K. Ramer · E. Mantel · J.S. Reddin
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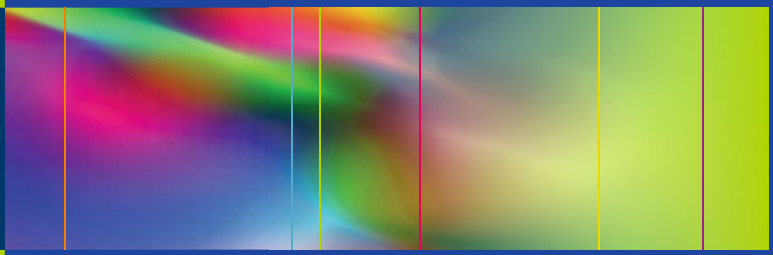

Nuclear Medicine Technology

Review Questions for the Board Examinations

Fourth Edition

Springer

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Karen Ramer • Eleanor Mantel
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ISBN 978-3-642-38284-0 ISBN 978-3-642-38285-7 (eBook)
DOI 10.1007/978-3-642-38285-7
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013945414

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Printed on acid-free paper

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Acknowledgments

As in earlier editions, many thanks go to Dr. Abass Alavi; without his support this book would not exist. It is a pleasure and privilege to work with Ms. Dörthe Mennecke-Bühler, Dr. Ute Heilman, Ms. Wilma McHugh, and their colleagues at Springer-Verlag. I would also like to thank Mr. Frank Gontowski for igniting my interest in nuclear medicine technology and for being a highly valued friend.

Karen Ramer

Contents

1 Introduction

Nuclear medicine technology has been a fascinating subject ever since the early rectilinear scanner produced images and is becoming ever more interesting (and demanding) with the growth of positron emission tomography and other molecular imaging. Taking and passing the exam offered by the Nuclear Medicine Technology Certification Board (NMTCB), or that offered by the American Registry of Radiologic Technologists (ARRT), is the final step in reaching the status of nuclear medicine technologist. Both of these exams are challenging, and the breadth of knowledge that they cover means that a thorough review is in order before attempting either exam.

This book was created to assist in preparation for those exams. In addition to recalling information, the questions require application of information and analysis of situations. This edition provides detailed explanations for answers to the questions in each chapter and offers a new chapter on positron emission tomography. (Since 2004, the NMTCB has offered a specialty exam in this modality, allowing technologists to continue their education and augment their career qualifications.)

Both the ARRT and the NMTCB use computer testing for these exams. Because of this, questions cannot be skipped. A good strategy is to try to get through all of the questions and marking or flagging each one that was a guess. In the event that another question provides you with information that changes your guess

K. Ramer et al., *Nuclear Medicine Technology*,
DOI 10.1007/978-3-642-38285-7_1,
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later, you will be able to return to that question and change your answer. If you have not marked it, you may not have time to find it.

It is well worth the time (even if one is extremely comfortable using computers) to take time for the tutorials offered before the exam timer begins. This will familiarize you with the location of buttons and functions on the screens and may save you a few minutes of navigating during the actual exam especially while reviewing.

As was the case with paper exams, careful reading of the question cannot be overstressed. Consider, for example, the difference between being asked to state what distance must be maintained to reduce exposure to a radioactive source by 75 % as opposed to being reduced to 75 % of the original. It is also extremely important to ask oneself whether the answer makes sense at the end of a calculation. For instance, if the question is about the amount of radioactivity present at some time prior to an assay, if the calculation does not result in an amount greater than the assayed amount, a recalculation is in order. When completely stumped by a question, try to rule out a few of the answers offered, thereby increasing your chances of a correct guess. As was the case with paper exams, there is no penalty for a wrong guess, and so it is always better to give any answer than to give none. Pacing to get through all the questions is therefore important.

All the best in reviewing, testing, and performing as a certified or registered nuclear medicine technologist!

