CT Instrumentation 2

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. The detectors convert the attenuation data into _____ signals.
   a. digital
   b. electrical
   c. light
   d. mechanical

____ 2. What form of archiving has proven most popular among CT departments?
   a. Film-based recording
   b. Optical card
   c. Picture archiving and communication system
   d. Magnetic tapes

____ 3. Data from the CT detectors are first sent to the _____ before going to the computer.
   a. array processor
   b. host computer
   c. back-projector
   d. digitizers

____ 4. A high-kilovolt (kV) technique is necessary in CT imaging for all of the following reasons *except*:
   a. to reduce the contrast of bone relative to soft tissues.
   b. to increase the probability of beam hardening.
   c. to reduce the dependence of attenuation coefficients on photon energy.
   d. to produce a high-radiation flux at the detector.

____ 5. Which X-ray generator is used in modern CT scanners?
   a. Single-phase half-wave rectified
   b. Single-phase full-wave rectified
   c. High-frequency generator
   d. Three-phase, six-pulse generator

____ 6. Which of the following X-ray tubes is most likely used in spiral/helical CT scanners?
   a. A tungsten target fixed anode tube
   b. A tungsten target rotating anode tube
   c. A molybdenum target rotating anode tube
   d. A rotating anode tube with a rhenium tungsten disk

____ 7. All of the following are radiation beams produced by an X-ray tube designed for CT *except*:
   a. homogeneous beam.
   b. heterogeneous beam.
   c. polychromatic beam.
   d. polyenergetic beam.

____ 8. The main purpose of a filter used in CT is to:
   a. reduce the intensity of the beam at the detector.
   b. make the beam less uniform at the detector.
   c. decrease the mean energy at the detector.
   d. protect the patient.

____ 9. What style of filter is common in CT filtration because it compensates for the difference in beam path length through the axial plane of the object such that a more uniform fluence can be delivered to the detector?
   a. Straight filter
   b. Bowtie filter
   c. Cone filter
   d. Star filter

____ 10. The purpose of collimation in CT is each of the following *except*:
   a. create an homogenous beam.
   b. to protect the patient.
   c. to ensure a constant beam width at the detector.
   d. to reduce scatter radiation.

____ 11. The slice thickness in CT is determined by the:
   a. focal spot.
   b. anode.
   c. collimator height.
   d. collimator width.

____ 12. Which of the following refers to the ability of the CT detector to capture, absorb, and convert X-ray photons into electrical energy?
   a. Efficiency
   b. Stability
   c. Response time
   d. Dynamic range

____ 13. Which detector characteristic refers to the steadiness of the detector response?
   a. Efficiency
   b. Stability
   c. Response time

d. Dynamic range

____ 14. The speed with which a CT detector can detect an X-ray event and recover to detect another event is the:
a. response time.
b. stability.
c. efficiency.
d. dynamic range.

____ 15. The ratio of the largest signal to the smallest signal measured by a CT detector is the:
a. response time.
b. dynamic range.
c. efficiency.
d. stability.

____ 16. The following crystals have been used in scintillation CT detectors except
a. bismuth germiate
b. calcium tungstate.
c. Sodium fluoride.
d. sodium iodide (NaI).

____ 17. Which of the following is commonly used in gas-ionization CT detectors?
a. Xenon
b. Oxygen
c. Neon
d. Helium

____ 18. The data acquisition system (DAS) performs each of the following functions *except*:
a. measures the transmitted radiation beam.
b. encodes these measurements into binary data.
c. powers the rotating components of the gantry.
d. transmits the binary data to the computer.

____ 19. What provides doubling sampling by obtaining two overlapping slices for each detector row per 360-degree rotation?
a. z-flying focal spot technique
b. Double-dynamic focus
c. Quarter-shifted detection
d. Aliasing method

____ 20. The collimator that limits the patient's radiation exposure is the:
a. prepatient collimator
b. predetector collimator
c. A and B
d. none of the above

____ 21. The collimator that reduces the amount of scatter produced in the patient is the:
a. prepatient collimator
b. predetector collimator

c. A and B
d. none of the above

____ 22. This collimator is located between the tube and the patient.
a. prepatient collimator
b. predetector collimator
c. A and B
d. none of the above

____ 23. The detector found between the patient and the detectors is the:
a. prepatient collimator
b. predetector collimator
c. A and B
d. none of the above

____ 24. The collimator that improves image contrast by limiting the amount of scatter radiation that reaches the detector is the:
a. prepatient collimator
b. predetector collimator
c. A and B
d. none of the above

____ 25. *DAS* stands for:
a. digital absorption system
b. data acquisition system
c. diode acquisition system
d. data absorption system

____ 26. The DAS is located:
a. just below the couch
b. inside the x-ray tube
c. within the gantry
d. none of the above

____ 27. It is important to balance reductions in patient dose with:
a. examination cost
b. image quality
c. scan time
d. all of the above

____ 28. Automatic tube current modulation is a method:
a. to reduce patient exposure
b. to improve image quality
c. similar to automatic exposure control
d. A and C

True/False
Indicate whether the statement is true or false.

