is very close to bone, for example, during transcranial scanning of the neonatal skull.
(C) True. The raised tissue temperature due to probe self-heating is greater for endo-probes (e.g. vaginal, rectal or oesophageal probes) than for surface probes. This is because the adjacent tissue is at an initial temperature of 37 °C or higher in certain patient, rather than closer to room temperature as in the case of surface-applied probes. It is also more difficult for endo-probes to move heat to the surrounding area.
(D) True. The eye (of any age) is particularly vulnerable to thermal hazard since the lens and the aqueous and vitreous humours have no cooling blood supply.
(E) True. For neonatal cardiac imaging, the recommended scanning time is restricted to 15 min or less for TI of 2.5.

38. The key element of a fluorescent imaging system includes

(A) True. The laser supplied photon light to fluorophore molecules that will decay to emit fluorescent light photons.
(B) True. Lenses focus the light.
(C) True. Optical filters control the colour of light photons transmitted in the system.
(D) False. A light scintillator is not required in an optical system.
(E) True. Photomultiplier tube amplifies the weak signal in the system.

39. Regarding functional and molecular imaging (FMI):

(A) True. Molecular imaging is defined as the ability to visualise and quantitatively measure the function of biological and cellular processes in vivo.
(B) True. The function of attenuation map in PET/CT is for correction of attenuation.
(C) True. For FMI with ultrasound contrast imaging, the small gas-filled bubbles (microbubbles) are used. It is attached to antibodies, peptides

and other ligands and distributed to tissues via the vascular system. It provides contrast due to the echogenicity.

(D) False. Bismuth germanate (BGO) crystals are preferred for PET imaging over sodium iodide (NaI) because they are more sensitive to 511 keV photons.

(E) True. MRI application in molecular imaging is limited by requirement of contrast agents. Most of the contrast agents are larger in size and difficult to be delivered into the cells.

40. Concerning functional and molecular imaging (FMI):

(A) True. Cellular MRI is based on tracking of migration and distribution of cells labelled with an MR contrast agent.

(B) False. Cerebral glucose metabolism and cerebral blood flow are increased during seizures.

(C) True. In vivo optical imaging technique known as optical coherent tomography is used in clinical applications for imaging of atherosclerosis. It uses catheter devices with protease-activated fluorescent probes.

(D) True. The uptake of FDG is increased in certain types of cells due to the increased metabolism of glucose by the cells.

(E) False. Cervical carcinoma has high uptake of FDG in PET.

Examination Three: Answers

1. Overall detection efficiency of a detector in nuclear medicine department is affected by

(A) True. Quantum detection efficiency (QDE) is defined as the probability of detecting an incident photon.
(B) True. Intrinsic efficiency is the fraction of photons reaching the detector that are detected.
(C) True. Photopeak efficiency is the fraction of all detected photons that contributes only to the photopeak.
(D) True. Geometric design of the detector affects the fraction of emitted photons that reach the detector.
(E) True. Distance of the source from the detector affects the fraction of emitted photons that reach the detector.

2. Regarding scintillation detector in an imaging detector:

(A) True. Scintillators are materials that emit visible or ultraviolet light after the interaction of ionising radiation with the material.
(B) True. The two bands determine the size of the energy band (in eV) which is dependent on the type of the material.
(C) True. Dopants or impurities are added in the material to create the electron traps.
(D) False. Phosphorescence occurs with the electron trap, and fluorescence occurs without the electron trap.
(E) True. Organic scintillation detector such as anthracene, stilbene and *para*-terphenyl derivatives exists in a liquid form.

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3. Regarding dead time of a detector system:

(A) True. The period lost from an inactive detector is called the dead time of the system.
(B) False. Geiger-Muller counter systems have the longest dead time compared to other type of detectors. The dead time is in the range of 100–500 μs.
(C) True. In a paralysable system, an interaction that occurs during the dead time after a previous interaction extends the dead time, whereas in a non-paralysable system, it does not extend the dead time.
(D) False. Current mode averages the input and has no effect on dead time.
(E) True. If the second interaction occurs in this interval, its signal will be lost.

4. Gamma ray

(A) True. An example of metastable nuclide is ^{99m}Tc.
(B) True. The half-life of ^{60}Co is 5.27 years.
(C) False. The decay doesn't change the mass number.
(D) True. Gamma decay often precedes alpha decay.
(E) False. Gamma ray is produced from a radionuclide.

5. Interaction of electrons with the anode in an X-ray tube results in

(A) True. Most interaction produces heat.
(B) True. Interaction of electron with the target nucleus produces bremsstrahlung X-ray.
(C) False. Interaction with anode decreases the kinetic energy of the electron due to interaction of electrons with atoms in the anode.
(D) True. Interaction of electron with the orbital electron produces characteristic X-rays.
(E) True. The resulted X-ray photons generate a spectrum of polyenergetic X-rays.

6. Regarding characteristic X-ray produced in an X-ray tube:

(A) False. The maximum energy photon is a bremsstrahlung X-ray.
(B) False. It results in a discrete spectrum.
(C) True. The energy is discrete and is dependent on the electron orbits involved.
(D) False. It is produced from interaction of electrons with the electrons in the target atom.
(E) True. The energy has to be higher to overcome the binding energy.

7. Beam attenuation

(A) True. Beam attenuation is due to scatter and absorption.
(B) True. Beam attenuation is the basis of radiological imaging.
(C) True. Photoelectric interaction resulted in absorption of photon.

(D) True. Compton interaction resulted in absorption and scatter of photon.
(E) False. Coherent scatter passed through the material without absorption or scatter.

8. Correctly matched radiation measurement and its unit

(A) True. Absorbed dose is the energy imparted to the matter per unit mass of the material.
(B) False. Equivalent dose is measured in Sv.
(C) False. Dose limit is an effective dose or equivalent dose to an organ and is measured in Sv.
(D) True. Effective dose is the absorbed dose, adjusted to account for the effectiveness of the type of radiation and the sensitivity of the organ to radiation.
(E) False. Dose area product is the absorbed dose multiplied by the area irradiated and is measured in $Gy.cm^2$.

9. Regarding the tissue weighting factor:

(A) False. The gonads have a tissue weighting factor of 0.08. The highest tissue factor is 0.12 for the red bone marrow, colon, lung, stomach, breast and remaining tissues (adrenals, extrathoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate, small intestine, spleen, thymus, uterus/cervix).
(B) True. The stomach and colon have a tissue weighting factor of 0.12.
(C) False. The skin and the bone have a tissue weighting factor of 0.01.
(D) True. The factor takes into account the different sensitivities of various tissues.
(E) True. The factor is a relative measure of the risk of stochastic effects that might result from irradiation of that specific tissue. Study of the atomic bomb survivors of Hiroshima and Nagasaki has shown that different organs show a different risk of stochastic effect.

10. Increasing the kVp of the beam

(A) False. Increasing kVp will increase photon energy and therefore makes photons more penetrating.
(B) False. Increasing kVp will increase exposure latitude resulting in larger range of tissue displayed.
(C) True. A high kVp beam will generate more forward scatter which are more likely to reach the receptor.
(D) True. This is to compensate for the increase of scatter radiation.
(E) False. The beam will become more penetrating leading to less deposition of energy in the patient's skin for the same receptor.

11. The advantage of digital radiography includes

(A) False. Real-time dose measurement is not in the digital radiography system.
(B) True. Digital images are easy to transfer via network.

(C) True. Image storing and retrieving are easy and less time consuming in comparison to conventional method.
(D) True. Contrast of digital images is possible to be manipulated using software.
(E) False. High initial cost for acquisition of hardware and software.

12. Part of fluoroscopic imaging chain includes

(A) True. CCD is used to collect lights from output phosphor of fluoroscopic equipment.
(B) True. It is used to measure kerma during fluoroscopic procedure.
(C) True. Modern fluoroscopic unit uses flat panel image receptor instead of image intensifier.
(D) False. Fluoroscopy equipment does not use molybdenum filter but uses 0.9 mm Cu.
(E) True. Intensifying tube is used in fluoroscopy to intensify the signal significantly.

13. Regarding the image intensifier in fluoroscopy:

(A) False. Image intensifier requires vacuum condition to accelerate electrons from photocathode to output screen.
(B) True. Potential difference of 25 kV is used to accelerate electrons to output phosphor.
(C) True. Flat panel detectors offer increased sensitivity to X-rays and therefore have the potential to reduce patient radiation dose.
(D) True. Input screen diameter of image intensifier is bigger compared to output screen diameter to intensify image output.
(E) False. It is used to prevent radiation from reaching the tube.

14. Exposure to radiation worker is reduced by

(A) True. Intensity of radiation is inversely proportional to the distance squared.
(B) True. Intensity of radiation is inversely proportional to time.
(C) True. Shielding materials will attenuate radiation before it reaches the personnel.
(D) True. ALARP concept consists of the fundamental principles of risk management in handling radiation sources.
(E) False. It is just monitoring radiation dose, not reducing exposure.

15. Radiation protection action practised in the department of radiology by

(A) True. Personnel radiation protective equipment attenuates and absorbs more radiation.
(B) True. Less time spent with radiation reduces absorbed dose proportionally.

(C) False. There is no dose limit of medical exposure to patients.
(D) True. Occupational radiation dose needs to be monitored.
(E) True. Inverse square law is very effective in reducing dose.

16. Regarding radioactive decay:

(A) True. A metastable nuclide emits gamma ray to become stable.
(B) False. Beta minus decay emits a negatively charged electron.
(C) True. The annihilation process produces two photons.
(D) True. The parent nuclide is the unstable atom that will decay to become more stable known as daughter nuclide.
(E) True. The half-life is the length of time for half of the radionuclides to decay.

17. Concerning radiopharmaceuticals selection in planar radionuclide imaging:

(A) False. ^{99m}Tc produces monoenergetic gamma emission at 140 keV.
(B) True. ^{201}Tl emits Auger electrons and therefore leads to an increase in the radiation dose even for smaller injected dosages.
(C) False. The selection of radionuclides that have energy close to 140 keV results in better quality images for less radiation dose.
(D) True. The renal imaging agent ^{99m}Tc-MAG3 has higher uptake and more rapid clearance than ^{99m}Tc-DTPA which is also used for renal imaging. For the same injected dosage, the ^{99m}Tc-MAG3 would be the preferred radiopharmaceutical.
(E) True. Encouraging patients to drink liquids and void frequently will also help to reduce the radiation dose for radiopharmaceuticals cleared by the kidneys.

18. Regarding safety in planar radionuclide imaging:

(A) True. The primary hazard when working with technetium is inhalation of dust; such radioactive contamination in the lungs can pose a significant cancer risk.
(B) True. Aerosol is produced when a needle separates from a syringe during use or a plunger separates from a syringe barrel. Needle-locking syringes or syringe-needle units are recommended.
(C) True. Personal protective equipment is important when handling ^{99m}Tc.
(D) True. Current method for preparation requires a lengthy boiling water bath procedure, and the rapid boiling causes airborne ^{99m}Tc aerosol contamination.
(E) True. The liquid scintillation counter, used for counting wipe tests, is not portable but is the most versatile counting instrument because it has a high counting efficiency for a wide range of radionuclides.

19. According to the Ionising Radiations (Medical Exposure) Regulations 2000 (IRMER)

(A) True. The practitioner is a person who is entitled in accordance with the employer's procedures to take responsibility for an individual medical exposure.

(B) True. The person who is permitted to request for medical exposure is known as a referrer. The referrer can be a registered medical practitioner, dental practitioner or other health professional.

(C) False. There is different enforcing authority (appropriate authority) for different parts of the UK.

(D) True. Medical physics expert should be involved in consultation on optimisation, including patient dosimetry and quality assurance, and give advice on matters relating to radiation protection concerning medical exposure, as required, in all other radiological practices.

(E) True. The employer shall establish quality assurance programme for standard operating procedures.

20. According to Ionising Radiations Regulations (IRR) 1999, the information in local rules contains

(A) True.

(B) True.

(C) False. Local rules contain the dose investigation level for restriction of exposure to staff, not the dose limit.

(D) True.

(E) True.

According to Ionising Radiations Regulations (IRR) 1999, the local rules:

A. Must contain the following (essential content):
- The dose investigation level, according to Regulation 8(7)
- Summary of any contingency plan for any possible accidents, according to Regulation 12(2)
- Name(s) of appointed RPS, according to Regulation 17(4)
- Identification and detailed description of designated area (Regulation 18(1))
- Summary of working instructions, including the written arrangements on non-classified persons entering or working in controlled areas (Regulation 18(2))

B. May also contain the following (optional content):
- Management and supervision of work
- Testing and maintenance of engineering controls and design features, safety aspects and warning devices
- Monitoring of radiation and contamination
- Examination and testing of radiation monitoring equipment
- Personal dosimetry
- Arrangement of pregnant and breastfeeding staff

21. Regarding radiation dose to patients and members of the public:

(A) True. For the members of the public, the equivalent dose for the skin shall be limited to 50 mSv in any calendar year averaged over 1 cm^2 area.

(B) False. There is no dose limit applicable to the patient due to medical exposure; the control of patient dose is based on the principles of justification and optimisation.

(C) True. Patient doses from interventional radiology (fluoroscopy) are amongst the highest received dose from medical exposures.

(D) True. The dose limits do not apply for any exposure related to biomedical and medical research programmes.

(E) False. The effective dose limit to the member of the public is 1 mSv per annum.

22. Regarding tomographic image reconstruction:

(A) True.
CT: the distribution of linear attenuation coefficient in the slice being imaged.
SPECT: the distribution of the radiotracer administered to the patient in the slice being imaged.
Ultrasound diffraction tomography: the distribution of refractive index in the slice being imaged.

(B) False. It measures the number of X-ray photons transmitted through the patient along individual projection lines in CT.

(C) True. In nuclear medicine imaging, gamma rays are emitted and it will be detected by the detector.

(D) True. The quantity that can be reconstructed is the distribution of refractive index in the slice being imaged.

(E) True. In CT, dividing the measured photon counts by the incident photon counts and taking the negative logarithm yield samples of the radon transform of the linear attenuation map. The radon transform and its inverse provide the mathematical basis for reconstructing tomographic images from measured projection or scattering data.

23. The iterative image reconstruction

(A) True. A direct algorithm has to approximate the solution, which might cause visible reconstruction artefacts in the image. Iterative algorithms approach the correct solution using multiple iteration steps, which allow to obtain a better reconstruction at the cost of a higher computation time.

(B) True. It estimates the likely distribution of attenuation events that led to the measured data, based on statistical principle, often providing better noise profiles and resistance to the streak artefacts common with filtered backprojection (FBP).

(C) True. The iterative approach is based on expectation-maximisation (EM). In the first iteration, the uniform 'trial' object is taken into account, and its projections are computed (using even a very sophisticated physical model). The projections obtained are compared with those acquired by measurement. Using this comparison, the trial object is modified to produce projections which are closer to the measured data. Then the algorithm iteratively repeats. The trial object is modified in each iteration, and its projections converge to measured data.

(D) False. It provides better image quality. EM is an iterative method used for CT image reconstruction that maximises the likelihood function under Poisson noise assumption. Total variation regularisation is a technique used frequently in image restoration to preserve edges, given the assumption that most images are piecewise constant.

(E) True. The algorithm iteratively repeats the process to produce the projection data.

24. Regarding CT number:

(A) False. Tissue with low attenuation coefficient (e.g., lung) has negative CT number.

(B) False. CT number for grey matter (35–45 HU) slightly differs from white matter (20–30 HU).

(C) True. CT numbers are depending on the beam filtration because attenuation coefficients are affected by X-ray beam energy.

(D) True. CT number range for soft tissues is between +10 and +100 HU. The CT number range for blood is within +35 to +45 HU, which is within the range of soft tissues.

(E) False. Changing the windowing will not change the values of CT number.

25. Concerning CT image:

(A) True. CT number is a normalised value of the calculated X-ray absorption coefficient of a pixel (picture element) in a computed tomogram, expressed in Hounsfield units, where the CT number of air is −1000 HU and that of water is 0 HU. Low-density tissues are assigned darker (blacker) colours and it has lower CT numbers.

(B) True. Radiation dose to patient describes the intensity of the energy deposited in any small amount of tissue located anywhere in the body.

(C) True. Contrast in CT images can be controlled by the window level and window width settings used to display the image.

(D) True. A sinogram is the 2D array of data containing the projections.

(E) True. Noise appears as grain on the image and is caused by a low signal-to-noise ratio. The penetrating power of the X-ray beam is controlled by varying the tube voltage.

26. Regarding SPECT system:

(A) True. For whole-body imaging, the camera heads are arrayed opposite to each other (180°) to allow simultaneous acquisition of anterior and posterior images.
(B) True. The measure of the camera ability to separate events of different energies is known as energy resolution.
(C) False. Increasing the septal thickness permits the use of higher-energy gamma emitters.
(D) True. The pinhole collimator is preferable for imaging small organs that lie close to the skin (e.g. thyroid) as it allows magnification.
(E) False. The geometric sensitivity of a parallel-hole collimator does not depend on the distance between the source and collimator, but it depends on the size and length of the hole and septal thickness.

27. Regarding SPECT:

(A) False. High-resolution collimator provides improved image quality compared to high-sensitivity collimator or general-purpose collimator.
(B) True. For dedicated cardiac imaging, the dual heads are arrayed in the 90° position (perpendicular to each other).
(C) True. ^{99m}Tc-sestamibi and ^{99m}Tc-tetrofosmin are used in myocardial perfusion imaging.
(D) False. PET imaging has more uniform resolution and high sensitivity than SPECT imaging.
(E) False. The centre of rotation calibration test is necessary for SPECT quality control.

28. Regarding positron emission tomography (PET):

(A) False. Attenuation corrections are inherently more accurate in PET than in SPECT because the pair of annihilation photons defines a line through the patient such that the total path length through the patient is always transverse when a decay is treated.
(B) True. Detection system is a key component of PET to detect and record a higher percentage of the emitted events.
(C) True. Bismuth germanate crystals have high gamma counting efficiency.
(D) False. PET resolution is lower than CT.
(E) True. For example, ^{15}O and ^{18}F.

29. In nuclear magnetic resonance (NMR)

(A) True. The field strength of a magnet is at the resonance frequency for a proton. Therefore, for different nuclei with different gyromagnetic ratios, different frequencies must be applied in order to achieve resonance.
(B) False. Resolution of the imaging technique depends on the magnitude of magnetic field gradient.

(C) True. Superconducting magnets can produce greater magnetic fields. It allows the high currents to flow without losing any energy to electrical resistance.

(D) True. In conventional MRI, only 1/100,000 of the nuclear magnetic spin dipoles contributes to the signal as described by Boltzmann statistics. By use of hyperpolarisation, this fraction can be increased with a factor of 10^4–10^5. The sensitivity of MRI can be drastically improved by use of hyperpolarisation.

(E) True. Another example of NMR nuclei is ^{1}H.

30. Regarding NMR:

(A) True. A key feature of NMR is that the resonance frequency of a particular substance is directly proportional to the strength of the applied magnetic field.

(B) False. The intensities of NMR signal depend on the differences of the energy levels.

(C) True. As the magnetic field increases, the difference in energy between levels (the transition energy) increases.

(D) True. NMR relaxation times and chemical shifts measured spatial variations in the molecular level and chemical environments of the nuclei. ^{1}H NMR relaxation time images are proving useful for the detection of a wide spectrum of disorders as water protons in the tissue dominate in ^{1}H NMR spectrum.