2 Radioactivity, Radiopharmacy, and Quality Assurance

1. How does ^{201}Tl decay?
   (a) By positron emission
   (b) By electron capture
   (c) By beta emission
   (d) None of the above

2. What is the role of the stannous ion in the preparation of pharmaceuticals labeled with ^{99m}Tc?
   (a) To increase the valence state from +4 to +7
   (b) To reduce the amount of Al3+ present
   (c) To reduce the valence state of 99mTc
   (d) To reduce the radiation dose

3. If an assay of a vial containing ^{131}I shows 50 mCi present on May 2, approximately what will the assay show on May 18?
   (a) 25 mCi
   (b) 12.5 mCi
   (c) 40 mCi
   (d) 6 mCi

4. If a bone scan has been ordered on a 5-year-old girl and the physician prescribes 62 % of the adult dose to be given, how many mCi should be administered?
   (a) 5 mCi
   (b) 12.4 mCi
   (c) 7.4 mCi
   (d) 3.1 mCi

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DOI 10.1007/978-3-642-38285-7_2,
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5. If the biological half-life of an isotope is 6 h and the physical half-life is 12 h, what is the effective half-life?
   (a) 6 h
   (b) 12 h
   (c) 2 h
   (d) 4 h

6. Which of the following is used to abbreviate physical half-life?
   (a) Tp
   (b) T/2
   (c) T2
   (d) P ½

7. The physical half-life of a radionuclide is the time it takes:
   (a) For half of the substance to leave the body
   (b) For the nuclide to decay to one-half of the original activity
   (c) For the kit to become half expired
   (d) For half of the substance to be metabolized

8. If a kit has 310 mCi of activity present at 8:00 a.m., what will the vial assay show in 4 h and 10 min if the decay factor is 0.618?
   (a) 175 mCi
   (b) 192 mCi
   (c) 501 mCi
   (d) 155 mCi

9. A vial containing ^{99m}Tc is assayed at 9:00 a.m. and contains 255 mCi. To calculate the remaining activity at 3:00 p.m., what decay factor would be used?
   (a) 721
   (b) 595
   (c) 127.5
   (d) 600

10. A vial of technetium eluate contains 50 mCi/ml. If 4 ml is withdrawn and added to a diphosphonate kit containing 16 ml of solution, what volume would then need to be withdrawn to prepare a 20 mCi dose at that moment?
    (a) 1.0
    (b) 1.5
    (c) 2.0
    (d) 2.5

11. If a preparation of ^{99m}Tc mertiatide has 60 mCi of activity present at 8:30 a.m., how many mCi will be present at 9:00 a.m. (DF = 0.944)?
    (a) 63.6
    (b) 56.6
    (c) 59.6
    (d) 53.6

12. Which of the following is boiled during preparation?
    (a) MAA
    (b) Sulfur colloid
    (c) Albumin colloid
    (d) Diphosphonates

13. The presence of 12 μg Al^{+3} in 1 ml of ^{99m}Tc eluate is:
    (a) An example of radionuclidic impurity
    (b) An example of chemical impurity
    (c) An example of radiochemical impurity
    (d) Acceptable since it is less than 15 μg/ml

14. Which body decides on the acceptable levels of radionuclidic impurity?
    (a) USP
    (b) NRC
    (c) FDA
    (d) Both (a) and (b)

15. Which of the following is an example of radionuclidic impurity?
    (a) Presence of free 99mTc in a preparation of 99mTc sulfur colloid
    (b) Presence of 99Mo in 99mTc eluate
    (c) Presence of aluminum ions in 99mTc eluate
    (d) Presence of pyrogens in eluate

16. What is the maximum amount of aluminum ions (Al^{+3}) allowed in 1 ml of ^{99m}Tc eluate according to the USP?
    (a) None is allowed
    (b) 5 μg
    (c) 10 μg
    (d) 15 μg

17. What is indicated by the front of an instant thin layer chromatography (ITLC) strip?
    (a) Radionuclidic impurity.
    (b) Particles of incorrect size.
    (c) Pyrogens.
    (d) This depends on the solvent and strip used.

18. If a kit contains 140 mCi of ^{99m}Tc in 23 ml, how much volume must be withdrawn to obtain a dose of 5 mCi?
    (a) 0.8 ml
    (b) 30 ml
    (c) 1.2 ml
    (d) 0.6 ml

19. If a kit contains 140 mCi of ^{99m}Tc in 23 ml at 9:00 a.m., how much volume must be withdrawn to obtain a dose of 5 mCi at 3:00 p.m.?
    (a) 0.8 ml
    (b) 1.6 ml
    (c) 2.4 ml
    (d) 0.6

20. An MAA kit contains 40 mCi of ^{99m}Tc in 5 ml at 8:00 a.m. What would be the best volume to be withdrawn for a 4 mCi dose at 10:00 a.m. if a perfusion lung scan is planned (=0.794)?
    (a) 0.63 ml
    (b) 1.54 ml
    (c) 2.2 ml
    (d) 0.25 ml