____ 1. Gas-ionization detectors (xenon gas) are used in the majority of commercial CT scanners today.

____ 2. Processing images by computer is referred to as digital image processing.

____ 3. Scintillation detectors convert X-ray photons to light and subsequently to electrical signals.

____ 4. Gas-ionization CT detectors convert X-ray photons into electrical signals with no light conversion process in-between.

____ 5. Photodiodes are now used in CT scintillation detectors.

____ 6. The high-voltage generators of slip-ring scanners are located in the gantry.

____ 7. High-frequency generators use a low-frequency inverter circuit to convert the low-voltage current from the main power supply to the high-voltage current required by the CT X-ray tube.

____ 8. Afterglow refers to the persistence of the image even after the radiation has been turned off.

____ 9. The CT gantry is stationary and cannot be tilted.
A. True
B. False

____ 10. The scintillation-type detector is commonly used in today's CT scanner.
A. True
B. False

Matching

Please match the following data acquisition concepts. All answer selections will be used just once.

a. Data acquisition system
b. Flashes of light
c. Beam hardening
d. Xenon gas
e. Slice thickness
f. Photodiode
g. Continuous gantry rotation

____ 1. Scintillation

____ 2. Ionization detector

____ 3. Slip-ring design

____ 4. Detector electronics

____ 5. Filtration

____ 6. Collimation

____ 7. Semiconductor

CT Instrumentation 2
Answer Section

MULTIPLE CHOICE

1. ANS: B
   The detectors convert the X-ray photons (attenuation data) into electrical signals or analog signals.

   PTS: 1 REF: p. 5
2. ANS: C
   CT departments now operate in a picture archiving and communications systems environment that allows the flow of CT data and images among devices and people not only in the radiology department but throughout the hospital as well.

   PTS: 1 REF: p. 5
3. ANS: D
   Before the data are sent to the computer, they must be converted into digital form. This is done by the analog to digital converters, or digitizers.

   PTS: 1 REF: p. 63
4. ANS: B
   In CT, a high-kV technique (about 120 kV) is generally used to reduce the dependence of attenuation coefficients on photon energy, reduce the contrast of bone relative to soft tissues, and produce a high-radiation flux at the detector.

   PTS: 1 REF: p. 58
5. ANS: C
   CT scanners now use high-frequency generators, which are small, compact, and more efficient than conventional generators.

   PTS: 1 REF: p. 76
6. ANS: D
   The brazed graphite anode disk consists of a tungsten-rhenium focal track brazed to a graphite base body. Graphite increases the heat storage capacity because of its high thermal capacity, which is about 10 times that of tungsten. The material used in the brazing process influences the operating temperature of the tube, and the higher temperatures result in higher heat storage capacities and faster cooling of the anode. Tubes for spiral/helical CT scanning are based mostly on this type of design.

   PTS: 1 REF: p. 77
7. ANS: A
   In clinical CT the beam is polychromatic, also called polyenergetic and heterogenous.

   PTS: 1 REF: p. 81
8. ANS: D

Filtration removes long wavelength X-rays because they do not play a role in CT image formation but instead contribute to patient dose. By eliminating long wavelengths, the patient's dose is reduced.

PTS: 1 REF: p. 81

9. ANS: B
Today, specially shaped filters conform to the shape of the object and are positioned between the X-ray tube and the patient. The term "bowtie" applies to a class of filter shapes featuring bilateral symmetry with a thickness that increases with the distance from the center. Bowtie filters compensate for the difference in beam path length through the axial plane of the object such that a more uniform fluence can be delivered to the detector.

PTS: 1 REF: p. 82

10. ANS: A
Collimation in CT plays a role in patient dose, ensures a constant beam width at the detectors, and reduces scatter radiation.

PTS: 1 REF: p. 82 | p. 83

11. ANS: D
The collimator section at the distal end of the collimator assembly also helps define the thickness of the slice to be imaged.

PTS: 1 REF: p. 83

12. ANS: A
Efficiency refers to the ability to capture, absorb, and convert X-ray photons to electrical signals.

PTS: 1 REF: p. 83

13. ANS: B
Stability refers to the steadiness of the detector response. If the system is not stable, frequent calibrations are required to render the signals useful.