(E) True. Chemical shift is the shift in the NMR frequency due to the electronic molecular orbital coupling to the external magnetic field. It is used to generate metabolic fingerprints from biological fluids to obtain information about disease states or toxic insults.

31. Regarding MRI:

(A) False. Saturation is a non-equilibrium state with no net magnetisation. Combining a larger flip and short TR results in saturation. There is no saturation when a long TR is used. Full saturation occurs when net magnetisation vector (NMV) is flipped to 180° and partial saturation when the NMV is flipped to 90°.

(B) True. T2* time is dephasing time due to magnetic field inhomogeneities. T2* decay is the decay of free induction decay (FID) when RF pulse is removed. T2* decay is faster than T2 decay and shorter than T1.

(C) False. Substances with negative magnetic susceptibility are known as diamagnetic, and positive magnetic susceptibility is known as paramagnetic.

(D) True. Fast STIR uses an inversion recovery pulse sequence that begins with 180° inverting pulse that inverts the NMV into full saturation.

STIR uses a tau (TI), time taken by fat to recover from full (180°) inversion to the transverse plane.

(E) True. After RF pulse is removed, MR signal is induced in the receiver coil and is known as free induction decay (FID). FID is the raw MR signal, before the computer processing for image reconstruction.

32. The proton density (PD)-weighted image in MRI

(A) True. T1 effects are reduced by selecting long TR, and T2 effects are reduced by selecting short TE. Image contrast principally depends on differences in the proton densities of the tissues.

(B) False. Tissue with high proton density appears bright (high signal) in PDWI.

(C) False. TR controls the T1 weighting, and long TR is used to maximise the PD weighting and reduces the effect of T1 contrast.

(D) True. PDW images are very useful for brain imaging (because of great contrast to differentiate the white and grey matter) and yield excellent anatomical details for orthopaedic imaging.

(E) True. Fat has higher PD than other soft tissues. The greater the PD, the larger is the signal and the brighter is the image pixel.

The properties of PD-weighted image are as follows:

- PD image shows better contrast for two tissues that have similar T1, but differ in PD (number of hydrogen protons).
- Short TE is used (~15 ms).
- Long TR is used (~1000–3000 ms) = 3T1.
- Longer TR, greater contrast between tissues of different PDs.
- Tissue with greater PD (CSF, fat) will appear brighter.
- PD-weighted image has less noise and high signal strength.

33. Concerning MRI safety:

(A) True. Physical movement within a static field gradient has been reported to induce transient sensations of vertigo and nausea and sometimes phosphenes and a metallic taste in the mouth. Occurrence of these effects is likely to be dependent on the gradient of the field and the movement of the subject.

(B) True. An accurate patient weight and height should be entered into the scanner, and manufacturer software will alert scanner operators to high specific energy absorption rate sequences.

(C) True. Burns will occur when patients are positioned in such a way to create a conductive loop pathway, for example, where thighs meet or when hands are clasped.

(D) True. To prevent the patient's skin from coming into contact with the bore of the magnet, insulation (foam pads) is used as necessary

(E) True. Adequate attention should be paid to the provision of the venting of the cryogens, including ensuring that the external vent pipes are of the correct dimensions and, in the case of a quench, able to withstand pressures above that recommended by the manufacturers as outlined in the Medicines and Healthcare Products Regulatory Agency (MHRA) guidelines.

34. Regarding ultrasonic waves:

(A) False. Sound needs medium to travel.
(B) False. Focusing transducer enhances lateral resolution at depth of interest.
(C) False. Velocity is affected by tissue density/compressibility.
(D) False. The velocity is highest in bone because it has high acoustic impedance value (5.3×10^6 kg $m^{-2}s^{-1}$).
(E) True. In constructive interference the amplitude is cumulative.

35. Changing from a 2 MHz to a 5 MHz ultrasound transducer produces

(A) True. Higher frequency produces shorter pulse and better resolution image for superficial structures.
(B) False. Higher frequency causes attenuation in the tissue to be increased which reduces penetration and the ability to image deeper site in the body.
(C) True. Changing to a higher frequency reduces the wavelength which in turn allows shorter ultrasound pulses.
(D) True. High frequency produces shorter ultrasound pulses.
(E) True. Higher frequency causes attenuation in the tissue to be increased.

36. Regarding acoustic impedance in ultrasound:

(A) True. Acoustic impedance, Z = sound velocity (v) × density (ρ).
(B) True. Reflection, $R = (Z_1 - Z_2)^2/(Z_1 + Z_2)^2$.
(C) True. It describes how much resistance an ultrasound beam encounters as it passes through a tissue.
(D) True. When ultrasound travels through the same material, reflection $R = 0$, but if it travels via different material interfaces, $R > 0$.
(E) False. The SI unit of acoustic impedance is k $gm^{-2}s^{-1}$.

37. Safety in ultrasound imaging

(A) True. The thermal index (TI) is an indicator that displays the relative potential of maximum tissue temperature rise after long exposure. TIB is one of the displayed TI values that assumes the bone is present at the depth where temporal intensity is greatest.
(B) True. According to the guidelines by UK Association of Sonographers (UKAS), for all ultrasound examinations, informed consent should be obtained before the exposure proceeding.
(C) True. For TI > 0.7, the overall exposure time (including pauses) of an embryo or foetus or of the neonatal central nervous system should be restricted.

(D) True. In obstetric imaging, TIS should be monitored at the early pregnancy period, up to 10 weeks after the last menstrual period (LMP), when ultrasound only insonates soft tissue. TIB is used thereafter (in any foetal scan of more than 10 weeks).
(E) True. Mechanical effect of ultrasound leads to cell lysis, cavitation injury and capillary haemorrhage.

38. Bioluminescent imaging

(A) False. Bioluminescent imaging utilises natural light emission from organisms which bioluminescence.
(B) True. One of the processes is light-generating luciferase enzymes.
(C) True. Regulation of gene expression is fundamental in cellular and molecular processes. So how does it relate to imaging?
(D) False. Bioluminescent imaging can provide real-time cell tracking.
(E) True. The light results from the oxidation of luciferin, an organic substrate, catalysed by an enzyme called luciferase.

39. Regarding functional and molecular imaging (FMI):

(A) True. The use of MRS for functional and molecular imaging is limited with its temporal resolution owing to long acquisition time.
(B) True. Uptake of contrast (dynamically) corresponds to vascularity of tissue, and it is used in tumour examination to noninvasively access tumour vascular characteristics.
(C) True. Attenuation correction is more accurate for SPECT than PET imaging because only one photon is attenuated in SPECT versus two for positron in PET imaging.
(D) True. The use of contrast-enhanced ultrasound imaging in characterisation of liver lesions is based on vascular enhancement patterns using non-targeted microbubbles.
(E) True. SPECT and PET are more sensitive than CT imaging for detecting the extent of cerebral infarction.

40. Concerning functional and molecular imaging (FMI):

(A) False. In PET, the uptake of FDG correlates with the tumour grade; the higher the tumour grade, the higher the FDG uptake.
(B) True. CT is more sensitive than FDG-PET in detecting renal cell carcinoma.
(C) True. DWI is used to differentiate malignant from benign lesions because these diseases have different ADC values. Depends on tissues.
(D) True. H-MRSI or MRS compares the chemical compositions of two different tissues (normal versus abnormal tissues) and produces hydrogen or proton spectrum.
(E) False. Lactation results in increased female breast uptake of ^{67}Ga.

Examination Four: Answers

1. Regarding image receptor in digital radiography:

(A) True. Image receptor in digital radiography such as flat panel image detector consists of matrix of pixel which is an array of pixels that form the digital image.
(B) False. Increasing the number of pixel or reducing the size of pixel will allow detection of finer details and increases the spatial resolution.
(C) True. Fill factor is the ratio of the pixel area that is radiation sensitive to the actual size of the pixel multiplied by 100.
(D) True. The electronic circuits transfer the charge from the pixels.
(E) True. Photoconductor produces electric charge following radiation interaction in the pixel.

2. Radiographic contrast:

(A) True. Subject contrast is the ratio of radiation intensities transmitted through different areas of the component being evaluated.
(B) True. Detector contrast refers to the intensity differences in the resulted image. It is dependent on the detector used such as film or flat panel imager.
(C) True. Different structures have different linear attenuation coefficients.
(D) False. Digital radiography has the capability to perform digital processing to enhance image contrast.
(E) True. Contrast media affects the attenuation coefficients of the structures.

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3. Regarding scintillation detectors in a dose calibrator:

(A) True. Sodium iodide activated with thallium is used for gamma ray energy measurements.
(B) True. Size of the energy band (in eV) depends on the type of the material.
(C) True. Scintillators are materials that emit visible or ultraviolet light after the interaction of ionising radiation with the material.
(D) True. Photomultiplier tubes are used to convert light to electrical signal and amplify the signal as well.
(E) True. Inorganic scintillator has high atomic number and high density. Examples are NaI, CsI, Gd_2O_2S, lithium glasses and ZnS.

4. Electrons in an atom

(A) False. Electrons have a mass of 9.12×10^{-31} kg, whereas protons have a mass of 1.67×10^{-27} kg.
(B) False. Electrons have a negative charge of -1.
(C) True. The number of electron is the same as the number of proton in a non-ionised atom.
(D) False. Mass number is the sum of proton and neutron.
(E) True. Electrons orbit the nucleus in electron orbits according to Bohr model.

5. Regarding X-rays produced in an X-ray tube:

(A) True. Characteristic X-rays are produced when filament electrons collide with an orbital electron. Each target material has a specific arrangement of the electrons at different energy levels. The collision resulted in the production of X-rays that is characteristic of the material.
(B) False. Bremsstrahlung X-ray is produced from filament electrons interacting with the target nucleus.
(C) False. An increase in the tube voltage does not lead to an increase in the X-ray energy.
(D) True. The filament electrons have an energy larger than the binding energy of the K-shell electrons in tungsten atoms which is 69.5 keV.
(E) False. Bremsstrahlung X-rays are the main component of X-rays produced from a tungsten target.

6. Regarding Compton interaction:

(A) True. Compton interaction involves the collision of X-ray with an outer shell electron.
(B) False. Probability of Compton interaction is dependent on the number of electrons in the absorbing material. The number of electrons per unit mass is the same for all materials irrespective of its atomic number.
(C) True. Probability of Compton interaction is inversely proportional to photon energy.
(D) True. The interaction produces scattered radiation.
(E) True. The interaction resulted in the electron orbit to be ejected from its orbit.

7. The heel effect is

(A) True. The heel effect is due to the higher attenuation of X-rays in the thicker side of the anode target.
(B) True. The anode angulation resulted in the photons emitted on the anode side of the field to have lower intensity as the photons need to penetrate larger target thickness and undergo more attenuation.
(C) True. The heel effect increases with smaller anode angle or steeper target as the thickness of the target material becomes larger and thus photons have to penetrate thicker target.
(D) True. The heel effect is more pronounced at lower kVp because the photons are less penetrating. The differences in the attenuation in the anode side are more noticeable.
(E) True. The technique can compensate the difference in patient thickness. Less penetrating X-rays can be positioned on the thinner side of the patient.

8. Regarding radiation units:

(A) True. Equivalent dose is the effective dose multiplied by the tissue weighting factor.
(B) True. Effective dose is the absorbed dose multiplied by the radiation weighting factor.
(C) True. Dose limit ensures each individual is not exposed to an excessive amount of ionising radiation.
(D) False. Dose area product is the absorbed dose divided by the unit area.
(E) True. For example, the tissue weighting factor is 0.04 for the bladder, liver, oesophagus and thyroid.

9. Regarding effects of ionising radiation on living tissue:

(A) True. Photoelectric interaction produces secondary electrons in the tissue that resulted in tissue damage through ionisation and excitation of atom.
(B) False. Cells with high mitotic rate are more affected because the cells are more radiosensitive.
(C) False. Gamma rays are indirectly ionising radiation and thus cause indirect damage.
(D) True. The damage in biological tissue is due to free radical production from interaction of electrons with water in the tissue.
(E) True. Children are more radiosensitive compared to adults.

10. Amount of transmission radiation detected by imaging device is decreased by

(A) True. Increasing the air gap distance reduces transmission radiation detected by receptors due to geometrical divergence.
(B) True. High-density collimator filters unnecessary scatter radiation detected from primary beam. Therefore, transmission radiation detected by imaging device is decreased.

(C) False. Thinner subject exposed to X-rays produced lesser scatter radiation compared to thicker subject. Thus, the amount of transmission radiation detected by imaging device is decreased.
(D) True. Anti-scatter grid filters scatter radiation before reaching the imaging device.
(E) True. As the kVp is reduced, the average photon energy is reduced, and most of the photons does not have sufficient energy to reach the imaging device.

11. Regarding intensifying screens in screen film radiography:

(A) False. The traditional phosphor used in intensifying screen is calcium tungstate.
(B) True. Rare earth screen has higher quantum detection efficiency (QDE) compared to calcium tungstate.
(C) True. Intensifying screen is able to convert one X-ray photon to multiple light photons as output.
(D) True. For an efficient signal detection, spectral emission of the screen should match the spectral sensitivity of the film.
(E) False. Unlike fluorescence, a phosphorescent material does not immediately re-emit the radiation it absorbs. Delay of image emission due to phosphorescence image would be recorded on the next film.

12. Part of fluoroscopic image intensifier includes

(A) True. Focusing electrodes are used to focus electrons from photocathode to output phosphor.
(B) True. Zinc cadmium sulphide was used as an output screen/output phosphor.
(C) True. A vacuum condition is needed for optimum acceleration of electrons to output phosphor.
(D) False. Rotating anode is a component of X-ray tube.
(E) False. Polyester base is a component of film and intensifying screen.

13. Adjustment of brightness in fluoroscopy is made by

(A) True. By controlling kVp, the average photon energy is modified; brightness in fluoroscopy can be controlled.
(B) True. mA influences number of photons produced therefore brightness in fluoroscopy.
(C) False. CCD is used as a video recorder in fluoroscopy, not controlling fluoroscopic image brightness.
(D) True. Adjusting sensitivity of TV system means adjusting automatic gain control on TV monitor.
(E) True. Automatic brightness control is the automatic adjustment of the exposure factors such as mA and kVp.

14. Practical methods in protecting the patients from radiation includes

(A) True. Tight collimation reduces unnecessary dose to patient.
(B) True. Selection of magnification reduces gain of image intensifier.
(C) True. When sensitive organs need to be protected, supplementary shield is used.
(D) False. Image intensifier should be as close as possible to reduce dose and improve image quality.
(E) True. Use of grids for extremity X-ray cases will require higher exposure factors. This procedure does not produce large scatter compared to thicker body part.

15. The risk of deterministic effect includes

(A) True. The sterility effect is a deterministic effect with threshold dose of 2–3 Gy.
(B) False. The leukaemia effect is a stochastic effect.
(C) True. The cataract effect is a deterministic effect with threshold dose of 5 Gy.
(D) True. Hair loss effect is a deterministic effect with threshold dose of 2–5 Gy.
(E) True. Skin erythema is a deterministic effect with threshold dose of 2–5 Gy.

16. In radioactive decay

(A) True. The energy released in a decay event is called the transition energy, sometimes designated as Q. Most of this energy is imparted to emitted particles and photons, with a small (usually insignificant) fraction being imparted to the recoiling nucleus.
(B) True. The amount of energy emitted will be equal to the amount of energy produced by fusion of hydrogen to helium over that lifetime. $E = mc^2$. Here m is the amount of matter that is converted into energy.
(C) True. Particles from one decay are used to transform to another atomic nucleus.
(D) True. The activity of a sample is the average number of disintegrations per second. Its unit is the becquerel (Bq).
(E) True. It is a probability of a nucleus to decay per second.

17. Concerning gamma camera:

(A) True. A scintillation camera detects radioactive energy that is emitted from the patient's body and converts it into an image.
(B) True. The detector efficiency is the percentage of X-rays from a source passing though the scintillator that interact and are counted in the final spectrum. Better detection efficiency is obtained with the use of thicker NaI(Tl) crystal.

(C) True. Only photons travelling along the desired path are allowed to pass through the detector.
(D) True. Pinhole collimator is used for magnification of small and thin structures.
(E) False. Septal materials with high atomic number and high density provide the best results.

18. Regarding rules for avoiding internal radiation dose:

(A) True. Absorbent pads are used to soak up the water-based liquid.
(B) True. This is to avoid any damage to the radioactive materials.
(C) True. This is to prevent the personnel from any accident during handling of radioactive materials.
(D) True. The ventilated fume hood protects the user by pulling air into and through the hood opening, and this inward airflow prevents vapours and gasses from entering the breathing zone of the fume hood user.
(E) True. Refrigerators used for storing food or beverages must be dedicated to food only and should be located outside of the laboratory.

19. According to the Ionising Radiations (Medical Exposure) Regulations 2000 (IRMER)

(A) False. Establishment of the DRLs is the duty of the employer, not the practitioner.
(B) True. A registered healthcare professional is entitled to act as a referrer as defined by the employer.
(C) True. The employer shall establish recommendations on referral criteria for medical exposures, including radiation doses to the referrer.
(D) False. Restrictions are applied to the referrer including other healthcare professionals on examination that may be requested. The requested examination shall follow the referral criteria recommended by the employer.
(E) True. A medical physics expert shall be involved in consultation on dose optimisation including patient dosimetry and quality assurance.

20. The content of local rules includes

(A) True. The local rules shall include a summary of contingency plans for any possible radiation accidents that covers the restriction of radiation exposure and the health and safety of persons who may be affected by such accident.
(B) True. The local rules shall adequately describe the identification and detail the description of designated, controlled and supervised areas including the identification of person who may remain in those areas.
(C) True. The local rules also describe the requirements for the use of personal dosimeters to monitor the dose to classified staff.

(D) False. Local rules only describe the safe methods of working with ionising radiation, not the dose limits.
(E) False. It includes the arrangements for pregnant and breastfeeding staff, not the pregnant patient.

21. Concerning the practical aspects of radiation protection for staff:

(A) True. A shielding with single thickness of solid brick of 120 mm thickness will provide protection equivalent to 1 mm of lead.
(B) True. Under-couch tube is recommended during fluoroscopy examination so as to reduce the dose from scattered radiation to the operator.
(C) False. A thicker lead apron (0.5 mm thickness rather than 0.25 or 0.35 mm) should be used for interventional radiology. The thickness of lead apron to be used depends on the local risk received from each procedure.
(D) False. The primary beam should be collimated only to the region being examined or should not be greater than or within the size of image receptor or no more than 10% larger than the FOV on the monitor.
(E) True. A glove of at least 0.25 mm should be worn by fluoroscopists to protect their hands in the primary beam when palpating patients.

22. Concerning tomographic reconstruction:

(A) True. Each ray that is acquired in CT is a transmission measurement through the patient along a line, where the detector measures transmitted X-ray intensity.
(B) True. The radon transform and its inverse provide the mathematical basis for reconstructing tomographic images from measured projection or scattering data.
(C) True. The filtered backprojection (FBP) algorithm is referred to as the convolution method using a one-dimensional integral equation for the reconstruction of a two-dimensional image.
(D) True. The backprojection describes the propagation of the measured projection data into the image domain.
(E) True. CT allows visualisation of internal structure without any overlapping tissue.

23. In CT windowing

(A) False. The CT image brightness is adjusted via the window width. It is the measure of the range of CT numbers that an image contains.
(B) False. The CT image contrast is adjusted via the window level. A window level is also referred to the window centre and is the midpoint of the range of the CT numbers displayed.
(C) True. A wide window displays all the CT numbers which will result in different attenuations between soft tissues to become obscured.

