
K. Ramer A. Alavi

Nuclear Medicine Technology

**Review Questions
for the Board Examinations**

Second Edition



Springer

Karen Ramer, B.A., R. T. (N), CNMT
Bystricka 64, 90033 Marianka, Slovakia

Abass Alavi, M. D.
Hospital of the University of Pennsylvania
117 Donnor Building, 3400 Spruce Street
19104-4283 Philadelphia, PA, USA

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1 Introduction to the Second Edition

Nuclear medicine technology is a fascinating subject, and anyone who has mastered it and been given the privilege to work as a technologist may justifiably be proud. 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. These exams are both challenging and the breadth of knowledge that they cover mean that a thorough review is in order before attempting them.

This book was created to assist in preparation for those exams. The scope of material covered by the book is meant to closely approximate that covered by the exams themselves. To that end the book was designed considering both the ARRT's Content Specifications for the Examination in Nuclear Medicine Technology and the NMTCB's Components of Preparedness, both of which have changed since the first edition of this book was printed. In 2005 the ARRT changed the number of questions in each of the content categories, adding questions in the areas of instrumentation and quality control, radionuclides and radiopharmaceuticals, and patient care, and decreasing questions in the diagnostic procedures category. Also, since the first edition, the Food and Drug Administration has approved the use of new radiolabelled antibody products. However, the most notable change to the exam content is its expansion to include PET scanning. The Centers for Medicare and Medicaid have approved reimbursement for the use of PET in certain new indications, which means that more technologists will encounter this imaging modality and will need to be well informed and well trained.

In response to all of these changes, eight of the sixteen chapters in this edition contain new questions. In addition to recalling information, these questions will require the application of information, and an analysis of situations.

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 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 $^{99\text{m}}\text{Tc}$?
 - a. to increase the valence state from +4 to +7
 - b. to reduce the amount of Al^{3+} present
 - c. to reduce the valence state of $^{99\text{m}}\text{Tc}$
 - 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. 21.7 mCi
 - b. 12.4 mCi
 - c. 7.4 mCi
 - d. 3.1 mCi

- 5) If the biological half-life of an isotope is 6 hours, and the physical half-life is 12 hrs, what is the effective half-life?
 - a. 6 hrs
 - b. 12 hrs
 - c. 2 hrs
 - d. 4 hrs

- 6) Which of the following has been used to abbreviate physical half-life?
 - a. T_p
 - b. $T/2$
 - c. T_2
 - d. $P^{1/2}$

- 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 hours and 10 minutes 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. .500
 - d. .600

- 10) A vial of technetium eluate contains 50 mCi/ml. If 4 ml are 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?
- 1.0
 - 1.5
 - 2.0
 - 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.? ($\lambda = 0.944$)
- 63.6
 - 56.6
 - 59.6
 - 53.6
- 12) Which of the following is boiled during preparation?
- MAA
 - sulfur colloid
 - albumin colloid
 - diphosphonates
- 13) The presence of $12\text{ }\mu\text{g Al}^{3+}$ in 1 ml of ^{99m}Tc eluate is:
- an example of radionuclidic impurity
 - an example of chemical impurity
 - an example of radiochemical impurity
 - acceptable since it is less than $15\text{ }\mu\text{g/ml}$
- 14) Which body decides on the acceptable levels of radionuclidic impurity?
- USP
 - NRC
 - FDA
 - both a and b

- 15) Which of the following is an example of radionuclidic impurity?
- presence of free ^{99m}Tc in a preparation of ^{99m}Tc sulfur colloid
 - presence of ^{99}Mo in ^{99m}Tc eluate
 - presence of aluminum ions in ^{99m}Tc eluate
 - presence of pyrogens in eluate
- 16) What is the maximum amount of aluminum ions (Al^{3+}) allowed in one milliliter of ^{99m}Tc eluate according to the USP?
- none is allowed
 - 5 μg
 - 10 μg
 - 15 μg
- 17) What is indicated by the front of an ITLC strip?
- radionuclidic impurity
 - particles of incorrect size
 - pyrogens
 - 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?
- 0.8 ml
 - 30 ml
 - 1.2 ml
 - 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.?
- 0.8 ml
 - 1.6 ml
 - 2.4 ml
 - 0.6

- 20) A MAA kit contains 40 mCi of ^{99m}Tc in 5 ml at 8:00 a.m. What would be the best volume to be withdraw at 10:00 a.m. if a perfusion lung scan is planned? ($\lambda = 0.794$)
- 0.63 ml
 - 1.54 ml
 - 2.2 ml
 - 0.25 ml
- 21) What is the most likely size of an MAA particle if correctly prepared?
- 0–100 mm
 - 10–30 μm
 - 10–30 mm
 - 0–250 μm
- 22) ^{99m}Tc MAA has a biologic half-life of 2–4 hours; what will the effective half-life be?
- 1.5–3.0 hours
 - 2.0–4.0 hours
 - 0.5–1.0 hours
 - 1.5–2.4 hours
- 23) Which radiopharmaceutical is made with ^{99m}Tc without a reducing agent?
- MAG3
 - MAA
 - sulfur colloid
 - sestamibi
- 24) Which of the following is an example of radiochemical impurity?
- presence of free ^{99m}Tc in a preparation of ^{99m}Tc sulfur colloid
 - presence of ^{99}Mo in ^{99m}Tc eluate
 - presence of aluminum ions in ^{99m}Tc eluate
 - presence of pyrogens in eluate