21. What is the most likely size of an MAA particle if correctly prepared?
    (a) 0–100 mm
    (b) 10–30 μm
    (c) 10–30 mm
    (d) 0–250 μm

22. ^{99m}Tc MAA has a biologic half-life of 2–4 h; what will the effective half-life be?
    (a) 1.5–3.0 h
    (b) 2.0–4.0 h
    (c) 0.5–1.0 h
    (d) 1.5–2.4 h

23. Which radiopharmaceutical is made with ^{99m}Tc without a reducing agent?
    (a) MAG3
    (b) MAA
    (c) Sulfur colloid
    (d) Sestamibi

24. Which of the following is an example of radiochemical impurity?
    (a) Presence of free 99mTc in a preparation of 99mTc sulfur colloid
    (b) Presence of 99Mo in 99mTc eluate
    (c) Presence of aluminum ions in 99mTc eluate
    (d) Presence of pyrogens in eluate

25. Which of the following can be said regarding effective half-life?
    (a) It is always longer than the physical half-life.
    (b) It always shorter than both the physical and the biologic half-life.
    (c) It is always shorter than physical half-life, but longer than the biologic half-life.
    (d) It is always longer than the biologic half-life, but shorter than the physical half-life.

26. The purpose of adding EDTA to sulfur colloid when labeling with ^{99m}Tc is:
    (a) To prevent aggregation of sulfur colloid
    (b) To bind excess Al3+
    (c) To prevent loss of the radiolabel
    (d) (a) and (b) only
    (e) (b) and (c) only

27. A diphosphonate kit should generally be used within how many hours after preparation?
    (a) 2 h
    (b) 12 h
    (c) 4–6 h
    (d) 24 h

28. What is the usual particle size of sulfur colloid?
    (a) 0.3–1.0 μm
    (b) .03–0.1 μm
    (c) 2.0–10 μm
    (d) 4.0–15 μm

29. Which radiopharmaceutical, when correctly prepared, will have the smallest particle size?
    (a) ^{99m}Tc sulfur colloid
    (b) ^{99m}Tc albumin colloid
    (c) ^{99m}Tc human serum albumin
    (d) ^{99m}Tc macroaggregated albumin

30. The advantages of albumin colloid over sulfur colloid include:
    (a) Does not require heating
    (b) Less expensive
    (c) Smaller dose can be administered
    (d) All of the above

31. Following injection of ^{99m}Tc MAA for a perfusion lung scan, activity is seen in the kidneys and brain. This is indicative of:
    (a) Right to left cardiac shunt
    (b) Renal failure
    (c) Congestive heart failure
    (d) Incorrect particle size

32. At 7:00 a.m., a technologist prepares a dose of ^{99m}Tc MDP for injection at 10:00 a.m. that day. The desired dose is 22 mCi and no precalibration factors are available. The 3 h decay factor for the isotope is 0.707. What amount of activity should the technologist draw up into the syringe at 7:00 a.m.?
    (a) 15.6 mCi
    (b) 27.07 mCi
    (c) 29.5 mCi
    (d) 31.1 mCi

33. What can be said regarding precalibration factors?
    (a) It is not necessary for problem solving if the decay factor is available.
    (b) It is always <1.0.
    (c) It is always >1.0.
    (d) Both (a) and (c).

34. What method is used to calculate pediatric dose?
    (a) According to weight
    (b) Clark's formula
    (c) According to body surface area
    (d) Using Talbot's nomogram
    (e) All of the above

35. If the recommended volume for a MAG3 kit ranges from 4 to 10 ml, and the ^{99m}Tc eluate that will be used contains 820 mCi in 10 ml, and 41 mCi will be used, what is the minimum amount of diluent that should be added?
    (a) 0.5 ml
    (b) 1 ml
    (c) 3.5 ml
    (d) 9.5 ml

36. If a 20 mCi dose of ^{99m}Tc HDP is needed at 9:00 a.m., how much activity should the syringe contain if the technologist prepares it at 7:00 a.m.? You may use the table of precalibration factors (Table 1) to determine the answer.
    (a) 15.9 mCi
    (b) 21.259 mCi
    (c) 25.18 mCi
    (d) 26.7 mCi