(D) True. When the window level is decreased, the range of the CT numbers displayed is small; thus, the CT image will be brighter.
(E) True. Wide window can visualise air and vessels clearly.

24. In computed tomography (CT) imaging

(A) False. CT number of fat (−60 to −120 HU) is lower than water (0 HU).
(B) False. CT is very effective in eliminating scatter via the use of thin collimators. This is the main contributing factor to their superior contrast resolution.
(C) True. Contrast can be adjusted by using windowing technique.
(D) True. High atomic number increases the X-ray attenuation value and subsequently increases the CT values.
(E) False. Air corresponds to a CT value of −1000 HU.

25. Concerning CT development:

(A) True. It used a single pencil beam.
(B) False. It used translate-rotate movement of tube detector with pencil beam.
(C) True. It used translate-rotate movements of tube detector with fan-shaped X-ray beam.
(D) False. Third-generation scanner utilised a rotating detector arc.
(E) True. It used multiple detectors (more than 2000) arranged in an outer ring which is fixed.

26. Regarding single-photon emission computed tomography (SPECT) system:

(A) True. It uses two or three detectors or heads and rotates around the patient's torso.
(B) False. Bismuth germanate oxide (BGO) is a PET detector element. NaI(Tl) is a SPECT detector element
(C) True. Line spread function is full width at half-maximum (FWHM) of the radiation profile from a point or line source of radiation projected by the collimator onto the detector.
(D) True. Four-quadrant bar phantom offers precise determination of camera intrinsic resolution, collimator spatial resolution, field size and linearity.
(E) True. It is referred to as lesion-to-background uptake or concentration ratio.

27. Concerning type of noise in SPECT:

(A) True. Statistical variations of the count rates give rise to random noise that increases with decreasing information density.
(B) True. Random noise (also referred to as statistical noise) is the result of statistical variations in the counts being detected.
(C) False. Structured noise is caused by imaging system artefacts.

(D) True. Structured noise is derived from non-uniformities in the scintillation camera and overlying structures in patient body.
(E) True. Motion of patients undergoing cardiac SPECT perfusion imaging causes artefacts in the acquired images which may lead to difficulty in interpretation.

28. Correctly match difference between positron emission tomography (PET) and single-photon emission computed tomography (SPECT) includes:

(A) True. PET: annihilation is the process that occurs when an electron collides with a positron to produce two photons. SPECT: it requires delivery of a gamma-emitting radioisotope (a radionuclide) into the patient, normally through injection into the bloodstream.
(B) False. PET uses ^{18}F as a tracer, while SPECT uses ^{99m}Tc as a tracer.
(C) False. Half-life of ^{18}F is 110 min, while half-life of ^{99m}Tc is 6 h.
(D) True. In PET, the annihilation photon energy is 511 keV, while the photon energy of radionuclide in SPECT is 140 keV.
(E) True. PET detects two gamma rays for each decay to trace the line that finds where the emission came from; thus, the sensitivity in PET is higher than in SPECT.

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) True. The spin-up nuclei have low energy and align their magnetic moments parallel to the external fields.
(B) False. The precession frequency (Larmor frequency) of the nuclei is directly proportional to magnetic field strength
(C) True. Nuclei gain energy from applied RF pulse becomes high-energy nuclei. The high-energy nuclei possess enough energy to oppose the magnetic field and align at antiparallel direction to the external field.
(D) True. For resonance to occur, an RF pulse of energy at exactly the precessional frequency of the nuclei known as Larmor frequency must be applied.
(E) True. The factors affecting the align direction of the nuclei are the strength of external magnetic field and thermal energy level of the nuclei. In low thermal energy, the nuclei are aligned in antiparallel direction or vice versa.

30. The nuclei that routinely used in NMR includes

(A) True
(B) True
(C) True
(D) True
(E) True

The NMR-active nuclei contain positively charged protons and have the tendency to align their direction to an applied magnetic field. Examples are ^{1}H, ^{13}C, ^{15}N, ^{17}O, ^{19}F, ^{23}Na and ^{31}P.

31. Regarding contrast media used in MRI:

(A) True. Deoxyhaemoglobin and metoxyhaemoglobin act as paramagnetic contrast agents in MR, while oxyhaemoglobin is a diamagnetic agent. This is the basic of BOLD technique used in fMRI.
(B) True. Gadolinium is a paramagnetic contrast media and shortens both T1 and T2 relaxation times.
(C) False. Positive contrast agents appear bright, while negative contrast agents appear dark on MRI images. Positive contrast agents cause reduction in the T1 relaxation time (increased signal intensity on T1-weighted images). They will appear bright in T1-weighted sequence.
(D) True. Air has low magnetic susceptibility and do not produce any MR signal. Thus, air appears dark on MRI images. Negative contrast agents make the intraluminal contents appear dark. For example, in bowel examination, negative contrast agent, such as Gastromark, is mixed with blueberry juice and air, to delineate the large bowel.
(E) True. Blood pool contrast agents are an example of superparamagnetic contrast agents. It is an intravascular contrast agent that will remain in the blood for a prolonged time compared with conventional contrast agents, which diffuse quickly into the interstitial space.

32. Regarding MR image quality:

(A) True. Random thermal movement of hydrogen atoms in the tissues induces signal with wide ranges of frequency, known as white noise.
(B) True. A spin echo (SE) signal is produced by pairs of RF pulses, whereas the gradient echo (GE) signal is produced by a single RF pulse. The applied RF pulse in GE sequence has reduced strength and smaller tip angle (<90°) as compared to SE sequence (180° rephasing pulse). Thus, SE produced reduced signal strength.
(C) True. Noise is higher in the areas of low PD and low signal.
(D) False. The SNR reduces when the number of excitation (N_{ex}) is reduced.
(E) True. Spatial resolution depends on pixel size, matrix and FOV. Spatial resolution is increased when larger matrix is used and reduced FOV and pixel size.

33. Regarding safety in MR scan room:

(A) True. The exclusion zone is defined at the boundary of five gauss line, the point at which magnetic field begins to affect electromagnetic devices and should clearly marked on the floor or walls.
(B) True. Area outside the controlled area where the field is below 0.51 mT is the free access zone for the public.
(C) True. Passive shielding is accomplished by surrounding the magnet coils or lining the magnet room with steel plates. The function is to block the outside RF signals into MR scan room and reduce the area covered by fringe fields.

(D) True. An area that has potential to cause projectile injuries is defined as MR security zone.
(E) True. Access to MR scan room must be restricted and should only have one access point and available by passing through zone III (control room).

34. Regarding ultrasound waves:

(A) True. Ultrasound refers to high-frequency sound waves (above 20 kHz), and it is inaudible to humans.
(B) True. It is a longitudinal wave and not electromagnetic wave.
(C) True. Reflection of ultrasound waves at medium interfaces is due to acoustic differences of acoustic impedance between two materials.
(D) True. As one of a longitudinal wave, ultrasound requires a medium to propagate.
(E) True. Piezoelectric material is used to convert electrical charge to ultrasound wave.

35. Regarding piezoelectric crystal:

(A) True. This specific temperature is known as Curie temperature.
(B) True. AC voltage changes its polarity and causes piezoelectric crystal expanding and contracting alternately.
(C) True. In a medium with lesser acoustic impedance, the velocity is slower relatively.
(D) True. Higher-ultrasound frequency energy is a result from a thinner piezoelectric crystal.
(E) True. Ultrasound wave requires a material to travel, and it is a longitudinal wave not a transversal wave.

36. Amplitude mode echo ranging in ultrasound

(A) True. A-mode that provides data on the length of the eye, which is an important information in sight disorders diagnosis.
(B) False. It is the simplest form of ultrasound imaging not a most complex form of ultrasound imaging.
(C) True. It shows only the position of tissue interface.
(D) True. In A-mode ultrasound, single transducer scans a line through the breast with the echoes plotted on the screen as a function of depth.
(E) True. Time gain compensation increases amplitude of sound pulses and diminishes as it travels into the body.

37. The risk of ultrasound imaging includes

(A) True. Mechanical damage of cell membranes is due to violent acceleration of particle.
(B) True. Acoustic streaming of cellular contents in the direction of the beam, affecting cell membrane permeability.

(C) True. Ultrasound imaging causing microbubbles in a liquid to expand.
(D) True. Local heating due to frictional, viscous and molecular relaxation process.
(E) False. It is caused by ionising radiation.

38. Fluorescent imaging system consists of

(A) True. The technique is based on light scattering.
(B) True. The technique uses laser pulses to increase tissue temperature that causes emission of photoacoustic waves.
(C) True. The technique uses light emitted inside the tissue.
(D) False. The technique uses positron emitters, not an optical technique.
(E) True. The technique detects relative changes of light interaction with tissue.

39. Concerning functional and molecular imaging (FMI) using MRI:

(A) True. Diffusion-weighted imaging (DWI) is based on random thermal movement of molecules (water protons) in extracellular space. The movement and displacement of molecules are characterised by apparent diffusion coefficient (ADC).
(B) True. MRS can only be feasible for active nuclei with high gyromagnetic ratio, and they must be abundant in tissues.
(C) True. Oxyhaemoglobin is diamagnetic and deoxyhaemoglobin is paramagnetic. Deoxyhaemoglobin creates an inhomogeneous magnetic field.
(D) True. Functional MRI (fMRI) acquires two sets of brain images during stimulus (active) and rest phase. The two images are subtracted to demonstrate the functional brain activity showing the increased blood flow to the activated cortex.
(E) True. MRS provides a spectrum of resonant frequencies of tissues based on their molecular and chemical compositions.

40. Regarding the principles of FMI:

(A) True. In DWI, image weighting is depending on tissue's ADC. Hypercellular tissues have restricted diffusion and ADC of the tissue is low.
(B) True. ^{18}F-FDG is the marker for the tissue uptake of glucose and is closely correlated with certain types of tissue metabolism. It is widely used clinically for tumour imaging due to increased glucose metabolism in most tumours.
(C) True. Tissues with high cellularity (higher cell density) display higher signal intensity in DW MRI. Solid tumour usually has higher cellularity compared to normal tissue.

(D) True. Microbubbles are used as targeted ultrasound contrast agents (tUCA) for molecular imaging. The size of microbubbles is usually 2–5 μm to allow them to pass through the smallest capillaries, without leakage in the extravascular space.

(E) True. Biomarker imaging is the detection of molecular parameters that relate with disease. Biomarker is defined as a characteristic that can be objectively measured as the indicator for normal biological processes, pathogenic processes or pharmacologic responses to a therapeutic intervention.

Examination Five: Answers

1. Regarding display and post-processing of digital radiographic images:

(A) True. The crystal in each pixel varies in their degree of polarisation when a voltage is placed across them. Manipulation of the level of light transmission to that pixel resulted in the image.
(B) True. Calibration is performed to ensure that images presented to an observer have equal perceived contrast appearance on all displays.
(C) True. A typical digital matrix size of 3000 × 3000 and 2 bytes of data per pixel is equal to 18 megabytes (Mb) of data. The size is calculated by multiplying the matrix size with the number of bytes.
(D) False. Windowing improves contrast and brightness within the image.
(E) True. Averaging a few images reduces the electronic noise.

2. The technique used to minimise motion unsharpness includes

(A) True. Immobilisation ensures limited motion during imaging.
(B) True. Reduction in exposure time reduces motion in the image.
(C) True. The amount of object movement will translate to smaller distance when the object-to-film distance becomes smaller.
(D) True. Reduction in imaging time reduces motion in the image.
(E) True. For example, using careful instructions to the patient to hold the breath during chest imaging.

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3. Regarding a multichannel analyser (MCA):

(A) False. An MCA system permits an energy spectrum to be automatically acquired much more quickly and easily than does a SCA system.
(B) True. ADC converts the analogue to digital signal.
(C) True. The range of channel numbers are represented by the memory of the MCA that typically ranges from 256 to 8192 channels, each of which can store a single integer.
(D) True. Most MCAs are interfaced to a computer that store, process and display the resultant spectra.
(E) True. A calibration curve is used to convert the channels of the multichannel analyser into actual energies.

4. Regarding electromagnetic radiation:

(A) True. Gamma rays are a form of electromagnetic radiation. Gamma originates from the nucleus of a radionuclide.
(B) True. The electromagnetic radiation consists of electromagnetic wave of electric and magnetic field that oscillates perpendicular to each other.
(C) False. The wavelength is inversely proportional to frequency.
(D) False. The frequency is proportional to photon energy.
(E) False. Electromagnetic radiation travels at the velocity of light in a vacuum.

5. Regarding X-ray tube:

(A) False. Filament cathode is heated to produce electrons.
(B) True. The potential difference of tube voltage provides kinetic energy to the electrons.
(C) True. Tube current is increased by increasing the filament voltage that heats the filament to emit electrons.
(D) True. The collision of electrons with tungsten results in 1% production of X-ray.
(E) False. Almost 99% of the energy is converted to heat.

6. Regarding photoelectric effect:

(A) True. The X-ray collides with a K-shell electron and ejects the electron.
(B) True. The resultant vacancy in the K-shell can be filled by an electron from another shell, and a K-fluorescent X-ray is generated from the transition.
(C) False. The X-ray is completely absorbed, resulting in no scattering of photon.
(D) True. The energy of X-ray has to be greater than the binding energy of the electron for photoelectric interaction to occur.
(E) True. The probability of photoelectric interaction increases with atomic number.

7. Concerning X-ray beam filtration:

(A) True. Some filtration will occur at the window.
(B) True. The minimum filtration is usually 2.5 mm for X-ray tube operating above 70 kVp.
(C) True. The lower-energy X-rays are filtered because these X-rays are mainly absorbed by the patient and contribute little to image.
(D) True. High-energy X-rays are filtered to improve contrast.
(E) True. Mammography uses molybdenum target and filter.

8. Regarding the deterministic effects of radiation:

(A) True. The effects only occur when the threshold dose exposure has been exceeded.
(B) True. The threshold is 3–5 Gy.
(C) True. The loss of function is due to killing of sufficient cells that prevented the cells from reproducing or functioning.
(D) False. The effect has no repair mechanism.
(E) True. The threshold dose is 2.5–6 Gy.

9. Regarding radiation dose:

(A) False. Kerma does not take into account the type of material being irradiated. Kerma is the kinetic energy of the secondary electrons released per unit mass of the irradiated material.
(B) False. The absorbed dose is measured in gray or Gy.
(C) False. LET is the average amount of energy, dE, deposited in tissue per unit path length (dl) it travels (dE/dl).
(D) False. Alpha particle has a higher LET because it has higher mass than electron.
(E) True. High-LET particles impart more energy per unit distance travelled, resulting in more non-repairable damage.

10. Regarding radiographic grid:

(A) False. It is constructed using plumbum strips.
(B) True. The larger the grid ratio, the more efficient the grid absorbing the scattered radiation, thus the greater the contrast of the image.
(C) True. Larger grid ratio allows only straight radiation to pass through.
(D) False. Less scatter produced in extremities imaging.
(E) False. Use of grids in air gap technique will filter more radiation, higher dose to patient.

11. Regarding characteristic curve in film-screen radiography:

(A) False. It consists of three regions (toe, region of correct exposure and shoulder).
(B) False. It is a graph of optical density as a function of exposure on a logarithmic scale.
(C) True. At higher optical density region (shoulder), the curve has shallow slope.
(D) True. This is known as latitude.
(E) True. Base plus fog value is an optical density due to polyester base of film and fog from storing condition.

12. Regarding gain in image intensifier of fluoroscopy:

(A) True. Increment of kinetic energy of electrons via acceleration contributes to the flux gain. Flux gain is an intensification of signals at output phosphor from an input phosphor of image intensifier.
(B) True. It is a gain of brightness images due to reducing image size between input phosphor and output phosphor.
(C) False. Conversion factor is used to describe the performance of image intensifier.
(D) True. The increment of brightness is a contribution from minification gain and flux gain.
(E) False. It has no unit because it is a ratio between input phosphor and output phosphor.

13. Regarding digital subtraction angiography (DSA):

(A) True. Iodine-based liquid is injected intravenously during DSA procedure.
(B) True. Movement during DSA procedure will cause motion artefact in resultant images.
(C) True. Pixel shifting realign two images affected by misregistration.
(D) False. It is taken before the patient is administered with contrast media.
(E) True. The third frame is a resultant image (the subtracted DSA image).

14. Regarding deterministic effects:

(A) True. Non-stochastic effects have a threshold in which the effect does not occur if it is not exceeded.
(B) True. Deterministic effect is an effect where the severity of effect increases with increased dose.
(C) False. The risk of the stochastic effects increases with dose.
(D) False. The deterministic effects occur immediately to the affected personal. If the effect was observed in their descendants, it is classified as stochastic effect.
(E) True. Unlike damage to the eye, most deterministic effects have repair mechanism if it does not exceed the threshold value.

15. Basic principles of radiation protection proposed by ICRP includes:

(A) True. Dose limit applies to those who are employed to work with radiation and to members of the public who are liable to be exposed to radiation as a result of work activity.
(B) False. Effective dose is not a basic principle of radiation protection proposed by ICRP.
(C) True. The principle of optimisation is that in using ionising radiation, the dose should be as low as reasonably achievable, economic and social factors being taken into account.
(D) False. It is not a basic principle of radiation protection but a guideline of deterministic effects will occur.
(E) True. Justification of medical exposures is principally concerned with the exposure of the patient.

16. Radionuclides in metastable state:

(A) True. Metastable radionuclides emit gamma ray to become stable.
(B) True. An example is ^{99m}Tc radionuclide generator.
(C) True. The parent nuclide undergoes isomeric transition by emitting energy and dropping from the metastable state to the ground state.
(D) True. The parent and daughter nuclides have the same atomic number and mass number.
(E) False. Gamma-emitting radionuclides are useful for gamma imaging.

17. Regarding collimator design parameters in planar radionuclide imaging:

(A) True. Collimator consists of a large number of small holes drilled in a lead plate. It only allows gamma rays entering along the direction of the holes to get through to cause scintillations in the crystal. The role of the collimator is essential because it provides the photomultiplier tubes (PMTs) with the ability to identify the location of each event and it stops scattered X-rays which spoil the contrast of the images.
(B) True. Obliquely incident gamma rays are absorbed by the septa.
(C) False. The collimator imposes a strong correlation between the position in the image and the point of origin of the photon within the patient.
(D) True. A poorly constructed or damaged collimator will affect primarily the sensitivity of the gamma camera. The sensitivity variations arise from the fact that a defective collimator will attenuate gamma rays in a non-uniform manner.
(E) True. The intrinsic resolution measures the accuracy of the position detection within the imaging plane of the camera.

18. Regarding patient dose in planar radionuclide imaging:

(A) True. ^{201}Tl emits Auger electrons and therefore lead to an increase in the radiation dose even for smaller injected dosages.
(B) True. As the energy of the photons increases, the linear attenuation coefficient and detection efficiency decreases. An example would be the use of ^{123}I (160 keV) rather than ^{131}I (364 keV) for the postsurgical evaluation of patients with thyroid cancer.
(C) True. It helps to reduce the radiation dose for radiopharmaceuticals cleared by the kidneys.
(D) True. The greater the dosage injected, the higher the radiation dose to the patient.
(E) True. Collimators with better resolution typically will have smaller holes and because of this will have lower sensitivity.