- 25) Which of the following can be said regarding effective half-life?
- it is always longer than the physical half-life
 - it always shorter than both the physical and the biologic half-life
 - it is always shorter than physical half-life, but longer than the biologic half-life
 - 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:
- to prevent aggregation of sulfur colloid
 - to bind excess Al^{3+}
 - to prevent loss of the radiolabel
 - a and b only
 - b and c only
- 27) A diphosphonate kit should generally be used within how many hours after preparation?
- 2 hours
 - 4 hours
 - 6 hours
 - 24 hours
- 28) What is the usual particle size of sulfur colloid?
- 0.3 – 1.0 μm
 - 0.03 – 0.1 μm
 - 2.0 – 10 μm
 - 4.0 – 15 μm
- 29) Which radiopharmaceutical, when correctly prepared, will have the smallest particle size?
- ^{99m}Tc sulfur colloid
 - ^{99m}Tc albumin colloid
 - ^{99m}Tc human serum albumin
 - ^{99m}Tc macroaggregated albumin

- 30) The advantages of albumin colloid over sulfur colloid include:
- does not require boiling
 - less expensive
 - smaller dose can be administered
 - 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:
- right to left cardiac shunt
 - renal failure
 - congestive heart failure
 - 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 three hour 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.?
- 15.6 mCi
 - 27.07 mCi
 - 29.5 mCi
 - 31.1 mCi
- 33) What can be said regarding precalibration factors?
- it is not necessary for problem solving if the decay factor is available
 - it is always < 1.0
 - it is always > 1.0
 - both a and c

- 34) What method is used to calculate pediatric dose?
- according to weight
 - Clark's formula
 - according to body surface area
 - using Talbot's nomogram
 - all of the above
- 35) If the recommended volume for a MAG3 kit ranges from 4–10 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?
- 0.5 ml
 - 1 ml
 - 3.5 ml
 - 9.5 ml
- 36) If a 20 mCi dose of ^{99m}Tc HDP are 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 2.1 a) to determine the answer.
- 15.9 mCi
 - 21.26 mCi
 - 25.18 mCi
 - 26.7 mCi

Table 2.1 a. Precalibration factors for $^{99m}\text{Technetium}$ (assuming $T_{1/2} = 6.0$ hours)

	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 2.1 b. Decay factors for ^{99m}Tc
(assuming $T_{1/2} = 6.0$ hours)

	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

- 37) Using Table 2.1 b, determine the decay factor for ^{99m}Tc at 7 hours.
- 1.337
 - 0.445
 - 0.432
 - 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 the SPECT brain scans at 8:00 a.m., 9:00 a.m. and 10:00 a.m. Each patient should receive 10 mCi. What is the minimum activity that should be added to the kit during preparation? Use Table 2.1 a if necessary.
- 42.6 mCi
 - 30.0 mCi
 - 44.5 mCi
 - 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?
- yes
 - no

- 40) What is the approximate labeling efficiency for the kit described in question 39?
- 21 %
 - 79 %
 - 18 %
 - 82 %
- 41) What is the approximate radiochemical impurity of the kit described in question 39?
- 21 %
 - 79 %
 - 18 %
 - 82 %
- 42) A vial of ^{99m}Tc eluate is tested for ^{99}Mo breakthrough, and the amount of breakthrough is 25 μCi 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?
- yes, because the amount of eluate will have decayed to below the amount needed for a patient dose
 - yes, because the molybdenum breakthrough will now exceed the limit allowed by the NRC
 - no
- 43) A ^{99m}Tc MDP bone scan dose was prepared at 7:00 a.m. and contained 32 $\text{mCi}/2\text{ ml}$. 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 hour decay factor of 0.794, what volume should be discarded so that the correct dose remains in the syringe?
- 0.65 ml
 - 0.87 ml
 - 1.13 ml
 - 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.
- 3.40 mCi
 - 3.54 mCi
 - 3.62 mCi
 - 3.97 mCi
- 45) A 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?
- 76,000
 - 380,000
 - 410,000
 - 450,000
- 46) What will happen to the dose in question 47 if it sits for one hour?
- the number of particles per mCi will increase
 - the number of particles per mCi will decrease
 - 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?
- 0.25 ml
 - 0.40 ml
 - 0.45 ml
 - 0.50 ml

- 48) Which of the following is not a desirable characteristic of radionuclides used for imaging?
- photon energy between 50 and 500 keV
 - effective half-life long enough to permit imaging
 - particulate emission
 - low toxicity
- 49) To reduce the possibility of pyrogenic reactions, all kits should be prepared using saline that contains bacteriostatic preservatives.
- true
 - false
- 50) 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?
- reimage the patient in the erect position
 - narrow the window around the photopeak
 - image the thyroid
 - have the patient drink 2 glasses of water and empty his or her bladder
- 51) Convert 23 mCi to SI units.
- 850 MBq
 - 850 kBq
 - 850 GBq
 - none of the above
- 52) If excessive aluminum is present in ^{99m}Tc eluate, which of the following would be expected on a bone scan?
- lung uptake
 - liver uptake
 - thyroid uptake
 - gastric uptake