37. Using Table 2, determine the decay factor for ^{99m}Tc at 7 h.
    (a) 1.337
    (b) 0.445
    (c) 0.432
    (d) 0.551

38. On a Monday morning at 6:00 a.m., a technologist is preparing a ^{99m}Tc ECD kit that is to be used for SPECT brain scan injections at 8:00 a.m., 9:00 a.m., and 10:00 a.m. Each patient should receive 10 mCi. What is the minimum

Table 1 Precalibration factors for ^{99m}Tc (assuming $T_{1/2} = 6.0$ h)

	0:00	00:15	00:30	00:45
1:0	1.122	1.156	1.189	1.224
2:0	1.259	1.297	1.335	1.374
3:0	1.414	1.456	1.499	1.543
4:0	1.587	1.634	1.681	1.730

Table 2 Decay factors for ^{99m}Tc (assuming $T_{1/2}$ = 6.0 h)

	0:00	00:15	00:30	00:45
1.0	0.891	0.866	0.841	0.817
2.0	0.794	0.771	0.749	0.728
3.0	0.707	0.687	0.667	0.648
4.0	0.630	0.612	0.595	0.578

activity that should be added to the kit during preparation? Use Table 1 if necessary.
(a) 42. 6 mCi
(b) 30.0 mCi
(c) 44.5 mCi
(d) 52.0 mCi

39. A chromatography strip is used to test a kit for radiochemical impurity and is counted in a well counter. Part A contains ^{99m}Tc pertechnetate, and Part B contains bound ^{99m}Tc in the desired form. If the results show 258,000 cpm in Part B, and 55,000 cpm in Part A, can this kit be used for injection into patients?
(a) Yes
(b) No

40. What is the approximate radiochemical purity for the kit described in question 39?
(a) 21 %
(b) 79 %
(c) 18 %
(d) 82 %

41. What is the approximate radiochemical impurity of the kit described in question 39?
(a) 21 %
(b) 79 %
(c) 18 %
(d) 82 %

42. A vial of ^{99m}Tc eluate is tested for ^{99}Mo breakthrough, and the amount of breakthrough is 25 uCi in 775 mCi at 6:00 a.m. Following the preparation of all kits to be used that day, 450 mCi of ^{99m}Tc is left. That night, a technologist is asked to perform a scrotal scan at 11:00 p.m. Must the generator be eluted again?
    (a) Yes, because the amount of eluate will have decayed to below the amount needed for a patient dose.
    (b) Yes, because the molybdenum breakthrough will now exceed the limit allowed by the NRC.
    (c) No.

43. A ^{99m}Tc MDP bone scan dose was prepared at 7:00 a.m. and contained 32 mCi/2 ml. At 9:00 a.m., when the patient arrives, the technologist realizes that the patient's age was overlooked (13 years). The technologist would now like to adjust the dose to 11 mCi. Given a 2 h decay factor of 0.794, what volume should be discarded so that the correct dose remains in the syringe?
    (a) 0.65 ml
    (b) 0.87 ml
    (c) 1.13 ml
    (d) 1.5 ml

44. A dose of ^{99m}Tc DMSA is prepared and calibrated to contain 5.0 mCi at 8 :00 a.m. The patient arrives late at 10:00 a.m. Without using any tables of decay factors, determine what activity will remain in the dose at that time.
    (a) 3.40 mCi
    (b) 3.54 mCi
    (c) 3.62 mCi
    (d) 3.97 mCi

45. An MAA kit contains 950,000 particles per ml. The activity in the kit is 50 mCi of ^{99m}Tc in 5 ml. If a 4 mCi dose is drawn up, how many particles will be in the dose?
    (a) 76,000
    (b) 380,000

(c) 410,000
(d) 450,000

46. What will happen to the dose in question 45 if it sits for 1 h?
(a) The number of particles per mCi will increase.
(b) The number of particles per mCi will decrease.
(c) The number of particles per mCi will remain unchanged.

47. A volume of 5 ml containing 40 mCi of ^{99m}Tc is added to an MAA kit with an average of 3,000,000 particles. What volume of the reconstituted kit should be withdrawn to prepare a dose for a patient with severe pulmonary hypertension?
(a) 0.25 ml
(b) 0.40 ml
(c) 0.45 ml
(d) 0.50 ml

48. To reduce the possibility of pyrogenic reactions, all kits should be prepared using saline that contains bacteriostatic preservatives.
(a) True
(b) False

49. While performing a GI bleeding study with labeled red blood cells, a technologist notices gastric activity that he suspects is the result of free pertechnetate. What could be done to support this suspicion?
(a) Reimage the patient in the erect position.
(b) Narrow the window around the photopeak.
(c) Image the thyroid.
(d) Have the patient drink two glasses of water and empty his or her bladder.