PTS: 1 REF: p. 84

14. ANS: A
The response time of the detector refers to the speed with which the detector can detect an X-ray event and recover to detect another event.

PTS: 1 REF: p. 84

15. ANS: B
The dynamic range of a CT detector is the ratio of the largest signal to be measured to the precision of the smallest signal to be discriminated.

PTS: 1 REF: p. 84

16. ANS: C
Scanners used NaI crystals, calcium fluoride, and bismuth germanate.

PTS: 1 REF: p. 85

17. ANS: A

The basic configuration of a gas-ionization detector consists of a series of individual gas (usually xenon) chambers.

PTS: 1 REF: p. 86

18. ANS: C
The DAS is located between the detectors and the computer, and it performs three major functions: (1) it measures the transmitted radiation beam, (2) it encodes these measurements into binary data, and (3) it transmits the binary data to the computer.

PTS: 1 REF: p. 93

19. ANS: A
The z-flying focal spot technique (referred to as the z-sharp technology) provides doubling sampling, where two overlapping slices for each detector row are obtained at the same time per 360-degree rotation. For example, in this technique, the data thus acquired with a 32×0.6 mm detector present is the equivalent to the sampling pattern of a 64×0.3 mm detector.

PTS: 1 REF: p. 97

20. ANS: A
The prepatient collimator restricts the beam that reaches the patient, limiting radiation exposure

PTS: 1 OBJ: 4

21. ANS: A
By limiting the volume of tissues exposed to radiation the prepatient collimator reduces the scatter produced in the patient.

PTS: 1 OBJ: 4

22. ANS: A
The prepatient collimator is located between the tube and the patient.

PTS: 1 OBJ: 4

23. ANS: B
The predetector collimator is found the patient and the detectors.

PTS: 1 OBJ: 4

24. ANS: B
The predetector collimator improves image contrast by limiting the amount of scatter radiation that reaches the detector.

PTS: 1 OBJ: 4

25. ANS: B
A key component of CT scanning is the data acquisition system (DAS).

PTS: 1 OBJ: 4

26. ANS: C
The DAS is located within the gantry along with the detectors, tube, generator, and filter.

PTS: 1 OBJ: 4

27. ANS: B

It is important to balance reductions in patient dose with appropriate image quality.

PTS: 1 OBJ: 18

28. ANS: D
Automatic tube current modulation serves to reduce patient exposure by adjusting the mA to the minimum needed throughout the scan to produce a quality image.

PTS: 1 OBJ: 18

TRUE/FALSE

1. ANS: F
Detectors fall into two categories, namely, solid-state detectors (scintillation detectors) and gas-ionization detectors (xenon gas). While the xenon gas detectors have become obsolete, scintillation detectors have evolved.

PTS: 1 REF: p. 21

2. ANS: T
Digital image processing involves the use of a digital computer to process and manipulate digital images.

PTS: 1 REF: p. 22

3. ANS: T
Scintillation detectors convert X-ray energy into light, and then the light is converted into electrical energy.

PTS: 1 REF: p. 84

4. ANS: T
Gas-ionization detectors convert X-ray energy directly to electrical energy.

PTS: 1 REF: p. 84

5. ANS: T
Scintillation detectors are solid-state detectors that consist of a scintillation crystal coupled to a photodiode tube.

PTS: 1 REF: p. 84

6. ANS: T
The high-voltage generators of slip-ring scanners are located in the gantry. Scanners with either low-voltage or high-voltage slip rings are available on the basis of the power supply to the slip ring.

PTS: 1 REF: p. 74

7. ANS: F
In a high-frequency generator, the circuit is usually referred to as a high-frequency inverter circuit. The low-voltage, low-frequency current (60 Hz) from the main power supply is converted to high-voltage, high-frequency current (500-25,000 Hz) as it passes through the components.

PTS: 1 REF: p. 76

8. ANS: T

Afterglow refers to the persistence of the image even after the radiation has been turned off.

PTS: 1 REF: p. 84

9. ANS: F
The CT gantry can be tilted.

PTS: 1 OBJ: 4

10. ANS: T
Today's CT scanner uses scintillation-type detectors that absorb the remnant radiation, produce a proportional flash of light, and then convert the light to an electrical signal.

PTS: 1 OBJ: 4

MATCHING

1. ANS: B PTS: 1 REF: p. 84
2. ANS: D PTS: 1 REF: p. 86
3. ANS: G PTS: 1 REF: p. 73
4. ANS: A PTS: 1 REF: p. 93
5. ANS: C PTS: 1 REF: p. 81 | p. 82
6. ANS: E PTS: 1 REF: p. 83
7. ANS: F PTS: 1 REF: p. 85