19. Regarding the controlled area:

(A) False. The controlled area for mobile X-ray is designated within 2 m of the X-ray tube and patient.
(B) True. The controlled area is an area in which any person working in this area is likely to receive an effective dose greater than 6 mSv per year or an equivalent dose greater than 3/10 of any relevant dose limit.
(C) True. The entry into controlled areas is restricted only to specified persons (classified workers) and circumstances.
(D) True. The dose rate from external radiation could exceed 7.5 $\mu Sv h^{-1}$ averaged over the working day (over 8 h work period).
(E) True. There is a requirement for employers to set out appropriate local rules for controlled or supervised areas.

20. According to the Ionising Radiations Regulations 1999 (IRR 1999)

(A) False. Assessment of the potential risks before the installation of new X-ray equipment is the duty of a radiation protection advisor, not radiation protection supervisor duty.
(B) True. Employer is required to set a dose constraint for comforters and carers, which can be as high as 5 mSv. However, the employer should explain to the person the risks involved and provide the guidance on precautions to ensure that the dose constraint is not exceeded.
(C) True. The employer is required to designate any area as a controlled area and ensure it has sufficient shielding to reduce radiation exposure to staff and public.
(D) True. An individual designated as a classified worker must be aged 18 years old or over and must be certified as medically fit to work.
(E) False. The employer has to ensure that personal protective equipment is properly used.

21. The employer has to notify the Health and Safety Executive (HSE) if the following incident occurs

(A) True. The employer is required to notify HSE if there is a major contamination due to radioactive spill.
(B) False. Notification is required only if the ^{99m}Tc source loss involved more than 100 MBq. The notification on the loss of radiation source is depending on the specified activities of that radioactive material.
(C) False. The employer is not required to notify the HSE for the loss of the dose record of the workers.
(D) True. The employer should notify HSE if it is confirmed overexposures to patient due to equipment malfunction or defect. However, overexposures due to human error should not be reported to HSE but rather to another appropriate authority.
(E) True. Employer is required to make an immediate investigation if overexposure to persons (staff, comforters or carers and members of the public) has been suspected. The employer should only notify the HSE if it is confirmed overexposure. The investigative reports should be made available to the local radiation safety committee and be kept for at least 2 years.

22. Regarding CT analytical reconstruction methods:

(A) True. It uses a 1D filter on the projection data before backprojecting (2D or 3D) the data onto the image space.
(B) True. The reconstruction kernel affects the image quality.
(C) False. A smoother kernel generates images with lower noise but with reduced spatial resolution. Smooth kernels are used in brain exams to reduce image noise and enhance low-contrast detectability.
(D) False. A sharper kernel generates images with higher spatial resolution but increases the image noise. Sharp kernels are used in exams to assess bony structures due to the clinical requirement of better spatial resolution.
(E) True. The selection of reconstruction kernel should be based on specific clinical applications.

23. Iterative reconstruction (IR) techniques

(A) True. Through an iterative process, the noisy data are penalised, and edges are preserved. This process ensures that the attenuation gradients of underlying structures are retained, thus preserving spatial resolution while allowing a substantial noise reduction.
(B) False. IR substantially reduces image quantum noise with no impact on spatial or contrast resolution. The substantial noise reduction can be taken as either improved image quality or as a reduction of patient radiation dose, typically in the 25–40% range compared to FBP.

(C) True. IR prevents photon starvation artefacts (streaks, bias) before image creation and maintaining image quality while avoiding the artificial appearance of images

(D) True. With the use of IR, image quality was both subjectively and objectively measured based on various indicators, such as image sharpness, noise, artefacts, visibility of small structures and overall diagnostic confidence.

(E) True. IR improves signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR). Thus, it increases the low-contrast resolution.

24. Regarding computed tomography (CT) filter:

(A) True. Copper absorbs the low-energy X-rays, which are mostly scatter radiation, and allows the high-energy X-rays to pass through.

(B) True. The filtration attenuates X-rays of all energies emitted from the tube. This shifts the spectrum to the high-energy side.

(C) True. Most of the body parts images with CT scanners are circular in shape; there is a higher X-ray fluence towards the periphery compared to the centre. A bow-tie filter is used which attenuates more of the beam towards the periphery and less in the centre, which creates a more uniform signal level at the detector.

(D) False. The material should be low atomic number to keep the spectral and beam hardening differences between centre and periphery of the fan beam as small as possible.

(E) True. CT filter is used to modulate an incoming X-ray beam as a function of the angle of the X-ray with respect to a patient to balance the photon flux on a detector array. Thus, the patient dose is reduced with the use of filter.

25. CT effective dose

(A) False. It is expressed in the unit of mSv.

(B) False. It uses a mathematical model for a standard body in its calculation and is hence not an appropriate risk indicator for any individual.

(C) True. Tissue-weighting factors represent the relative radiation sensitivity of each type of body tissue as determined from population averages over age and sex and are derived primarily from the atomic bomb survivors cohort.

(D) True. It reflects the relative risk from exposure to ionising radiation. It also reflects the risk of detrimental biologic effects from a nonuniform, partial-body exposure in terms of a whole-body exposure.

(E) True. Stochastic risk is probability of cancer induction and genetic effects.

26. Regarding SPECT:

(A) True. The ^{99}Mo is produced in a nuclear reactor and then shipped in a generator.
(B) True. SPECT detector rotates around the patient during emission imaging.
(C) False. Isotopes typically have longer half-lives (hours-days).
(D) True. Collimator only detects photons in a straight line parallel with the collimator.
(E) True. In SPECT, a collimator is placed in front of a NaI(Tl) scintillation crystal associated with a set of photomultipliers. With the presence of collimator, it cannot provide better detection efficiency and results in poor image quality.

27. Regarding image reconstruction in SPECT:

(A) True. It is referred to as a sinogram because the Radon transform of an off-centre point source is a sinusoid.
(B) True. Sinogram consists of rows and columns representing angular and radial samplings, respectively.
(C) False. Simple backprojection results in low image quality. Filtered back-projection is used to reduce the image noise.
(D) True. In 2D acquisition, each row of projections represents the sum of all counts along a straight line through the depth of the object being imaged.
(E) True. Backprojection technique redistributes the number of counts at each particular point back along a line from which they were originally detected. This process is repeated for all pixels and all angles.

28. The property of a scintillator in a PET includes:

(A) True. PET is based on the detection of two 511 keV photons.
(B) True. Short decay time is desirable to process each pulse individually at high counting rates and to reduce the number of random coincidence events.
(C) False. Long attenuation length provides minimum efficiency.
(D) True. Intrinsic energy resolution due to inhomogeneities in the crystal growth process as well as non-uniform light output for interactions within it.
(E) True. It helps to achieve good spatial resolution with a high ratio of number of resolution elements, or crystals, to a number of photodetectors and attain good energy resolution.

29. Regarding resonance in nuclear magnetic resonance (NMR):

(A) False. Resonance occurs when nuclei absorb the energy from the RF pulse, not from the external magnetic field.
(B) True. During resonance, protons are in the same direction on the precessional path around main magnetic field; B_0 and magnetic moments are in phase (coherent).
(C) True. Resonance only happened if the applied RF pulse has similar frequency with the Larmor (precessional) frequency of hydrogen nuclei. If the applied RF has different frequency to that of the Larmor frequency, resonance does not occur.
(D) False. Spin-down nuclei have higher energy than spin-up nuclei and enough energy to oppose the main field.
(E) False. The nuclei do not move; only NMV move from longitudinal plane to transverse plane.

A30. Factors that reduce the sensitivity of NMR signals

(A) True. Sensitivity is the ability to detect the NMR signals and expressed as signal-to-noise ratio. Increase of the temperature will increase the thermal noise and thus reduce the sensitivity of NMR signals.
(B) True. A small number of NMR-active nuclei will reduce the sensitivity of NMR signals.
(C) True. In the presence of magnetic susceptible nuclides, they will cause magnetic field distortions and reduce the sensitivity of NMR signals.
(D) False. Increase of magnetic field strength will increase the sensitivity of NMR.
(E) False. Increase of the density of the spin will increase the sensitivity of NMR.

31. Regarding proton density (PD)-weighted images in MRI:

(A) True. Contrast depends predominantly on the differences in proton density (number of hydrogen protons per unit volume in tissue).
(B) True. The bone has very long T1 and very short T2 and consists a few number of hydrogen protons. Thus, it appears dark in PD-weighted images.
(C) True. A long TR (~1000–3000 ms = 3 T1) is used to obtain PDW images. Long TR allows both water and fat to fully recover their longitudinal magnetization and thus diminishes the effects of T1 weighting.
(D) False. Grey matter has slightly higher PD as compared to white matter; thus it appears brighter than the white matter (~89% in grey matter compared to white matter ~80%).
(E) False. PD weighting produces greater signal strength and less noise compared to T1W images.

32. Regarding artefacts in MRI:

(A) True. The truncation artefacts appear as low-intensity band at interfaces of high- and low-contrast areas.
(B) True. Chemical shift artefact is caused by the differences in precessional frequency between fat and water and occurs along the frequency-encoding axis.
(C) False. The ghost (effect of motion/moving anatomy) is usually apparent only in the phase-encoding direction because phase encoding takes place so slowly but the frequency encoding so quickly.
(D) True. Aliasing or wrap artefact appears when anatomy outside the FOV is mapped inside the FOV. It can be reduced by using a surface coil that matches the FOV or by enlarging the FOV.
(E) True. Zipper artefact is caused by inference in MR signal due to outside RF of certain frequency that is caused by leakage in RF shielding of the room.

33. Regarding bioeffects from MRI:

(A) True. Changes in magnetic field causes induced current known as eddy current, affecting the surrounding of conducting materials. The nerves, blood vessels and muscles act as conductors in the body.
(B) False. The absorption of RF energy that caused increase in body temperature is expressed as specific absorption rate (SAR). SAR is the RF energy deposited per mass of tissue, expressed in unit of watt per kilogram (W/kg).
(C) True. Heating of tissue is largely frequency dependent. As frequency of transmitted RF is increased, absorbed energy is also increased.
(D) True. Time-varying magnetic fields (TVMF) can induce eddy currents in conductive tissues and causing stimulation such as peripheral nerve stimulation.
(E) True. Absorption of RF energy can cause excessive heating and induce burn hazards on the patient's skin.

34. Parameter describing the sound waves includes

(A) True. The amplitude of ultrasound is reduced with interface distance it interacts.
(B) True. In sound wave, compression of matter moved forward by a distance is called wavelength.
(C) True. The number of successive compression and expansion of piezoelectric crystal, per unit of time, is known as frequency.
(D) True. Period is defined as the interval between successive crest in a sine wave curve of ultrasound.
(E) False. Density is an acoustic impedance variable.

35. When ultrasound travels through material

(A) True. Frictional forces of materials are influenced by its acoustic impedance.
(B) False. It is attenuated exponentially with depth.
(C) True. Energy deposition depends on acoustic impedance of matter it passes through.
(D) True. Viscous forces of material are influenced by its acoustic impedance.
(E) True. Attenuation of ultrasound waves in a material produces heat.

36. Contrast agent used in ultrasound imaging includes

(A) True. It is used in immune-targeted procedure.
(B) False. It is MRI contrast agent.
(C) True. This contrast media is used to improve imaging of metastasis.
(D) True. It is used for vascular application, peripheral vascular disease and tumour vasculature.
(E) True. It is used to increase backscatter from ventricular boarders to improve visualisation and flow evaluation.

37. Regarding safety consideration in ultrasound:

(A) True. It is the ratio of the acoustic power reduced by the transducer to the power required to raise tissue in the beam area by 1 °C.
(B) True. It is a product of average ultrasound intensity and the absorption coefficient of the tissue.
(C) True. The mechanical index is an attempt to measure part of an ultrasound beam bioeffects.
(D) True. The mechanical index (MI) is a value that estimates the likelihood of cavitation by the ultrasound beam.
(E) True. Thermal effects are dependent not only on the rate of heat deposition in a volume of the body but also on how fast the heat is removed by blood flow and other means of heat dissipation.

38. Regarding fluorescence process:

(A) True. Fluorescence process occurs when fluorophore absorbs light and raises their energy level to an excited state, before they decay to emit fluorescent light.
(B) False. Fluorescent dye is a type of fluorophore required to absorb the light and emit the fluorescence.
(C) False. Excited state of fluorophore has a very short half-life, usually only a few nanoseconds.
(D) True. The fluorophore has two characteristic spectra known as the excitation spectrum and the emission spectrum.
(E) True. The intensity of emitted fluorescence is a linear function of the amount of fluorochrome present when the wavelength and intensity of the illuminating light are constant.

39. Regarding molecular imaging (MI):

(A) True. Molecular imaging is defined as characterisation and quantitative measurement of biological processes at molecular and cellular level in vivo.
(B) True. The range of spatial scales of MI modalities is from molecular to entire organ levels, which is approximately 1–10 mm resolution.
(C) True. Molecular imaging images the cells and biological species such as proteins and molecules, in vivo.
(D) True. The molecular imaging agents include both endogenous and exogenous probes.
(E) True. Quantification of MI refers to the determination of regional concentrations of molecular imaging agents and biological parameters.

40. FMI techniques used for evaluating hypoxia in clinical setting includes

(A) True. ^{99m}Tc-HL91 uptake in hypoxic tumour is used in SPECT imaging for hypoxia evaluation.
(B) True. CT perfusion imaging can quantitatively measure blood perfusion, by showing which areas are adequately perfused (supplied with blood), and provides detailed information on blood flow. CT perfusion imaging can be used to evaluate hypoxia.
(C) True. Blood oxygen level-dependent (BOLD) MRI is an imaging technique for hypoxia evaluation that distinguishes paramagnetic deoxyhaemoglobin from oxyhaemoglobin. It provides qualitative assessment of oxygenation changes in tissues.
(D) False. Fluoromisonidazole, F-MISO, PET imaging is used for evaluating hypoxia in clinical. Studies have shown lack of correlation between ^{18}F-FDG metabolism and hypoxia.
(E) True. Diffusion optical spectroscopy is used to assess the vascular oxygenation in hypoxia evaluation.

Examination Six: Answers

1. Picture archiving and communications system (PACS)

(A) True. Digital radiographic images are stored in a standard DICOM format.
(B) True. All digital images are stored digitally on the server.
(C) False. PACS is accessible from different locations simultaneously.
(D) True. Digital images are compressed to reduce the storage size.
(E) True. HL7 is a standard used for information transfer from the hospital information system (HIS).

2. Regarding quality assurance in radiography:

(A) False. The tube kV is measured using a digital kV metre.
(B) True. The tube output is measured using an ionisation chamber.
(C) True. The tube output is proportional to the square of the peak kV at a fixed mAs in the range of 60–120 kV. In mammographic energy range, the tube output is proportional to power of 3 of the peak kV.
(D) True. HVL of an X-ray beam is defined as the amount of absorbing material that is needed to reduce the beam to half of its original intensity.
(E) True. The radiation protection supervisor (RPS) must ensure the implementation of a quality assurance programme.

3. Detection efficiency of a thallium-doped sodium iodide detector is affected by the

(A) True. Source to the detector distance affects the fraction of emitted photons that reach the detector.
(B) True. Thickness of the detector affects the fraction of emitted photons that reach the detector.
(C) True. Intrinsic efficiency is a fraction of photons reaching the detector that are detected.

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(D) True. Quantum detection efficiency is a fraction of photons reaching the detector that are detected.
(E) True. Photopeak efficiency is a fraction of all detected photons that contribute only to the photopeak.

4. Regarding the nucleus of an atom:

(A) True. The nucleus is composed of protons and neutrons.
(B) True. The strong nuclear force is responsible for holding the nucleons (protons and nucleus) in the nucleus together.
(C) False. Nucleus is positively charged because protons are positively charged and neutrons are neutral.
(D) False. The number of nucleons represents the mass number. The number of protons represents the atomic number.
(E) True. The size of a nucleus is about 10,000 times smaller than the atom.

5. Regarding characteristic X-ray produced in an X-ray tube:

(A) False. Characteristic radiation results from the difference in binding energies between the two shells. Molybdenum produces two characteristic X-ray energies of 17.9 and 19.5 keV.
(B) True. Characteristic radiation is due to filament electrons dislodging K-shell electrons.
(C) True. The increase in tube voltage increases the rate of production of photons, but do not influence the photon energy of the characteristic X-rays, which is dependent on the atomic number of the target material.
(D) True. The kinetic energy of the filament electrons has to exceed the binding energy of K-shell electrons for tungsten (70 keV).
(E) False. Tungsten target produces approximately 80% bremsstrahlung radiation.

6. The radiation interaction occurs in medical imaging includes

(A) True. Photoelectric interactions occur in diagnostic radiology.
(B) True. Compton interactions occur in diagnostic radiology.
(C) True. Pair production occurs in nuclear imaging.
(D) False. Photodisintegration occurs at photon energy above 15 MeV.
(E) True. Coherent scatter or Rayleigh scatter occurs in diagnostic radiology.

7. Regarding the focal spot:

(A) True. Focal spot is the area on the surface of the anode that produced X-ray. It is determined by the area of the electron beam arriving from the cathode.
(B) False. The dimension of the effective focal spot is smaller than the actual focal spot. The effective focal spot is the area of the actual focal spot due to anode angulation, projected down the central axis of X-ray beam.

(C) True. Focal spot sizes typically employed in general radiography are 1.0 and 1.2 mm, whereas in mammography are 0.3 and 0.6 mm.
(D) True. The effective focal spot can be determined by multiplying the actual focal with the sine of the angle of the anode surface. The range of anode angle is 6–20°.
(E) True. The magnification of the slit image can be used to calculate the focal spot size.

8. The stochastic effects of radiation

(A) True. The stochastic effect may occur in the descendants of individuals exposed because of the lesions in the germinal cells.
(B) True. It is a probabilistic effect.
(C) False. The severity of stochastic effects is not affected by the dose levels.
(D) False. The stochastic effects have no threshold.
(E) True. Cancer is a stochastic effect.

9. The quantity of radiation is measured based on ionisation in air because

(A) True. Radiation interaction in the chamber produces ion pairs.
(B) True. The temperature affects the reading accuracy to a few percent that is acceptable for diagnostic radiology dosimetry.
(C) False. The charge measured has to be amplified and read out using sophisticated electrometer.
(D) False. The number of ion pairs produced is proportional to dose.
(E) False. IRR (1999) does not specify how dose is measured, but the quantities measured have to conform to international standards of measurement and quantities.

10. Unsharpness in radiographic imaging is worsen due to

(A) False. Increased object-film distance causing an unsharpness known as geometric unsharpness.
(B) True. Voluntary and involuntary movements cause motion unsharpness.
(C) True. Increased distance from focal spot-film distance increased the penumbra at peripheral of images.
(D) False. Smaller focal spot size reduces blurring.
(E) False. Anode heel effects do not relate directly with unsharpness.

11. Regarding amorphous selenium detector:

(A) True. The photoconductor material is typically used in a photodetector. It increases its electrical conductivity when exposed to light.
(B) False. Amorphous selenium detector converts X-ray to electrical charge.
(C) False. Amorphous selenium detector converts one X-ray photon to multiple light photons.

(D) True. Detector quantum efficiency of amorphous selenium detector is 65% and barium fluorohalide doped with europium is 30%.
(E) True. Ionisation in amorphous selenium produces charges for digital image formation.

12. Regarding veiling glare in fluoroscopic image quality:

(A) True. It is mainly from light scattering in the output window of image intensifier.
(B) True. Electron scattering also contributes to veiling glare effect in image intensifier.
(C) True. The larger the image intensifier, the more vignetting effect, thus the greater the veiling glare.
(D) False. Maladjustment of the electron-focusing system causes 'S' distortion.
(E) True. It is one type of artefact that occurs in fluoroscopy.