50. Convert 23 mCi to SI units.
(a) 850 MBq
(b) 850 kBq
(c) 850 Gbq
(d) None of the above

51. If excessive aluminum is present in ^{99m}Tc eluate, which of the following would be expected on a bone scan?
    (a) Lung uptake
    (b) Liver uptake
    (c) Thyroid uptake
    (d) Gastric uptake

52. Radiochemical impurities often result from:
    (a) Introduction of water into the kit
    (b) Introduction of oxygen into the kit
    (c) Introduction of nitrogen into the kit
    (d) (a) and (b) only
    (e) All of the above

53. It is proper technique to clean the septum of a kit reaction vial and inject an amount of air equal to the volume being withdrawn when preparing a unit dose.
    (a) True
    (b) False

54. 15 rem is equal to:
    (a) 150 mSv
    (b) 15 grays
    (c) 15 Sv
    (d) 150 MBq

55. What is the purpose of adding hetastarch to a blood sample drawn for the purpose of leukocyte labeling?
    (a) To act as an anticoagulant
    (b) To hasten the settling of erythrocytes
    (c) To separate platelets from leukocytes
    (d) To improve labeling efficiency

56. Following reconstitution of a kit with ^{99m}Tc pertechnetate, a technologist should ensure that all of the following are present on the vial except:
    (a) Date and time of preparation
    (b) Lot number
    (c) Concentration and volume
    (d) Patient name or identification number

57. If the proper centrifuge speed is not used during separation of cell types for leukocyte labeling with ^{111}In oxine, what may happen?
    (a) Platelets may be inadvertently labeled.
    (b) 111In oxine will not tag WBCs.
    (c) Red blood cells may become damaged.
    (d) White blood cells may become damaged.

58. In most reconstituted radiopharmaceutical kits, in what form is ^{99m}Tc present?
    (a) Free pertechnetate
    (b) Bound technetium
    (c) Reduced, hydrolyzed technetium
    (d) All of the above

59. For determination of plasma volume, 10 μCi of human serum albumin in 2.5 ml is added to 500 ml of water. What is the concentration of the resulting solution?
    (a) 0.019 μCi/ml
    (b) 0.020 μCi/ml
    (c) 50.00 μCi/ml
    (d) 50.20 μCi/ml

60. A ^{99}Mo/^{99m}Tc generator exists in _____ equilibrium and the parent isotope has a _____physical half-life than the daughter isotope.
    (a) Transient, longer
    (b) Transient, shorter
    (c) Static, longer
    (d) Static, shorter

61. If 630 mCi of ^{99m}Tc is eluted from a ^{99}Mo/^{99m}Tc generator, what is the NRC limit of total ^{99}Mo activity that may be present?
    (a) 0.15 μCi
    (b) 94.5 μCi
    (c) 42 mCi
    (d) 94.5 μCi/ml
    (e) 42 μCi

3 Radiation Safety

1. Which of the following bodies regulates transportation of radiopharmaceuticals?
   (a) NRC
   (b) DOT
   (c) TJC
   (d) FDA

2. Which of the following bodies regulates the use of investigational pharmaceuticals?
   (a) NRC
   (b) DOT
   (c) IRB
   (d) FDA

3. In the event of a spill of ^{99m}Tc to clothes, one should immediately:
   (a) Enter a shower fully clothed
   (b) Remove and store the clothes until they decay to background
   (c) Wash the clothes in hot water and then survey them to determine remaining activity
   (d) Remove and destroy the clothing

4. If a radiopharmaceutical is spilled on the floor, the first priority is to:
   (a) Contact the Radiation Safety Officer
   (b) Pour a chelating solution over the area of the spill

K. Ramer et al., *Nuclear Medicine Technology*,
DOI 10.1007/978-3-642-38285-7_3,
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(c) Cover the area with absorbent paper and restrict access around it
(d) Call the housekeeping department to arrange for cleaning

5. The inverse square law, in words, says:
   (a) If you double the distance from the source of activity, you reduce exposure to 25 % of the original intensity.
   (b) If you halve the distance from the source of activity, you decrease exposure to 25 % of the original intensity.
   (c) If you halve the distance from the source of activity, you decrease exposure to one-fourth of the original intensity.