13. Concerning dual-energy subtraction:

(A) True. Low and high kVp settings were used in producing dual-energy subtraction images.
(B) True. Using low kVp, contrast between soft tissue and the bone is the best.
(C) True. Using low kVp setting, average photon beam energy is decreased; less photons are transmitted. Therefore, less signals are detected at image receptor and minimise visualisation of the bone.
(D) True. Image contrast for high-density materials is best with high kVp setting.
(E) False. Modern fluoroscopic equipment utilises temporal subtraction technique, not dual-energy subtraction technique.

14. Concerning equivalent dose:

(A) True. Different radiation has different severity of the effects.
(B) True. The Si unit of equivalent dose is J kg^{-1} and Sievert.
(C) False. It is dependent of radiation type due to difference in radiation weighting factor.
(D) True. Radiation weighting factor for gamma is 1, so absorbed dose is equal to equivalent dose.
(E) True. Radiation weighting factor for X-rays, gamma, electrons and beta is 1.

15. Dosimeter used in personal dosimetry system includes

(A) False. Gel dosimeter is not convenient for personal dosimetry system compared to conventional dosimeters such as TLD and film.
(B) True. The TLD is a semiconductor material that will release lights when heated with suitable temperature.

(C) True. The OSL is a semiconductor material that will release lights when stimulated with suitable light.
(D) True. Film will record doses imparted to personnel with the optical density value of the film.
(E) True. Semiconductor is used widely in pen dosimeters system.

16. In radioactivity

(A) True. When an unstable atomic nucleus emits two protons and two neutrons, the radioactive process is known as alpha decay. For example, when the $^{238}_{92}\mathrm{U}$ undergoes alpha decay, a new element with mass number of 238 – 4 = 234 and charge number of 92 – 2 = 90 is formed ($^{234}_{90}\mathrm{U}$).
(B) True. Positron emission or beta plus decay is a subtype of radioactive decay called beta decay, in which a proton inside a radionuclide nucleus is converted into a neutron while releasing a positron and an electron neutrino.
(C) False. Gamma decay emits high-energy photons.
(D) True. It measures the time it takes for a given amount of substance to reduce by half as a consequence of decay.
(E) False. 1 Ci is equal to 3.7×10^{10} Bq. Curie (Ci) is a large unit, and the more frequently used activity units are the mCi and μCi.

17. Regarding planar radionuclide imaging:

(A) True. It uses radiopharmaceuticals to examine the function and structure of organs.
(B) False. Extrinsic resolution is the spatial resolution with a collimator in place. Intrinsic resolution is the spatial resolution without a collimator in place.
(C) True. The choice of a collimator varies in terms of the diameter of each hole, the depth of each hole and the thickness of lead between each hole.
(D) False. The half-life of $^{99m}\mathrm{Tc}$ is 6 h.
(E) False. The energy of gamma ray is close to 140 keV.

18. The use of dose calibrator in radionuclide imaging includes

(A) True. Dose calibrators are also known as radioisotope calibrator or radionuclide calibrator. It verifies activity produced by generator.
(B) True. It determines radioactivity measurements within the accuracy levels received from radiopharmaceutical suppliers.
(C) True. It is used to make measurements of radiopharmaceutical doses prior to patient administration.
(D) True. Only isotope-specific can be monitored by the dose calibrator.
(E) False. Dose calibrator is used to measure radioactivity of radiopharmaceutical before being administered into human body for diagnosis or treatment.

19. Regarding the dose limits:

(A) True. The annual effective dose is 20 mSv for whole body of staff (18 years of age and over).
(B) False. The dose limits are applied to employee aged 16–18 years (known as trainee) including student who is working with radiation.
(C) False. There are no dose limits for patient undergoing treatment.
(D) True. The equivalent dose limit averaged throughout the abdomen of woman of reproductive capacity shall be 13 mSv in any consecutive period of 3 months.
(E) False. There are no dose limits for comforters or carers, but the employer should set a dose constraint (might be as high as 5 mSv).

20. Regarding radiation protection:

(A) False. For chest radiography, the focal spot to skin distance should not be less than 60 cm.
(B) False. The total permanent filtration in mammography should not be less than 0.03 mm molybdenum (equivalent to 0.5 aluminium).
(C) True. The walls with sufficient thickness are important for radiation protection. Twelve millimetres of barium plaster is approximately equal to 1 mm lead equivalent.
(D) True. Periodic examination on radiation protective equipment (RPE) is to ensure that the RPE is fit for the intended use and that physical deterioration has not occurred.
(E) False. In the presence of higher-energy radiation from nuclear medicine imaging, a lead apron acts as an X-ray source and therefore should not be used.

21. According to the Medicines (Administration of Radioactive Substances) Regulations 1978

(A) False. The certified clinicians (doctor and dentist) are responsible for the patients treated under the Act.
(B) True. The certificates are issued by Minister of Health, through the appointed committee known as Administration of Radioactive Substances Advisory Committee (ARSAC).
(C) True. The chairman of the advisory committee should be a doctor, whom is appointed by Minister of Health.
(D) False. The application for the certificate must be signed by a radiation protection advisor.
(E) True. During certificate renewal, any procedures that are no longer required can be removed.

22. Concerning simple backprojection:

(A) False. Each X-ray transmission path through the body is divided into equally spaced elements.
(B) True. Sum the attenuation for each element over all intersecting X-ray paths.
(C) False. A final summed attenuation coefficient is determined by summing the attenuation for each element at different angular orientations.
(D) True. A merged image of the linear attenuation coefficients is obtained in backprojection process.
(E) True. Backprojection smears back the projection across the image at the angle it was acquired. By smearing back all of the projections, the image will be reconstructed. This image looks similar to the real image but is blurry.

23. X-ray attenuation

(A) True. X-ray beam attenuation is a phenomenon when the X-ray beam passes through the tissue; the photons are absorbed; thus, there is less energy.
(B) True. The rate of attenuation (or penetration) is determined by the photon energy spectrum (kV and filtration). Higher tube voltage will have higher beam penetration.
(C) True. It relates the attenuation of X-ray to the properties of the material through which the X-ray is travelling.
(D) False. It is defined as the natural logarithm of the ratio of primary intensity to attenuated intensity.
(E) True. Based on Lambert-Beer law, the number of photons passing through an object drops off rapidly (exponentially).

24. A computed tomography (CT) detector system

(A) True. The scintillation crystal converts X-rays into visible light, and the photomultiplier tube (PMT) converts light into an electric current.
(B) True. The amplifier amplifies the signal.
(C) True. The multichannel readout electronics perform analogue to digital conversion with typical sampling rates.
(D) True. The scintillation crystal has high quantum efficiency and fast response time.
(E) False. CT detector has low radiation drift, $\leq 0.5\%$ for longest scan duration.

25. Regarding CT image noise:

(A) True. The noise in a CT image causes a statistical variation in the actual CT numbers from pixel to pixel. The range of this variation, as measured by the calculated standard deviation, is a measure of the noise.
(B) True. The effect of this blurring is it reduces visibility of detail (small objects and features).
(C) True. Increasing the quantity of X-ray photons will increase the signal-to-noise ratio, and it will decrease the CT image noise.
(D) True. A large voxel has a greater photon flux and is subject to less noise.
(E) False. When the mAs increases, more photons deposit in a voxel, thus less noise in the image.

26. The radioisotope used in SPECT includes

(A) False. This radioisotope is produced for PET imaging.
(B) False. This radioisotope is produced for PET imaging.
(C) True. This radioisotope is produced from ^{99}Mo-^{99m}Tc generator.
(D) True. This radioisotope is produced in proton or α-particle-induced reactions on cadmium or silver targets.
(E) True. This radioisotope is produced by a cyclotron.

27. The similarity between SPECT and PET includes

(A) True. Both imaging modalities use tracer that emits gamma rays for imaging.
(B) True. Both SPECT and PET are equipped with high efficient of detectors to detect the gamma rays.
(C) True. Gamma rays emitted from patient's body represent the activity accumulated in the body.
(D) True. Filtered backprojection filters sinogram data and then backprojects it.
(E) False. SPECT and PET are emission imaging.

28. The level of radiation exposure to the PET patient depends on the

(A) True. Radiation exposure to patients is directly proportional to the administered activity.
(B) True. Half-life determines cumulative activity. For a given amount of administered activity, the number of transitions (decay) that occur within the body (cumulated activity) is directly proportional to the half-life of the radionuclide. The radiation exposure relies on half-life of radionuclide.
(C) True. Different age group will have different level of radiation exposure. Paediatric will receive low radiation exposure to PET compared to adult examination.

(D) True. Mass of respective organ affects the level of radiation exposure to PET examination. Heavier organ receives more activity administered, so high radiation exposure will be received by patient.

(E) True. Biokinetics of radiopharmaceutical used can be obtained by observing the time-activity curves in different organs; thus, the level of internal dose can be assessed.

29. Regarding nuclear magnetic resonance (NMR):

(A) True. In thermal equilibrium, more nuclei aligned parallel to the magnetic field (spin-up nuclei), and therefore the bulk magnetic vector is at the same direction (parallel) with magnetic field.

(B) True. Larmor equation states that the precession frequency is the product of magnetic field strength multiplied by gyromagnetic ratio. In 1 T field, the precession frequency is 42.6 MHz.

(C) False. At equilibrium, the magnetic moments of nuclei are out of phase (incoherent) with each other.

(D) True. The recovery of longitudinal magnetisation (T1 recovery) is caused by release of energy from nuclei to surrounding environment (lattice) and is also known as spin-lattice relaxation.

(E) True. A signal or voltage is induced in the receiver coil when there is fluctuation in magnetic field inside the coil.

30. During the free induction decay (FID) in NMR:

(A) True. The recovery of longitudinal magnetisation is known as T1 recovery or spin-lattice relaxation.

(B) True. The decay of transverse magnetisation is known as T2 decay or spin-spin relaxation.

(C) True. The amplitude of the induced voltage (signal) in the receiver coil decreases or decays.

(D) True. The hydrogen nuclei lose their energy given by the RF pulse and the process known as relaxation.

(E) False. The sum magnetic vector turns back to the longitudinal plane from transverse plane.

31. Concerning image formation in MRI:

(A) True. The Fourier transform process converts the spatial frequency in k-space into frequency domain to produce image.

(B) False. The central k-space contains data with high signal amplitude, and the outer lines contain data with low signal amplitude.

(C) True. The unit of k-space is radians per cm (is defined as phase change over distance).

(D) True. Received bandwidth contains range of frequencies to be digitised or encoded across the FOV.
(E) False. One hundred and twenty-eight phase matrix consists of +64 to −64 lines and 256 matrix consists of +128 to −128 k-space lines.

32. Regarding MR angiography (MRA) principles:

(A) True. MRA uses velocity differences to provide contrast in flowing vessels. Slow-moving blood (constant velocity) appears bright (in venous, CSF). It is known as bright blood imaging.
(B) True. Gradient moment rephasing is one of the techniques used in bright blood imaging to enhance the signal from flowing blood.
(C) True. In time-of-flight MRA (TOF-MRA), blood flowing in transverse direction of FOV appears dark.
(D) True. In phase contrast MRA (PC-MRA), bipolar gradient is used to shift the phase and generate velocity differences in flowing vessels.
(E) True. Fast-moving blood (in aorta) appears as void or dark because it has low signal intensity. It is known as black blood imaging.

33. Regarding terms used in defining devices in MRI:

(A) True. An item that is known to cause hazards in all MRI environments is known as MR unsafe.
(B) True. A device that is not safe for exposure to MRI is termed as MR incompatible.
(C) True. MR conditional refers to an item that has been proved to pose no known hazards in a specified MRI environment and specified conditions of use such as static magnetic field strength, spatial gradient, time-varying magnetic fields and radiofrequency fields.
(D) False. An item that poses no known hazards in all MRI environments is known as MR safe.
(E) True. An item that causes only minor magnetic field interactions and is unlikely to pose hazard or risk in association with movement or dislodgment is termed as MR unsafe type 2.

34. The velocity of ultrasound is changed greatly when it travels from muscle to

(A) False. It slightly varies from one soft tissue to another.
(B) True. It differs greatly due to density between the muscle and lung.
(C) False. The kidney and muscle do not differ greatly by its density.
(D) True. It differs greatly due to density between the muscle and air.
(E) True. It differs greatly due to density between the muscle and bone.

35. Fresnel zone in ultrasound

(A) True. Fresnel zone distance of ultrasound is directly proportional to transducer frequency.
(B) False. It is known as near field.
(C) True. At Fresnel region the sound energy is confined to the beam of diameter, *D*.
(D) True. Fresnel zone of ultrasound is directly proportional to D^2 (diameter) of transducer.
(E) True. It is a near field and adjacent to the transducer face.

36. Common artefact in ultrasound imaging includes

(A) True. Refraction of a beam falling obliquely on two surfaces of bone displaces the beam and the images of structures beyond.
(B) True. Ring-down artefacts happen when a small bubble resonates and emits ultrasound continuously, therefore resulted in a track throughout the scans.
(C) True. Reverberation artefacts occur when a series of delayed echoes are produced with equally spaced time that falsely appear to be distant structure.
(D) True. Acoustic shadowing happens when highly attenuating or reflecting structures reduce the intensity of echoes from the region behind, to cast shadows behind the structure.
(E) True. Interference between the waves due to scattering from many structures produces a textured appearance.

37. Regarding the risk of ultrasound:

(A) True. Particles receive energy from ultrasound and cause vibration.
(B) True. Release of heat by ultrasound imaging affects cell membrane permeability.
(C) True. Operators should keep this value below this safety level.
(D) True. The mechanical index is a coefficient to measure part of an ultrasound beam bioeffects.
(E) True. Local heating effects are used for therapeutic reason.

38. Bioluminescent imaging

(A) True. The technique captures light emitted and creates only planar images and is difficult to be reconstructed to tomographic images.
(B) True. The tissue penetration of bioluminescent signal is weak and limits the application to small animal.
(C) False. The method is non-invasive.
(D) True. Fluorescent imaging is less sensitive and has a lower spatial resolution due to high levels of autofluorescence in the imaging technique.
(E) False. The method doesn't require fluorescent.

39. Regarding modalities for functional and molecular imaging (FMI):

(A) False. CT produces an excellent spatial resolution (0.5–0.625 mm) compared to other imaging modalities. The spatial resolution of CT is superior to resolution of MRI (typically 1–2 mm).

(B) True. The molecular sensitivity of a molecular imaging modality is the capability to detect, visualise and accurately quantify low concentrations of molecular probe interacting with a molecular target within the living subject.

(C) True. FDG-PET alone is less sensitive than CT imaging or combined CT and bone scan in detecting renal cell carcinoma. PET-CT has been recommended because of improved image resolution and signal-to-noise ratio.

(D) True. The advantage of SPECT and PET for FMI is unlimited depth of penetration.

(E) False. Ultrasound imaging produces better spatial resolution compared to SPECT imaging.

40. Regarding application of FMI in clinical setting:

(A) True. Contrast-enhanced ultrasound (CEUS) improves the detection and characterisation of focal liver lesions with the injection of microbubble contrast agents.

(B) True. ^{123}I-SPECT is widely used for assessment of neurodegenerative imaging such as Parkinson's disease.

(C) True. Dynamic contrast-enhanced (DCE) MRI is based on diffusions of contrast agents to assess tissue vascularity and to demonstrate tumour responses to therapeutic agents.

(D) True. In inflammation imaging, FDG-PET can accurately localise the area of infection and the extent of inflammation based on metabolic level.

(E) True. DW-MRI can be used to differentiate malignant from benign lesions because both have different apparent diffusion coefficient (ADC) values.

Examination Seven: Answers

1. Regarding digital radiography:

(A) False. The modulation transfer function (MTF) describes the spatial resolution capability of an imaging system.
(B) True. The MTF is the magnitude of the Fourier transform of the point or line spread function.
(C) True. The MTF value is high for a high-resolution system. The images produced have better visibility of small structures.
(D) True. Each imaging system has a specific MTF curve.
(E) False. MTF value is applicable for both digital and analogue imaging system.

2. DICOM

(A) True. It is a digital format standard.
(B) True. Most digital radiological images are stored in DICOM format.
(C) True. The file header contains the metadata.
(D) True. The calibration produces better visual consistency in the way images appear on different computer display.
(E) False. The standards are the same.

3. Regarding ionisation chamber:

(A) True. Another example is proportional counter.
(B) True. Phototimer measures radiation exposure to the detector and stops the x-ray beam when the exposure is sufficient to produce good image.
(C) True. Ionisation chamber measures the charge from ion pairs created within the gas.
(D) True. Two electrodes, anode and cathode, are supplied with voltage potential to collect the charge.
(E) True. An ionisation chamber is calibrated to provide absolute dose measurement.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
https://doi.org/10.1007/978-981-13-0911-3_16

4. Regarding an atom:

(A) False. Neutron has a mass of 1.67×10^{-27} kg.
(B) True. Neutron has no charge. Protons and electrons have charge.
(C) True. Atom consists of a nucleus and orbiting electrons.
(D) False. The mass number equal to the number of protons and neutrons.
(E) True. The number of proton in an atom determines the atomic number of the atom and the chemical element to which the atom belongs.

5. Regarding electrons in an atom:

(A) False. Electrons have a negative charge.
(B) True. The Bohr model depicts the atom constitutes of electrons that travel in circular orbit around the nucleus.
(C) False. The binding energy of the K-shell is higher than the L-shell.
(D) False. Electrons have a smaller mass than protons.
(E) False. The K-shell holds two electrons.

6. Regarding x-ray:

(A) True. The process happens in an x-ray tube.
(B) True. The energy spectrum is polyenergetic.
(C) False. The process produces a lot of heat.
(D) True. This will be the maximum energy of the bremsstrahlung radiation.
(E) False. It is emitted from an x-ray tube. Metastable radioisotope emits gamma ray.

7. Rotating anodes

(A) True. Rotating anode has superior heat dispersal compared to stationary anode.
(B) True. Higher rotation speed spreads the heat over longer focal spot track.
(C) True. The anode is mounted on an electric motor.
(D) True. The rotation increases the area on the target bombarded with electron and improves heat dissipation.
(E) False. Rotating anode has a larger effective focal spot size compared to a stationary anode.

8. Regarding absorbed dose:

(A) True. Absorbed dose is the amount of energy deposited in a medium.
(B) False. The SI unit is J/kg or Gy.
(C) True. Ionisation chamber provides absorbed dose.
(D) True. 1 rad is equal to 0.01 J/kg.
(E) False. Effective dose takes into account the type of tissue.

9. Equivalent dose is

(A) False. Equivalent dose is measured in Sv.
(B) False. Equivalent dose is dependent on radiation weighting factor.
(C) True. Radiation weighting factor accounts for the type of radiation.
(D) False. Effective dose is dependent on radiation weighting factor and tissue weighting factor.
(E) True. Equivalent dose is absorbed dose multiplied by radiation weighting factor.

10. Concerning base plus fog of radiographic film:

(A) False. Moving grids do not affect base plus fog readings.
(B) True. Fog is a value from background radiation prior to use.
(C) False. Storing in moist condition does not increase base plus fog value. It is affected by high temperature.
(D) False. Base plus fog is measured from unexposed film.
(E) False. All film types have base plus fog value.

11. Regarding digital mammography system:

(A) False. Film-screen mammography has better resolution compared to digital mammography.
(B) True. Digital mammography receptor has a linear respond over dose increment.
(C) False. It is lower due to inherent quantum detection efficiency that digital mammography has.
(D) True. Smaller pixel size provides a better spatial resolution of digital imaging system.
(E) False. Digital mammography uses low kVp technique.

12. Concerning the image intensifier:

(A) False. It is due to reduced size of images from input phosphor to an output phosphor.
(B) True. Image intensifier has an ability to increase the image brightness produced by fluoroscopy.
(C) True. Design of fluoroscopy tube which curved at input phosphor but flat at output phosphor lead to vignetting problem.
(D) False. Focusing a curved input screen onto a flat output screen causes pincushion distortion.
(E) False. Minification gain is dependent on output phosphor diameter.

13. Image sensor used in fluoroscopy includes

(A) True. Vidicon is used in cathode ray tube version of fluoroscopy system.
(B) True. Plumbicon is used in cathode ray tube version of fluoroscopy system.
(C) False. Focusing dynodes system is used in gamma camera to amplify signals.
(D) True. Thin-film transistor is a transistor device that amplifies an electric signal.
(E) True. Use of charge couple device (CCD) increases the dynamic range of the image, because CCD generally has 12-bit image depth.

14. Method of reducing dose to patient undergoing barium enema procedure includes

(A) True. Carbon fibre material is a radiolucent material used to minimise attenuation with incident beam.
(B) True. Last image hold reduces dose to patient significantly by displaying last image at monitor with radiation was turning off.
(C) False. Magnification using image intensifier in fluoroscopy results less bright image and system will increase exposure to patient.
(D) False. X-ray tube position does not help in reducing dose to patient but reduces dose to staff. Adjustment of the x-ray tube distance from patient's skin is more helpful.
(E) True. Low pulse rate digital fluoroscopy results a lower dose to patient.

15. In radiography, dose of patient is reduced by

(A) True. Low ratio grid allows more radiation to pass through, and dose to patient can be reduced.
(B) False. Increasing the object distance from image receptor does not help in reducing patient dose.
(C) True. Increasing filter thickness will increase the beam average energy and filters unwanted low energy from the beam.
(D) False. Radiosensitive organ should only be protected if it is near to FOV and not as an organ of interest in the image.
(E) True. Dose absorbed is directly proportional with exposure time.

16. Alpha decay

(A) True. Alpha decay occurs in massive nuclei that has large proton to neutron ratio.
(B) False. ^{226}Ra in nature decays into radon gas by emitting alpha.
(C) True. Alpha particles are identical to helium nuclei.

(D) False. Alpha particles are heavy particles. They are easily absorbed by materials because of the mass, and they can travel only a few centimetres in air.

(E) True. Alpha consists of two protons and two neutrons. Atomic number is equal to the number of proton. The alpha decay resulted a reduction of two protons from the parent nuclide that is equivalent to the reduction of two atomic number.

17. Regarding the scintillation crystal in gamma camera:

(A) True. Sodium iodide converts gamma ray to lights.
(B) True. The crystal is encased in a housing.
(C) False. It converts gamma ray to lights.
(D) True. Thicker crystals decrease spatial resolution.
(E) True. Photomultiplier tube multiplies the signal.

18. Absorbed dose delivered to an organ by the activity within it increases in proportion to the

(A) False. Total scanning time does not increase absorbed dose in nuclear medicine imaging.
(B) True. Radionuclide uptake is a major contributor of absorbed dose in nuclear medicine.
(C) True. Absorbed dose increases with the increasing activity of radionuclide administered to patient.
(D) True. The longer the half-life of radionuclide, the higher dose will be imparted to related organs.
(E) True. Beta radiation has low penetration power and high linear energy transfer (LET). It will transfer all of its energy when it is deposited in an organ.

19. Regarding supervised area:

(A) True. Warning sign is compulsory to be displayed in supervised area.
(B) True. It is an area that could exceed the dose limit for a member of public.
(C) True. Whenever the worker would likely to receive dose lesser than this limit, supervised area is not required.
(D) False. Injection room of radionuclide imaging is classified as controlled area.
(E) False. Average dose rate value at supervised area is less than controlled area.

20. According to IRMER 2000

(A) False. Person who carries out the practical aspect of the exposure refers to the operator.
(B) True. This statement is stated in duties of the practitioner, operator and referrer in IRMER 2000.
(C) True. Practitioners and operators shall have successfully completed training, including theoretical knowledge and practical experience in regulation 2(1), IRMER 2000.
(D) True. Referrer means a registered medical practitioner, dental practitioner or other health professional who is entitled in accordance with the employer's procedures to refer individuals for medical exposure to a practitioner.
(E) True. This statement is stated in duties of employer in IRMER 2000.

21. Concerning dose constrain for comforters and carers in IRR 99:

(A) False. Electronic personal dosimeter is used to give the real-time dose.
(B) False. Lead apron is only used to protect comforters from scattered radiation. Tight collimation is very helpful to protect comforters from primary beam.
(C) True. Immobilisation device is used to reduce motion artefact.
(D) True. Comforter means an individual who (other than as part of his occupation) knowingly and willingly incurs an exposure to ionising radiation resulting from the support and comfort of another person who is undergoing or who has undergone any medical exposure.
(E) False. Effective dose limit for comforters is 5 mSv/year, not 15 mSv/year.

22. The advantage of iterative reconstruction (IR) technique against filtered backprojection (FBP) includes

(A) False. IR is a slower technique compared to FBP due to longer calculation time and complexity of the model.
(B) True. The IR is possible for quantitative imaging such as in nuclear medicine.
(C) True. IR provides improved insensitivity to noise and better handling of projection noise.
(D) False. The FBP reconstruction needs more filtering compared to IR.
(E) True. IR results in improved spatial resolution and low contrast resolution.

23. Reducing the number of projection views for image reconstruction results in

(A) False. Reduction in number of projection views will result in lower spatial resolution.
(B) True. Reducing the number of projections is due to reduced exposure and will result in reduced dose to patient.

(C) True. Aliasing artefact is due to insufficient radial sampling (undersampling) and number of projections.
(D) False. Incomplete projection data is the portion of data that cannot be acquired due to physical or instrumental limitations. For example, the x-ray photons totally absorbed by metal object result in incomplete projection data.
(E) True. Reducing the number of projections will result in reduced acquisition time.

24. Regarding the principles of computed tomography (CT):

(A) False. The bow-tie filter is used to produce more uniform beam throughout the patient. Post-patient collimator is used to reduce scattered radiation.
(B) True. CT raw data is an attenuation value measured by detectors and is stored as set of detector readings at all angular positions that corresponds to sinusoidal curve, known as sinogram.
(C) True. A pixel value represents the average linear attenuation coefficients of a voxel.
(D) True. In diagnostic energy ranges such as in CT, the most predominant interaction is Compton scatter for substances and tissues with low atomic number.
(E) False. In fourth-generation CT, only x-ray tube is rotated, and a ring of stationary or fixed detectors is used.

25. Regarding dose in CT imaging:

(A) True. Doubling the tube current (mA) will double the exposure and CT dose.
(B) True. High-resolution CT (HRCT) chest delivers higher dose per slice compared to routine CT chest. It is because HRCT uses sharp reconstruction filter and thinner slice.
(C) True. Narrow beam collimation will reduce the CT dose.
(D) False. Dose is greater in smaller patient as compared to larger-sized patient.
(E) False. Dose in multi-slice CT is slightly higher than single-slice CT for similar image quality.

26. Regarding the ^{99m}Tc generator:

(A) True. ^{99}Mo decays to ^{99m}Tc.
(B) False. The generator has a life of about 1–2 weeks.
(C) True. ^{99m}Tc decays to ^{99}Tc to produce gamma ray.
(D) True. Sterile saline is used to obtain sterile sodium pertechnetate solution.
(E) False. It undergoes transient equilibrium.

27. Regarding single-photon emission computed tomography (SPECT):

(A) True. Noise is high because a limited number of counts in each voxel.
(B) False. SPECT imaging does not require image fusion.
(C) True. Signal needs to be collected from multiple angles in SPECT and rotating detector is needed.
(D) False. Spatial resolution is better in CT image compared to SPECT.
(E) True. Tomographic images are generated in SPECT scanning by acquiring images 360° around patient.

28. Regarding positron emission tomography (PET):

(A) False. The emitters used in PET imaging generally have short half-life.
(B) True. Two coincidence detection events must occur to generate a line of response (LOR). Any pulses that do not coincide in time (single or multiple photons) will not produce any LOR.
(C) False. Positrons tend to be emitted from nuclides with an excess of protons that can then be converted into neutron and positron.
(D) True. The common scintillation detector used is bismuth germanate (BGO). Other efficient scintillators use in PET are such as lutetium oxyorthosilicate (LSO) and gadolinium oxyorthosilicate (GSO).
(E) False. Random coincidence occurs when two unrelated 511 keV photons from two separate annihilation events are detected by a detector pair within the same time window. Scatter coincidence is due to scattering of annihilation photons.

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) True. In nuclei with odd numbers, a number of neutrons are slightly more or less than protons, spin directions are not equal, and it has angular momentum. Alignment of protons is represented as a vector known as magnetic moment.
(B) False. The frequency at which resonance occurs is directly proportional to the applied magnetic field.
(C) True. The precession frequency is proportional to the strength of magnetic field. It is determined by Larmor frequency:

$$\omega_O = B_O \times \lambda$$

where ω_O is the precessional frequency, B_O is the magnetic field strength, and λ is the gyromagnetic ratio (constant).
(D) False. Spin-up dipoles are slightly more than spin-down inside a magnetic field because less energy is needed.
(E) False. The magnetic moment of protons is affected by temperature of sample, and it determines either high- or low-energy population.

30. Regarding relaxation in MRI:

(A) True. Substances with fast molecular motion (molecular tumbling rate) dephase or decay slowly because the exchange of energy with neighbouring nuclei is less efficient.
(B) False. The recovery of the longitudinal magnetisation is termed spin-lattice relaxation, and the decay of transverse magnetisation is termed spin-spin relaxation.
(C) True. T2 decay happened when nuclei exchange energy with the neighbouring nuclei and the spins dephase slowly.
(D) False. Water decays slower than fat because water has faster molecular motion than fat.
(E) False. Typical T1 relaxation time of CSF in 1 T field is 2000 ms, and T2 relaxation time is 150 ms.

31. Regarding magnetic resonance imaging (MRI) instrumentation:

(A) True. Permanent magnets are limited to maximum field strengths of 0.4 T. The lower field strength scanner produces less uniform (homogeneous) fields than that of superconducting scanners that will impair the image quality.
(B) True. Gradient coils are used to produce gradient magnetic fields for spatial encoding of the signal and in the formation of gradient echoes.
(C) True. RF receiver coils known as surface coils are used to improve the signal-to-noise ratio (SNR). The closer the coil to body parts, the greater the SNR because only noise near the coil is detected, rather than the whole body.
(D) True. Shim coils are used to produce uniform magnetic fields (homogenous) across the imaging volume.
(E) False. Surface coils have smaller FOV compared to body coils (for larger parts).

32. Concerning image quality in MRI:

(A) True. Reducing the slice thickness will increase spatial resolution and produces better anatomical details. Thinner slice has greater ability to resolve the small structures.
(B) True. White noise is due to random thermal movement of the hydrogen protons in the tissues with wide range of frequencies.
(C) False. Noise is reduced as the receive bandwidth decreases.
(D) True. High spatial resolution is achieved with thin slice and small FOV. A thin slice and small FOV can be achieved with steep gradient slope.
(E) False. SNR is increased as TR increases. SNR is proportional to TR and TE.

33. Regarding MRI safety guidelines by UK Medicines and Healthcare Products Regulatory Agency (MHRA):

(A) True. The exposure staff is limited to not more than 2 T for whole body and 5 T for limbs.
(B) False. Pregnant patients should not be exposed above 2.5 T.
(C) True. Ethics committee approval is required for exposure above 4 T of field strength, as adverse bioeffects may occur.
(D) True. The restricted whole-body exposure time for staff in 2 T field strength is 2 h.
(E) True. Refer to the table below.

MHRA guidelines for whole-body exposure of patients undergo MRI:

Exposure mode	Field strength limit
Normal mode	<2.5 T
Controlled mode	Between 2.5 and 4 T
Research/ experimental	>4 T
Pregnant patients	<2.5 T

Allisy-Roberts. Farr's Physics for Medical Imaging. 2nd Edition, W.B. Saunders Co. Ltd.

34. Concerning ultrasound:

(A) True. Lateral resolution is affected by the width of the beam and the depth of imaging. Focused transducer has wider beam width.
(B) False. It is directly proportional to frequency of transducer.
(C) True. It is relative intensity measurement to water.
(D) True. The velocity is highest in high-density material (bone).
(E) False. This happened in constructive interference.

35. Phase array in ultrasound is used to alter the

(A) True. Uniform time delay is used to alter the pulse repetition frequency of ultrasound.
(B) True. Minor phase differences of adjacent beams form a constructive and destructive wave summations, steer or focus of the ultrasound beam profile.
(C) True. Using phased array transducer, focusing to a specific depth is achieved by beam steering and transmit or receive focusing, to reduce the effective beam width and improve lateral resolution.
(D) True. Phased array transducer allows a selectable focal distance by applying specific timing delays between transducer elements that cause the beam to converge at a specified distance.
(E) True. The beam former is responsible for generating the electronic delays for individual transducer elements in an array to achieve transmit and receive focusing in phased arrays beam steering.

36. In diagnostic ultrasound

(A) False. High-frequency beams are more attenuated so unable to penetrate deeper structures.
(B) False. Bowel gas is hyper-reflective and usually acts as an acoustic barrier.
(C) True. Curvilinear array probes are used in abdominal ultrasonography to provide wide field of view.
(D) True. This is via a cavitation process.
(E) True. The main utilisation of Doppler is to measure the speed and the direction of flow.

37. Regarding biological effect of ultrasound:

(A) True. Acoustic steaming of cellular content affects cell membrane permeability.
(B) True. Threshold of risk starts with 0.3 mechanical index value.
(C) True. High peak pressure changes cause cavitation.
(D) False. Tissue heating happens in therapeutic range.
(E) False. Ionising radiation causes more biological damage to tissue.

38. Fluorescence microscope

(A) True. The laser supplied energy that is absorbed by the fluorophores (certain molecules that absorbed light), to a brief excited state. As they decay from this excited state, they emit fluorescent light.
(B) True. Optical camera collects the visible light.
(C) False. It is an optical system, not sensitive to gamma rays.
(D) False. It has high sensitivity to protein detection such as DNA.
(E) True. Light filter is to collect only the emission light from the fluorophore.

39. Regarding the principles of functional and molecular imaging (FMI):

(A) True. Molecular imaging probe is a targeted agent used to visualise, characterise and quantify biological processes in the body and has potential to increase image contrast between normal and abnormal tissue.
(B) True. Multimodality imaging combines anatomical and functional information obtained by the synchronous image acquisition with two or more modalities, with the images being registered in space and in time.
(C) True. Cross-validation is performed to assess the accuracy of multimodality imaging by comparing information obtained independently from different modalities.
(D) False. Spatial co-registration of single modality data is easier and simpler than integration from multimodality data.
(E) True. Doppler method measures the intensity of backscattered signals or pulse-echo from blood cells.

40. Regarding FMI technique for assessment of the biological process:

(A) True. The non-oncological applications of ^{18}F-FDG PET/CT include the assessment of pathological conditions such as infection and inflammation.

(B) True. Blood oxygenation level dependent (BOLD) is very useful for assessment of hypoxia, to assess the oxygenation level in tissues. BOLD uses the differences in magnetic susceptibility between oxyhaemoglobin and deoxyhaemoglobin. BOLD is used to study the oxygenation level in tissues and very useful for assessment of hypoxia.

(C) True. DWI-MRI is useful to differentiate acute and chronic stroke by assessment of the extracellular environment alteration and different ADC values. Diffusion-weighted MRI has high sensitivity in detecting early cerebral ischaemic changes in acute stroke patients.

(D) True. Optical coherence tomography (OCT) is a catheter-based imaging system that used lights. OCT allows accurate diagnosis of coronary atherosclerotic plaques.

(E) True. ^{18}F-FDG PET is useful for in vivo quantification of cellular proliferation in individual tumours.

Examination Eight: Answers

1. Regarding the photographic emulsion of radiographic film:

(A) True. Film consists of a photographic emulsion that contains a suspension of silver halide crystals.
(B) True. Radiation-sensitive emulsion is coated on both sides of the base to produce double emulsion film or on a single side of the base to produce single emulsion film.
(C) False. The emulsion layer is much thinner. A typical thickness of emulsion is 10 μm.
(D) True. It is sensitive to both visible light and x-rays.
(E) True. Sensitivity to light is higher than x-ray.

2. Regarding digital radiography:

(A) True. Amorphous silicon detector converts x-ray to electrical signal.
(B) True. Indirect conversion system uses a scintillator such as gadolinium oxysulphide to convert x-ray to light before being detected by the photodiode in the detector.
(C) False. IP plate is used in computed radiography.
(D) False. Digital radiography has a detector quantum efficiency of 65% compared to computed radiography and films screens which have a detector quantum efficiency of 30%.
(E) True. Digital radiographs are stored in DICOM format.

3. Regarding artefacts in computed radiography (CR):

(A) False. Ghost image is resulted from image plate that has been incompletely erased since the previous exposure.
(B) True. Improper handling resulted finger or nail marks on the screen.
(C) True. The venetian blind effect is a formation of parallel lines on the image due to presence of strong electromagnetic field.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
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(D) False. Dust may block the emission of light from imaging plate when struck by the laser.
(E) True. The artefacts could interfere with the quality and interpretation of the image.

4. Regarding the tungsten atom:

(A) True. Tungsten has 74 protons and 110 neutrons in its nucleus.
(B) False. The mass number is 184.
(C) True. Tungsten is also known as Wolfram.
(D) False. The binding energy of K-shell electrons is 69.5 keV.
(E) True. The anode target in x-ray tube is made of tungsten.

5. Type of electromagnetic radiation includes

(A) True. Visible light is in the range of electromagnetic spectrum between ultraviolet and infrared. It has a wavelength between 380 nm and 740 nm.
(B) True. X-ray has a wavelength ranging from 0.01 nm to 10 nm.
(C) False. Sound is a mechanical wave that results from the back and forth vibration of the particles of the medium through which the sound wave is moving.
(D) True. Microwave has a wavelength ranging from 1 mm to 30 cm.
(E) True. Infrared extends from the red edge of the visible light spectrum ranging from 700 nm to 1 mm.

6. The x-ray tube component includes a

(A) True. A vacuum tube is an airtight envelope to maintain a vacuum in the tube.
(B) True. The cathode consists of a heated filament to expel the electrons through a process called thermionic emission.
(C) True. The cathode consists of a tungsten target that convert electronic energy into x-ray from interaction with cathode electrons.
(D) False. Radionuclide emits gamma rays.
(E) False. Dynode is an electron multiplier in a photomultiplier tube.

7. Regarding the quality and quantity of the x-ray beam:

(A) True. X-ray quantity is the number of photons in the beam. As the number of photons increases, the beam intensity increases.
(B) True. X-ray quality is a measure of the x-ray penetrating power.
(C) False. X-ray quantity is affected by many factors including tube current (mA) and tube voltage (kVp).
(D) True. The number of incoming electrons striking target increases as the tube current increases.
(E) True. Filter absorbs low-energy photons from the beam and increases the mean energy of the beam as well as the penetrability of the beam.