6. What is the best way to decrease the radioactive dose to visitors if a patient is surveyed to emit 3 mR/h at bedside?
   (a) Have the patient wear lead aprons
   (b) Keep the patient well hydrated and encourage frequent voiding.
   (c) Have the visitor sit or stand as far as possible from bedside.
   (d) Have the visitor wear lead shielding.

7. Which of the following isotopes would be effectively shielded by a plastic syringe?
   (a) ^{67}Ga
   (b) ^{89}Sr
   (c) ^{99m}Tc
   (d) ^{81m}Kr
   (e) ^{133}Xe

8. What is the NRC annual dose limit allowed to the lens of the eye?
   (a) 1.5 mrem
   (b) 15 rem
   (c) 50 rem
   (d) 5 rem

9. Which of the following should be used when administering an intravenous pharmaceutical to a patient?
   (a) Lead syringe shield
   (b) Leaded eyeglasses
   (c) Gloves
   (d) All of the above
   (e) (a) and (b) only

10. Which of the following is the most effective means of measuring low levels of removable radiation?
   (a) By performing an area survey
   (b) By performing a wipe test
   (c) With a pocket dosimeter
   (d) With a TLD

11. What is the dose rate limit at the package surface for a shipment of radioactive material bearing a Yellow-III label?
   (a) 200 mR/h
   (b) 50 mR/h
   (c) 200 rads
   (d) 200 mrem

12. Which of the following measures absorbed doses?
   (a) mCi
   (b) Becquerel
   (c) Gray
   (d) All of the above

13. If the dose rate at 3 m from a radioactive source is 100 mrem/h, what will the dose rate be at 6 m?
   (a) 25 mR/h
   (b) 50 mR/h
   (c) 75 mR/h
   (d) 12.5 mR/h

14. The philosophy of the ALARA program is to keep the radiation dose:
    (a) As low as recently authorized
    (b) As long as reasonably attained
    (c) As long as reasonably acceptable
    (d) As low as reasonably achievable

15. All of the following are critical factors in keeping radiation exposure to a minimum except:
    (a) Time spent near the radioactive source
    (b) Geometry of the container holding the source of radiation
    (c) Distance from the source of radiation
    (d) Shielding of the radioactive source

16. Gaseous radiopharmaceuticals may only be used in rooms that:
    (a) Have at least one window
    (b) Contain an oxygen supply
    (c) Are at a positive pressure compared to surrounding rooms
    (d) Are at a negative pressure compared to surrounding rooms

17. If the exposure rate at 4 m from a radioactive source is 5 mR/h, what will the exposure rate be at 3 m?
    (a) 2.8 mR/h
    (b) 6.5 mR/h
    (c) 7.4 mR/h
    (d) 8.9 mR/h

18. A spill of ^{99m}Tc increases the exposure rate in a room from 1.7 to 3.15 mR/h. The room is posted with a sign reading "Caution-Radioactive Materials". What would be the ideal solution?
    (a) Change the sign to one reading "Caution-Radiation Area"
    (b) Call the NRC

(c) Decontaminate the floor with water and cleanser
(d) Place absorbent paper over the spill and close the room until the activity has decayed.

19. A technologist has 500 mrem registered on his ring badge in 1 month. What should be done to decrease exposure in the future?
(a) Use lead pigs and syringe shields when preparing radiopharmaceuticals
(b) Have another technologist elute the generator
(c) Wear lead aprons
(d) All of the above

20. OSHA requires that personnel exposure records be provided to employees:
(a) Monthly
(b) Quarterly
(c) Annually
(d) Biannually

21. A room containing a ^{57}Co sheet source is posted with a sign reading "Caution-Radioactive Materials". The exposure rate measured next to the source is 5.2 mR/h. What should be done?
(a) Change the sign to one reading " Caution-Radiation Area"
(b) Store the source in a leaded container
(c) Monitor the length of time a technologist can work near the source
(d) None of the above

22. A technologist discovers that a patient in the room next to a radioiodine therapy will receive 2.5 mrem/h when lying in his bed which is against the shared wall. What should be done?
(a) Move the bed to the other side of the room
(b) Discharge the therapy patient