8. Linear energy transfer (LET)

(A) False. LET is the total amount of the energy deposited in the material per unit path length it travels (dE/dl).
(B) False. Alpha particles are heavier than electrons and disperse more energy per unit distance travelled.
(C) True. Neutron is a particle.
(D) True. Heavier particles disperse more energy per unit distance travelled.
(E) True. High LET radiation results in lower cell survival per unit absorbed dose compared to low LET radiation.

9. The threshold dose

(A) True. The threshold dose for skin erythema is between 2 and 5 Gy.
(B) False. Cancer is a stochastic effect and has no threshold.
(C) False. Threshold dose for cataract is 5 Gy.
(D) False. The threshold dose for hair loss and skin erythema is the same.
(E) False. The threshold dose for foetal abnormality is lower than sterility.

10. Subject contrast is decreased when

(A) False. Contrast media increases the photoelectric interaction in injected region; thus, subject contrast is increased.
(B) False. Exposure factors (kVp, mA and exposure time) only affect radiographic contrast, not subject contrast.
(C) True. Subject contrast is reduced when tissues are difficult to be distinguished.
(D) False. Fogs from film only affect radiographic contrast, not subject contrast.
(E) False. Grids only affect the radiographic contrast, not subject contrast.

11. A factor that leads to loss of sharpness in film-screen system includes

(A) False. Motion unsharpness is reduced with shorter exposure time.
(B) True. Geometric unsharpness is increased with larger focal spot size.
(C) True. Geometric unsharpness increases with increased magnification.
(D) True. Veiling glare by image intensifier causes unsharpness at periphery.
(E) True. The larger the distance (air gap) between object and imaging plate, causing geometric unsharpness to be more noticeable.

12. Regarding digital flat panel detector in fluoroscopy:

(A) True. Flat panel detector has flat design, making it free from geometrical distortion produced by image intensifier.
(B) True. Flat panel detector has wider dynamic range that influences contrast of the image.
(C) True. Flat panel detector can produce rectangular image.

(D) False. It uses amorphous silicon detector, not caesium iodide.
(E) True. Flat panel detector has a better spatial resolution of 3 line pair/mm in comparison with image intensifier 1–1.2 line pair/mm.

13. Concerning digital subtraction angiography:

(A) True. Identical exposure factor is used in temporal subtraction technique, but different kVp is used in energy technique.
(B) True. Carbon dioxide is a negative contrast used in lower gastrointestinal procedure.
(C) True. Mask image is a non-contrast image taken before contrast medium reaches target area.
(D) False. Pixel shifting is used to reduce misregistration of image.
(E) True. Varying kVp with identical mAs produces images with different radiographic contrasts useful for digital subtraction angiography.

14. Collimation in fluoroscopy

(A) False. Collimation limits the field of view and reduces scatter reaching fluoroscopic detector.
(B) True. Unnecessary region near to organ of interest can be protected with tight collimation.
(C) True. Collimation reduces production of scatter and increases image contrast.
(D) True. Veiling glare is produced by scattering effects in image intensifier.
(E) True. Collimating to the volume of interest decreases the dose to the patient and results in less x-ray scatter production.

15. Method of reducing dose to patient in fluoroscopy includes

(A) True. Last image hold, display the last image on monitor for the reference of operator without introducing an extra dose to patient.
(B) True. Collimation limits unnecessary dose to non-ROI of the patient.
(C) False. Under couch x-ray tube only reduces dose to operator.
(D) True. Pulse dose rate modalities reduce radiation in pulse rather than continuous, resulting substantial dose reduction to patient.
(E) True. Digital fluoroscopy offers signal amplification, therefore dose reduction to patient.

16. Regarding positron decay:

(A) False. It is called beta plus decay.
(B) True. It happens in “proton-rich” radionuclides.
(C) False. It has a charge of +1.
(D) True. The positron will undergo annihilation process to produce two gamma rays for PET imaging.
(E) True. One proton is converted to neutron and reduces the atomic number by 1.

17. Regarding the pulse height analyser (PHA) in a scintillation detector system:

(A) True. PHA is used to select scintillations related to only the photoelectric events in the crystal (those within the photopeak of the gamma ray energy spectrum).
(B) True. PHA rejects all voltage pulses except those occurring within the photopeak of the gamma ray energy spectrum.
(C) False. A wider window reduces the image quality.
(D) True. Multiple channel PHA can be used to resolve entire range of energies into spectrum showing specific peaks.
(E) True. The photopeak is contributed only from photoelectric interaction in the scintillation crystal.

18. Regarding dose received during radionuclide imaging:

(A) True. Patients are advised to drink plenty of water and empty the bladder frequently as to minimise the dose to gonads and pelvic bone marrow.
(B) False. Breastfeeding patient is recommended to stop breastfeeding for an appropriate period following administration of radionuclides.
(C) True. For patient that is or may be pregnant, examination that results in foetal dose greater than 10 mSv should be avoided.
(D) True. The activity of the administered radionuclide should be checked using dose calibrator before the injection.
(E) False. The target organ and organs of excretion received the highest dose compared to other remaining tissues after an intravenous injection.

19. Concerning controlled area:

(A) True. Access of this area is restricted to staff and patient who are required to be present.
(B) False. The staff is likely to receive an effective dose of 6 mSv per year.
(C) True. Radiation protection supervisor has a responsibility to monitor exposure in this area from time to time.
(D) True. Controlled area for portable x-ray unit is 2 m from the x-ray tube and patient.
(E) False. Waiting room for injected patients is classified as supervised area, not controlled area.

20. According to IRR 99, local rules must contain

(A) True. An appropriate summary of the working instructions, including the written arrangements relating to non-classified persons entering or working in controlled areas (HSE, 2000).
(B) True. Name(s) of the appointed radiation protection supervisor(s) (regulation 17(4)).
(C) False. It is an optional content.

(D) False. It is an optional content.
(E) True. The identification and description of the area covered, with details of its designation (regulation 18(1)).

21. According to IRMER 2000, practitioners and operators shall have successfully completed training, including theoretical knowledge and practical experience in

(A) True. Practitioner and operator need to know the biological effects of radiation to the patient to avoid misuse of medical exposure.
(B) True. Practitioner and operator need to have a knowledge of using radiation protection device to protect themselves from unnecessary radiation.
(C) True. Practitioner and operator need to know the fundamental interaction of radiation in patient for a proper use or x-rays.
(D) True. Practitioner and operator need to equip themselves with knowledge on medical and biomedical research to provide a better treatment quality.
(E) True. They should also know the importance of health screening for radiation worker.

22. Regarding tomographic reconstruction:

(A) True. Tomographic reconstruction is a summation of all line integrals (rays) through object at defined angle.
(B) True. A sinogram depicts the intensity plots (histogram) of detected events at all angles.
(C) False. Convolution is performed on the attenuation profiles to reduce the blurring effects by filtering the low-frequency component.
(D) True. The backprojection produces a blurred image due to collimator-detector response.
(E) True. Emission reconstruction measures the events of activity (distribution of radioactive) for each line of response.

23. Regarding filtering in filtered backprojection (FBP):

(A) True. Filter selection results in trade-off between noise and image resolution. A good image resolution will have higher noise or vice versa.
(B) True. Filtering can only be applied directly to each projection in frequency domain.
(C) False. Bow-tie filter is used to compensate the uneven attenuation of the beam. The low-pass filter is used to cut off the high-frequency signals (e.g. Shepp-Logan, Hamming, Hanning and cosine filter).
(D) False. Conversion process of attenuation data into Hounsfield unit (HU) values is known as logarithmic transmission by log amplifier component in data acquisition system.
(E) True. Filtering corrects the blurring effect inherent to backprojection by reducing the low-frequency components in the projection data.

24. Concerning detectors used in CT scanner:

(A) True. Ionisation chamber detectors in CT usually used Xenon or Krypton gas, or combination of both gaseous.
(B) True. Two types of detector array are used in MDCT, fixed array detector and adaptive array detector. Adaptive array detector comprises detector rows with different sizes.
(C) False. The detection efficiency in solid-state detectors is higher (90%) than gas-filled detector (45%).
(D) True. Ceramic material produces higher scintillation efficiency (about three times higher) than cadmium tungstate.
(E) True. Gas-filled detector is better than solid-state detector because of no afterglow effects. Afterglow happened during the conversion of x-ray photons into light by scintillation detector.

25. The dose reduction strategy in CT includes

(A) True. Patient dose is inversely proportional to pitch. Higher pitch value (> 1) will reduce the patient dose because there is gap between the beams.
(B) True. Proper patient centring within the scanner gantry can reduce dose to patients.
(C) True. Limiting the number of contrast phases will reduce the dose to patient.
(D) False. Increase the kVp will increase the dose because radiation output also increased (about 40% for each increment of 20 kV).
(E) False. Unnecessary multiphase exams add substantial excess radiation for both paediatric and adult patients.

26. Resolution in SPECT image is increased by

(A) False. High-resolution collimator is used to increase the SPECT image resolution.
(B) True. Mathematical filter is useful to increase SPECT image resolution.
(C) True. The higher the image bit, the higher the image resolution in SPECT.
(D) False. Smooth reconstruction kernel reduces the spatial resolution in SPECT.
(E) False. Resolution is influenced by the detector sensitivity, not activity of radiopharmaceuticals in patient.

27. Advantage of PET over SPECT includes

(A) True. PET produces better contrast and spatial resolution than SPECT imaging.
(B) False. Patient dose received from PET is similar to that of SPECT imaging.

(C) True. PET has increased sensitivity compared to SPECT and leads to improved image quality with lesser noise.
(D) True. PET scanner has a ring of detectors, and no collimator is required because detection of PET is based on coincidence detection.
(E) True. PET uses shorter half-life radionuclides (minutes) compared to SPECT radionuclides (hours).

28. Radionuclide produced in a cyclotron includes

(A) True. ^{111}In is produced in a cyclotron through the proton reaction on cadmium.
(B) True. ^{123}I is produced in a cyclotron through the proton reaction on Xenon-123 precursor that decays to Iodine-123.
(C) True. ^{222}Xe is produced in a cyclotron through the proton reaction on Iodine-127.
(D) True. ^{11}C is produced in a cyclotron through the proton reaction with nitrogen gas.
(E) False. ^{99m}Tc is produced in a radionuclide generator.

29. Concerning Larmor frequency of a nucleus:

(A) True. Larmor frequency is proportional to magnetic field strength and is described by the equation:

$$\omega_O = B_O \times \lambda$$

where ω_O is the precessional frequency, B_O is the magnetic field strength, and λ is the gyromagnetic ratio (constant = 42.6 MHz/T for hydrogen).
(B) False. The precession frequency of protons is different at different field strengths.
(C) False. At 1.5 T, the Larmor frequency of hydrogen is 63.9 MHz ($\omega_O = B_O$ x λ = 42.6 x 1.5 T).
(D) True. Each MR active nuclei has specific gyromagnetic constant and will precess at different frequencies in the same magnetic field strength.
(E) True. Both spin-up and spin-down protons precess at the same frequency, but they aligned at different direction to the magnetic field.

30. Regarding free induction decay (FID) in NMR:

(A) True. Reduction of magnetisation at transverse plane is due to dephasing of nuclei or loss of coherent magnetisation. It is termed as spin-spin relaxation or T2 decay.
(B) True. As the magnitude of transverse magnetisation decreases, the magnitude of the induced voltage in receiver coil also decreased. The reduced signal is termed as free induction decay (FID) signal.
(C) True. FID occurs when RF pulse is switched off (free means free from RF pulse).
(D) False. Magnetic moments of nuclei lose coherency due to dephasing (out of phase).

(E) True. The nuclei giving up their energy to the environment (from spin-down back to spin-up alignment). The magnetic moments of nuclei recover their longitudinal magnetisation.

31. Regarding MR signal:

(A) True. Gradients are applied for spatial localisation of MR signal at X, Y and Z axes.
(B) False. Spin echo produces greater signal strength compared to gradient echo.
(C) True. Air has no protons to resonate and produces no signals. Thus, it appears black in MR image.
(D) False. Signal along the short axis is localised using spatial encoding and along the long axis is by the frequency encoding.
(E) True. The intensity of MR signal is proportional to proton or spin density (spin density = concentration of nuclei precessing at Larmor frequency).

32. Technique to improve image acquisition speed in MRI includes

(A) True. Gradient echo (GE) sequences use variable flip angles (less than 90°) and can be acquired using short TR; therefore, scan time can be reduced without producing saturation.
(B) True. Fast spin echo (FSE) or turbo spin echo (TSE) imaging is one of the rapid acquisitions with refocused echoes (RARE) technique that used multiple phase-encoding during each TR interval and significantly reduced imaging time.
(C) False. Inversion recovery technique uses long scan times (long TR).
(D) True. Echo-planar imaging (EPI) can acquire more echoes in single RF excitation and shorten the acquisition time.
(E) True. Parallel imaging used multiple coils around the area to be imaged, and multiple lines in K space are filled per TR and therefore reduce scan times.

33. Regarding safety precautions in MRI:

(A) True. Any electrically conductive material such as cable of surface coil should be prevented from being placed near surface coils because it has potential of forming a conductive loop with itself or with the patient.
(B) False. Most of the prosthetic heart valves are MR safe and cause minimal deflection in magnetic field, and careful screening is advisable.
(C) False. When quenching occurs, the room ventilation should be turned on to remove the helium to the outside environment because it can increase pressure inside closed room.
(D) True. Tattoos can heat up during scanning, and cool wet cloth is recommended to be placed on tattoos to dissipate heat.
(E) True. Pregnant patients are not recommended to be screened during the first trimester because developing foetus is more susceptible to adverse effects of electromagnetic field.

34. Regarding ultrasound transducer:

(A) False. The frequency of transducer depends on the frequency of alternating current applied to the transducer.
(B) True. Piezoelectric crystals change size and shape when a voltage is applied, and alternating current (AC) voltage makes them oscillate at the same frequency and produces ultrasonic sound.
(C) False. Ultrasound transducer converts electrical energy to ultrasound wave.
(D) False. Lead zirconate titanate (PZT) is used.
(E) True. Backing layer provides impedance matching layer to ensure maximum energy transfer into and out of the patient.

35. Regarding lateral resolution of ultrasound imaging:

(A) True. Lateral resolution of the image is better if it is located at near field.
(B) True. Increasing the frequency can improve lateral resolution but reducing the depth of penetration.
(C) True. If two structures at the same depth and the beam width is narrower than the gap, single structure image will be produced using normal transducer size. In this case, small transducer is best to display the lateral resolution.
(D) False. Lateral resolution only depends on frequency, transducer diameter and depth.
(E) False. The B-mode determines the brightness of each point by the amplitude of the returned echo signal. It is not related to lateral resolution of ultrasound.

36. Advantage of tissue harmonic imaging includes

(A) True. Tissue harmonic imaging reduces acoustic noise; thus, liquid-filled cavities are better visualised.
(B) True. Low amplitude echoes do not produce harmonics; therefore, reverberation artefacts are reduced.
(C) False. Tissue harmonic imaging technique takes longer imaging time.
(D) True. Scattering from fatty tissues is reduced, as this is at the fundamental frequency, and thus it is suppressed.
(E) True. Reduction of acoustic noise provides better visualisation of low-contrast lesion and liquid-filled cavities.

37. The potential bio-effect of ultrasound to human includes

(A) True. Ultrasound wave produce heating and indicated as thermal index value.
(B) True. Ultrasound imaging causing microbubbles in a liquid to expand and cause cavitation.
(C) True. Local heating due to frictional, viscous and molecular relaxation process.

(D) False. It is caused by ionizing radiation.
(E) True. Acoustic streaming of cellular contents in the direction of the beam, affecting cell membrane permeability.

38. Regarding fluorescent imaging:

(A) True. For example, in spectrally encoded endoscopy.
(B) False. Fluorescent dye is used.
(C) True. For example, bioluminescent imaging and tissue spectroscopy.
(D) False. The technique does not involve ionising radiation.
(E) True. Different light filters allow different light wavelength to pass through.

39. The multimodality integration used for functional neuroimaging includes

(A) False. Diffusion tensor imaging (DTI) is an MRI-based neuroimaging technique and is not a multimodality integration technique with other related MR techniques.
(B) True. Near-infrared optical spectroscopy (NIRS) is a functional neuroimaging modality to investigate the cerebral hemodynamic. NIRS can be used as independent neuroimaging method or in combination with MRI.
(C) True. Functional neuroimaging is the study of human brain function based on analysis of data acquired using brain imaging modalities such as electroencephalography (EEG) combined with PET imaging.
(D) False. BOLD contrast fMRI is not a multimodality integration. It is a method in fMRI. But, there is a growing interest in combining the EEG-fMRI techniques in neuroimaging study.
(E) True. Hybrid PET-MRI technique measures haemodynamic changes induced by regional changes in neuronal activity.

40. Regarding imaging agents used in functional and molecular imaging (FMI):

(A) True. ^{18}F-FDG is a novel imaging biomarker that measures glycolytic activity of the cells in PET imaging.
(B) True. MR spectroscopy (MRS) measures the concentration of marker molecules such as lipids, lactate, choline, creatine and glutamine. MRS produces a spectrum of the chemical shift between different elements in human tissues.
(C) True. Iron in deoxyhaemoglobin is a paramagnetic contrast agent and has positive magnetic susceptibilities. Deoxyhaemoglobin creates an inhomogeneous magnetic field and increases T2* decay.
(D) True. The advantage of perfluorocarbon nanodroplets as contrast agent in CEUS is its smaller size. The size is roughly five times smaller than gas microbubbles.
(E) False. Apparent diffusion coefficient (ADC) is used as marker in diffusion-weighted MRI.

Examination Nine: Answers

1. Optical density is

(A) True. Optical density (OD) = $\log_{10}$ (I_0/I_1) where I_0 is the incident light intensity and I is the transmitted light intensity.
(B) True. Densitometer is a tool to measure OD. OD is often measured for film.
(C) True. The film is darker with higher OD value.
(D) True. Radiographic density is also known as OD.
(E) False. Optical density is 0 if 100% of light is transmitted, 100/100 = 1, log 1 = 0.

2. Regarding photostimulable phosphor used in computed radiography (CR):

(A) True. The phosphor requires light input to release the trapped energy in the form of light.
(B) True. The common phosphor used is barium fluorohalide doped with europium (BaFX(Eu)).
(C) True. The plate is inserted into a light-tight cassette.
(D) False. It requires light stimulation, for example, laser beam that moves across the plate.
(E) False. It is reusable by removing the stored energy in the plate using exposure to a bright light source.

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
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3. Regarding image quality in radiography:

(A) False. Increasing the mA increases the image quality by increasing the signal-to-noise ratio at the expense of increasing patient dose.
(B) True. Compression reduces scatter and improves the contrast.
(C) True. A grid placed between the patient and the receptor absorbs the scatter and increases contrast.
(D) True. The latitude is the range of detector exposures that forms an image and determines the contrast.
(E) True. Less volume irradiated will result in less x-ray scatter.

4. Isotopes of an element

(A) True. Isotopes have different number of neutrons.
(B) False. Isotopes have different physical properties.
(C) True. A number of protons determine the chemical element.
(D) False. Not all isotopes are stable. Carbon-12 is a stable isotope, while carbon-14 is a radioactive isotope (radioisotope).
(E) True. A number of neutrons between isotopes are different.

5. Regarding the intensity of x-ray produced in an x-ray tube:

(A) True. Intensity is the energy fluence per unit time.
(B) False. Energy fluence is the number of photons multiplied with the mean photon energy.
(C) True. The intensity is proportional to mAs.
(D) True. The intensity is reduced by one over square of the distance which follows inverse square law.
(E) True. The intensity is approximately proportional to the square of kV

6. The mass attenuation coefficient is

(A) False. It is a linear attenuation coefficient divided by the density of the material it passes.
(B) False. It is dependent of the material density.
(C) False. The unit is cm^2/g.
(D) True. The product of the mass thickness in g/cm^2 and mass attenuation coefficient in cm^2/g is the attenuation of the beam.
(E) False. Hounsfield unit (HU) uses linear attenuation coefficient.

7. Regarding anode angle:

(A) True. Anode angle of 12–15° is most common.
(B) False. Anode angle is the angle of the anode surface with respect to the central ray in the x-ray field.
(C) False. Smaller angle decreases the field coverage.
(D) False. Smaller angle improves geometric unsharpness.
(E) True. The heel effect is more pronounced with steeper anode angle.

8. Regarding the deterministic and stochastic effects of radiation:

(A) False. There is no threshold for stochastic effect, but deterministic effect has threshold.
(B) True. Sterility is considered as deterministic effect because the effect occurs immediately after the irradiation.
(C) True. Below threshold, cells can repair.
(D) True. The effect may occur in descendants of the exposed individuals.
(E) False. Cataract has a dose threshold, and thus, it is a deterministic effect.

9. Regarding radiation damage to DNA:

(A) True. This is an indirect action of DNA damage.
(B) True. Cell death due to radiation can be via direct action and indirect action of DNA damage.
(C) True. This is useful to kill the cancer cells in radiotherapy.
(D) False. Gamma rays are indirectly ionising radiation and thus cause indirect damage. Particles are directly ionising and cause direct damage.
(E) False. The damage is repairable if below threshold dose.

10. Regarding digital radiography (DR) detectors:

(A) True. Scintillating material is used to convert x-rays to lights in DR detectors.
(B) False. Active matrix array (AMA) is made of an amorphous silicon doped with hydrogen.
(C) True. There is no latent image stage in DR; image is converted immediately after exposure.
(D) True. Amorphous selenium is ionised with x-ray irradiation to produce charges directly from the process.
(E) False. There is no change in dose between direct and indirect DR detector. Dose is dependent on exposure factors.

11. Cause of misregistration in digital subtraction angiography includes

(A) True. Peristalsis is an involuntary movement that can cause misregistration.
(B) True. It is a voluntary movement that can cause shift in coordinate of images.
(C) False. Contrast concentration does not cause misregistration in DSA.
(D) True. Cardiac motion is involuntary movement of cardiac muscle that can cause misregistration.
(E) False. Metal implant causes streak artefact, not misregistration.

12. Concerning the input screen in image intensifier:

(A) False. Input phosphor converts the x-rays photons to visible light.
(B) True. Caesium iodide is a scintillating material used as input phosphor layer.

(C) True. Photocathode layer converts lights to electrons in image intensifier.
(D) True. Input screen is larger compared to output screen to provide minification gain of an image produced.
(E) False. Caesium iodide layer is used in input screen not zinc cadmium sulphide layer.

13. Artefact in fluoroscopy imaging includes

(A) True. Fluoroscopic systems also experience temporal blurring due to system lag. This temporal blurring has the effect of averaging frames together.
(B) False. Ring artefact is an artefact in CT, not fluoroscopy.
(C) True. Pincushion distortion is magnification toward the edges of images produces by curvature of input screen.
(D) True. Veiling glare is produced by the scattering effects in the image intensifier.
(E) True. Vignetting happens when central area of image is brighter than periphery.

14. Concerning dose in fluoroscopic procedure:

(A) True. In zoom option, kV and mAs will be increased; therefore the patient entrance skin dose will also increase.
(B) True. Automatic brightness control adjusts the image brightness by increasing either kV or mA, therefore related with entrance dose rate.
(C) True. Reducing fluoroscopy pulse rate mean reducing number of exposure per unit of time.
(D) True. Scattered dose rate is higher near the area which the x-ray enters the patient.
(E) True. Increasing filter thickness will increase absorption of low scatter radiation from reaching patient skin.

15. Technique for reducing dose to patient in fluoroscopy imaging includes

(A) False. Filter is used to filter low-energy photon to patient not grid.
(B) True. Iso-centric imaging distributes entrance dose to multiple skin areas of the patient.
(C) True. Last image hold displays last image as a reference for operator without turning to reduce dose to patient significantly.
(D) False. Image magnification in fluoroscopy increases dose to patient.
(E) True. Use of pulse fluoroscopy able to reduce dose to patient compared to continuous fluoroscopy modality.

16. The half-life of a radionuclide

(A) True. The values range from milliseconds to years.
(B) True. The tendency of the nucleus to decay is based on probability.
(C) False. The half-life is time taken for 50% of the radionuclide to decay.
(D) True. It is independent of the nuclide physical state.
(E) True. Decay constant is equal to 0.693 divided with the half-life.

17. Regarding collimators used in planar imaging:

(A) False. Convergent hole collimator is useful for imaging children and smaller organs.
(B) True. Divergent hole collimator produces larger FOV, and the organ of interest appears larger at the face of crystal.
(C) False. Low-energy collimator is used for imaging with ^{99m}Tc radionuclide, while medium-energy collimator is used with energy source up to 400 keV such as ^{111}In, ^{67}Ga, and ^{131}I.
(D) True. High-sensitivity collimator has larger holes to allow more scattered photons to be counted. High-resolution collimator has smaller and deeper holes to produce higher-resolution images.
(E) True. A pinhole collimator generates magnified images of small organ and is preferable for imaging the superficial small organ.

18. Regarding image quality in gamma camera:

(A) True. Routine measurement of spatial resolution for a gamma camera is performed using a four-quadrant bar test pattern.
(B) False. Sensitivity is increased with crystal thickness. The thicker the crystal, the higher the quantum detection efficiency.
(C) True. The nearer the source to detector, the better the resolution of the image.
(D) True. Scattered radiation reduces image contrast in gamma camera. It is filtered using collimator in gamma camera imaging.
(E) False. Resolution is reduced with crystal thickness.

19. Regarding radiation protection in radiographic procedure:

(A) True. A 2 mm lead protective barrier is sufficient to shield maximum x-ray energy of 140 kVp from radiographic procedure.
(B) True. A comparison of measured radiation doses using over-couch versus under-couch systems revealed that radiation doses to the forehead and finger are about fivefold to sixfold greater.
(C) False. Thyroid shield used in radiology is 0.5 mm lead equivalent thickness.
(D) True. Tight collimation reduces scatter radiation production.
(E) True. The distance can reduce dose significantly to patient skin during fluoroscopy examination.

20. Regarding dose records in IRMER 2000:

(A) True. Classified persons must have an assessment of their dose of ionising radiation made by an approved dosimetry service and their dose records must be kept by their Employer for at least 50 years or until the individual reaches the age of 75 (Regulation 21 (3a).
(B) True. Persons who are likely to receive an effective dose more than 6 mSv per year or three-tenths of any relevant dose limit must be classified (Regulation 20 (1).
(C) False. Health records for classified staff are kept for at least 50 years.
(D) True. This should also trigger a review of working conditions in the event of recorded doses exceeding the appropriate investigation level.
(E) False. Dose excess of 6 mSv per year must be classified.

21. According to IRR 99, an incident should be reported if a patient received

(A) False. For mammogram, it is 10 times the intended dose.
(B) True. Refer to the table below.
(C) False. For skull x-ray, it is 20 times the intended dose.
(D) True. Refer to the table below.
(E) True. Refer to the table below.

Guidelines on incident involving patient overexposures from examinations

Diagnostic examinations	Multiplying factor for intended dose
Interventional radiology	1.5
Radiographic and fluoroscopic contrast study	1.5
Nuclear medicine with intended $D_{eff} > 5$ mSv	1.5
CT examinations	1.5
Mammography	10
Nuclear medicine with intended $D_{eff} < 5$ mSv but >0.5 mSv	10
Other radiographic examinations	10
Radiography of extremities, skull, dental, shoulder, chest, elbow and knee	20
Nuclear medicine with intended $D_{eff} < 0.5$ mSv	20

(Allisy-Roberts. *Farr's Physics for Medical Imaging.* 2nd Edition, W.B. Saunders Co. Ltd)

22. Concerning reconstruction kernel:

(A) True. Smooth kernel is used for imaging the low-contrast areas such as brain, abdomen, liver and soft tissues.
(B) True. High-pass filter will cut off the low-frequency signal that contributes to blurring effects.
(C) True. Bone kernel is a sharper kernel and known as edge-enhancement kernel because it produces image with high spatial resolution and sharpen the edges.

(D) True. Sharper kernel is used for imaging the high-contrast areas such as musculoskeletal, bones, inner ear and lung, which require better spatial resolution.
(E) False. Smooth kernel produces smoother images with lower image noise.

23. The iterative reconstruction (IR) technique

(A) True. IR is capable of reconstructing an optimal image from incomplete projection data or limited angular range of projection data.
(B) True. IR is based on estimation and the correction of projection data is repeated until a condition predefined by the algorithm is fulfilled and the final image is generated.
(C) True. IR corrects the beam hardening effects and thus reduces the metal streak artefacts.
(D) False. IR technique results in higher spatial resolution as compared to FBP technique.
(E) True. IR technique reduces the image quantum noise and thus reduces radiation dose.

24. Regarding high-pitch technique in helical CT:

(A) True. Higher-pitch technique (>1) can reduce scan time as it can cover larger scan length with shorter acquisition time.
(B) False. The gated cardiac CT uses low-pitch technique because the scanner must acquire images of the entire heart during diastole, so it has to cover each point multiple times.
(C) True. Higher-pitch technique will reduce the patient dose because dose is inversely proportional to pitch.
(D) True. When pitch is high (>1), resolution is poor. The gap between the beam requires greater interpolation on the data and causes loss of resolution.
(E) False. The low-pitch technique produces more respiratory motion artefact.

25. Regarding image quality in CT:

(A) False. Increasing slice thickness will increase the partial volume effect.
(B) False. CT noise is reduced by increasing the voxel size, because more photons are to be detected.
(C) True. Reducing the field of view (FOV) will reduce the voxel size. Smaller voxel size allows smaller structures to be imaged and thus improve the spatial resolution.
(D) True. Soft reconstruction kernel or smooth kernel improves the low-contrast lesions detectability.
(E) False. Narrowing the window width will increase the image contrast because of the small differences in CT numbers (grayscale range).

26. Regarding the principles of single-photon emission computed tomography (SPECT):

(A) True. SPECT system consists of multiple gamma cameras that continuously rotate around patient.
(B) False. The system sensitivity is increased as triple-headed camera is used.
(C) True. Iterative reconstruction produces more accurate attenuation correction and less sensitive to noise as compared to filtered backprojection.
(D) True. Gamma ray attenuation inside patient results in fewer counts at the centre than the edges of patient. SPECT has algorithm for gamma attenuation correction during image reconstruction.
(E) True. The gamma camera must have sufficient circular orbit of movement to miss the patient's shoulders. An elliptical orbit is recommended to optimise the distance around the patient.

27. Concerning image quality of SPECT imaging:

(A) True. SPECT images usually have limited number of counts when compared to planar imaging; therefore SPECT images contain more noise. Noise is based on the number of counts per slice.
(B) False. The spatial resolution in SPECT is worse than in conventional planar imaging, but contrast resolution is improved.
(C) True. Area with very high activity (has excessively high count rate) may cause streaking artefacts in reconstructed image.
(D) True. Noise can be reduced by increasing the thickness of the reconstructed image. Thicker slices will allow for more counts per pixel and therefore reduce image noise and increase the signal-to-noise ratio.
(E) False. The spatial resolution in SPECT can be improved using high-resolution collimator. A high-sensitivity collimator produces low spatial resolution.

28. The positron emitter used in PET imaging includes

(A) True. ^{18}F is the most common positron emitters used in PET, having a half-life of 110 min.
(B) False. ^{133}Xe is not a positron emitter. It emits beta rays and gamma rays and is used in lung ventilation imaging.
(C) True. ^{68}Ga is a positron emitter produced by radionuclide generators, having a half-life of 68 min.
(D) True. ^{82}Rb is a positron emitter with short half-life of only 1 min and is also produced by radionuclide generator.
(E) False. ^{123}I is not a positron emitter. It emits gamma rays and is used in SPECT.

29. Regarding nuclear magnetic resonance (NMR) principles:

(A) False. Each MR active nuclei has specific gyromagnetic constant value and will precess at its own precessional frequencies in the same magnetic field strength.
(B) False. The magnetic moments of the nuclei move into phase with each other.
(C) True. MR active nuclei have an odd number of protons and have tendency to align with the applied magnetic field.
(D) False. More nuclei are aligned parallel to the magnetic field than the antiparallel nuclei.
(E) True. As the magnetic field strength increased, the energy difference between two populations (spin-up and spin-down nuclei) increases. Thus, the magnitude of NMV is larger.

30. Regarding resonance induced by RF pulses in MRI:

(A) True. During resonance, nuclei gained energy from RF pulse and become high-energy nuclei. The high-energy nuclei aligned at opposite directions of the magnetic field (spin-down nuclei), and the NMV moves out of alignment from magnetic field.
(B) True. All magnetic moments move at the same precessional path around B_o (in phase).
(C) True. The absorption of energy from applied RF pulse causes excitation of nuclei.
(D) False. 90° flip angle completely rotates the NMV from longitudinal to transverse plane.
(E) True. For resonance to occur, the applied RF pulse must have energy exactly at the same precessional (Larmor) frequency.

31. Concerning magnetic resonance imaging (MRI):

(A) True. The k-space stores an organised collection of spatial frequencies of MR signal. Resultant MR signal at each point in time represents the spatial frequencies and phase angles from all locations in the image.
(B) False. Higher proton density tissue appears bright in MR image (high signals).
(C) True. The gradients are used to control the slice thickness and FOV. The steeper the frequency and the phase-encoding gradients, the smaller the FOV.
(D) True. T1 is the time taken for longitudinal magnetisation to recover approximately 63% [1 – 1/(e)] of its initial value after RF pulse is applied.
(E) True. Air and hard bone do not give any MRI signal, so these areas appear black and do not produce any artefacts.

32. Regarding pulse sequences in MRI:

(A) True. The pulse sequence consists of RF pulses and pulsed field gradients with several time periods such as TR and TE.
(B) False. Echo time (TE) controls the amount of T2 weighting, while the repetition time (TR) controls the amount of T1 weighting in image
(C) True. 180° pulse causes rephasing of protons in a spin-echo sequence after the applied RF pulse is switched off.
(D) True. An inversion recovery pulse sequence begins with 180° inverting pulse followed by 90° excitation pulse at TI (time from inversion).
(E) True. Spin-echo (SE) sequence is used clinically as a preferable method for obtaining high-quality images.

33. Regarding safety in MRI:

(A) True. Specific absorption rate (SAR) is defined as the rate of radiofrequency (RF) power absorbed (increased body temperature) per unit mass by any part of the body.
(B) True. Anyone with cardiac pacemaker should be excluded from areas where stray fields greater than or equal to 0.5 mT (5 Gauss).
(C) False. Hearing protection is required for all patients to prevent irreversible hearing damage.
(D) False. The SAR limits are different for each part, 4 W/kg for body and 12 W/kg for extremities (FDA limit).
(E) True. For safety purposes, the 5 G line should be restricted with at least two physical barriers and signage to exclude access by members of the public.

34. Parameter that affects ultrasound velocity includes

(A) True. The higher the density of tissue, the slower the velocity of ultrasound wave.
(B) False. Voltage of ultrasound transducer does not affect ultrasound velocity.
(C) True. Velocity is equal to wavelength multiplied by frequency.
(D) False. Shape and diameter of transducer do not affect velocity of ultrasound wave.
(E) True. Velocity is equal to wavelength multiplied by frequency.

35. Regarding Doppler effect:

(A) True. The period of ultrasound wave is decreased when object is moving towards the transducer; therefore the frequency is increased.
(B) False. Velocity of sound does not change; only frequency changes.
(C) True. This is happened when $\theta = 0$. Cos 0° = 1.
θ = angle between the ultrasound beam and the vector of red blood cell flow.

(D) True. There is no change in period and frequency if the reflector is static.
(E) False. This is happened when $\theta < 90^{o}$.

36. Regarding ultrasound equipment:

(A) True. Cardiac transducer is able to do M-mode, B-mode and real-time scanning.
(B) True. A stand for amplitude which measures the distance.
(C) True. Doppler measures the direction and velocity of blood.
(D) True. This annular array produces different frequencies of sound and converts electrical pulse into ultrasound pulses.
(E) True. The crystals in linear array are aligned in a linear fashion within a flat head and produce sound waves in a straight line to produce a rectangular in shape image.

37. Method of quantifying biological effects of ultrasounds includes:

(A) False. It is used to quantify dose in organs in nuclear medicine.
(B) False. It is used to quantify effects of ionising radiation.
(C) True. Mechanical index gives information regarding the power deposition to the patient.
(D) True. It is the ratio of the acoustic power reduced by the transducer to the power required to raise tissue in the beam area by 1 °C.
(E) True. The spatial peak-temporal average intensity, $I_{SPTA} = I_{SATA}(I_{sp}/I_{sA})$, which is a good indicator of thermal ultrasound effects.

38. Regarding bioluminescent imaging:

(A) True. Bioluminescence imaging utilises native light emission from a bioluminescent organism.
(B) True. Luminescent light is produced by the tissue sample.
(C) True. It enables study of ongoing biological processes in vivo.
(D) False. The non-invasive method can provide real-time luminescence information from the organism.
(E) True. A CCD camera is used to detect the visible light from bioluminescent.

39. Technical requirement for functional imaging includes

(A) True. Functional imaging requires larger FOV which is helpful in image interpretation.
(B) True. Temporal resolution (TR) refers to the precision of a measurement with respect to time. Functional imaging requires modality that is able to describe an accurate temporal scale with functional event that occurred (time-of-flight method).
(C) False. It should offer non-rigid image registration for easier image integration between different modalities.

(D) True. It should offer faster acquisition times and significantly reduce dose to patients.

(E) True. Functional imaging is capable for measuring and quantitatively analyse any changes in metabolism, blood flow, regional chemical composition and absorption.

40. Comparison of imaging modalities for functional and molecular imaging (FMI)

(A) True. Ultrasound offers less quantitative information (limited) compared to optical imaging (semi-quantitative).

(B) True. Both ultrasound and optical imaging can be applied externally and internally (endoscopy).

(C) False. Optical imaging has shorter acquisition time (sec-min) than ultrasound (min).

(D) True. MRI offers better soft tissue contrast than CT imaging. MRI has greater range of available soft tissue contrast, can depict anatomy in greater detail and can better differentiate between normal and abnormal tissues.

(E) True. Both PET and SPECT have unlimited depth penetration through human tissue (can visualise deeper structures).

References

Allisy-Roberts P, Williams J (2008) Farr's physics for medical imaging, 2nd edn. W.B. Saunders, Philadelphia
The Ionising Radiations Regulations 1999. SI 1999/3232 The Stationery Office, UK
The Medicines (Administration of Radioactive Substances) Regulations 1978, SI 1978/1006, Stationary Office, ISBN 0-11-084006-2
Westbrook C (2002) MRI at a glance, 1st edn. Blackwell Science, Oxford
Westbrook C, Roth CK, Talbot J (2005) MRI in practice, 3rd edn. Blackwell Science, Oxford

I. L. Shuaib et al., *FRCR Physics MCQs in Clinical Radiology*,
https://doi.org/10.1007/978-981-13-0911-3