QUESTION 1

A criticality accident occurred at a nuclear fuel reprocessing plant. You, the facility Health Physicist, are at the command post providing technical support to the Incident Commander.

POINTS

15 A A search and rescue team has been established. The Incident Commander asks you if it is OK to send in a team to rescue a worker who is in the vicinity of the criticality accident. What are your 3 primary considerations in developing your recommendation? **Number your responses. Only the first three will be graded.**

15 B. Name the primary exposure pathways and radiation sources for:

1. Workers in the room at the time of the accident;
2. Rescue workers (assume the criticality has stopped);
3. Other individuals within 0.1 to 1 km at the time of, and following the incident.

5 C. Describe a method that could be used to "quick sort" (i.e., quickly screen persons potentially involved) following a criticality accident.

10 D. Describe two medical interventions that could change the health outcome for an individual exposed to 750 rad (whole body, deep dose) if administered during the first month following the incident.

5 E. Why are large acute radiation doses (e.g., from a criticality accident) correctly presented in units of "rad", and not "rem"?

QUESTION 2

You are using an open-air ion chamber (specifications given below) to perform surveys at a food irradiation facility. Your ion chamber was calibrated to give the correct response at a temperature of 20 ^{o}C and at an atmospheric pressure of 760 mm of Hg. The facility uses a 100 Ci ^{137}Cs source. Assume negligible humidity.

GIVEN

- Active volume of 235.5 cm^3 (5 cm radius, 3 cm deep)
- ρ_{air} = 1.29 kg m^{-3}

POINTS

10 A. What current is generated by an exposure rate of 1 R/hr?

20 B. A measurement of 12.6 R/h is taken on a hot day of 35 ^{o}C and 740 mm of Hg. Calculate the correct exposure rate. **Show all work.**

20 C. You are surveying a shielding wall for radiation leakage. You discover a 1 cm wide crack in the shielding giving a detector response of 20 mR/hr when the active volume of the ion chamber is centered over the crack. Assuming that the crack length exceeds the dimensions of the ion chamber, provide an estimate of the true exposure rate. Assume electronic equilibrium and the following measurement conditions: 20 ^{o}C and 760 mm of Hg. **Show all work. Specify the detector orientation you are assuming.**

QUESTION 3

You are a graduate assistant on the Radiation Safety staff of Ground State University. You are involved in planning an activation experiment. It has been decided to examine the thermal neutron activation of Manganese.

The buildup and decay characteristics of this source require your attention.

GIVEN

- Thermal neutron absorption cross-section for Mn-56 = 13.3 barns
  for the Mn-55 (n, γ) Mn-56 reaction.
- Atomic weight of manganese = 55
- Half life of Mn-56 = 2.58 h
- Mn-56 decay gamma rays
  - Gamma 1 = 0.847 MeV @ 100%
  - Gamma 2 = 1.81 MeV @ 27%
  - Gamma 3 = 2.11 MeV @14%
- Density of air at STP = 0.00129g cm^{-3}

POINTS

25 A. What is the flux in neutrons per square centimeter per second which will produce 0.31 mCi of Mn-56 at saturation in a thin manganese target of 1 g in weight. Assume no attenuation in target material. **Show all work.**

25 B. What is the unshielded, gamma dose equivalent rate (in air) to a student standing one-half meter from the 0.31 mCi Mn-56 source, one hour after the irradiation ends? **Show all work.**

QUESTION 4

You are the radiation safety officer for a radiopharmaceutical laboratory. A laboratory worker reports to you that he accidentally boiled to dryness a beaker containing 15 mCi of ^{131}I in a room that is 5 m $\times$ 5 m $\times$ 5 m. He was not using the available fume hood. Assume that the ^{131}I is instantaneously vaporized and uniformly distributed at $t = 0$, and the worker is in the room for one hour after $t = 0$.

GIVEN

- Breathing rate, $B = 1.2\ \mathrm{m^3\ h^{-1}}$.
- Room ventilation rate, $F = 100\ \mathrm{m^3\ h^{-1}}$.
- Fractional thyroid uptake of ^{131}I from blood = 0.3 (remainder goes directly to excretion).
- Respiratory tract deposition fraction = 0.75. (Assume 100% goes instantaneously to blood).
- Committed dose to the thyroid = 5.5 rad $\mu\mathrm{Ci}^{-1}$ ^{131}I deposited in the thyroid.

POINTS

30 A. Calculate the worker's thyroid uptake of ^{131}I and the committed dose due to that uptake. **Show all work.**

20 B. In addition to performing bioassay on the worker, list five actions you will take following the accident. **Number your responses. Only the first five responses will be graded.**

QUESTION 5

A thin window, pancake GM instrument is labeled with an efficiency value of 0.20 cpm/dpm. This instrument was calibrated with a ^{137}Cs source of one inch diameter on an aluminum planchet in a calibration jig at your calibration facility. The nominal window diameter for the detector is 1.75 inches.

GIVEN

Isotope	$t_{1/2}$	Max Beta Energy (MeV)	% Beta Intensity	Gammas (MeV)	% Gamma Intensity
^{99}Tc	2 E 5 y	0.293	100	none	N/A
^{137}Cs	30 y	0.511 1.173	95 5	0.661	85
^{90}Sr	29 y	0.546	100	none	N/A
^{90}Y	64 h	2.283	100	none	N/A

POINTS

10 A. A 1.0 µCi ^{99}Tc source of 1.75" diameter on a thin plastic backing is counted in the field. Using the quoted efficiency, calculate the expected count rate. **Show all work.**

20 B. Assume that an observed net count rate of 3×10^5 cpm for the ^{99}Tc is lower than the calculated count rate. Provide four possible reasons for the discrepancy. **Number your responses. Only the first four will be graded.**

10 C. The background count rate for this detector system is 50 cpm. What is the MDA, in dpm, at the 95 % confidence level, for ^{137}Cs using the instrument's scaler and a one-minute count? Assume the same counting geometry as used for calibration. **Show all work. State any Assumptions.**

10 D. The GM tube has a dead time of 50 µs. If the observed count rate is 100,000 cpm, what is the true count rate? **Show all work.**

QUESTION 6

You are using the data below to prepare a special incident report that concerns a 27- year old male radiation worker.

GIVEN

Period	External Deep Dose Equivalent (rem)	Intake –Inhalation Class D (μCi)
1st Quarter	0.7	^{137}Cs 80 ^{131}I 19.5
2nd Q	1.2	
3rd Q	1.8	
4th Q	0.3	

Radionuclide	Inhalation ALI (ICRP 30) (μCi)
^{137}Cs (D)	200
^{131}I (D)	50 Non-stochastic Thyroid (200 Stochastic)

POINTS

10 A. What is the Committed Dose Equivalent to the thyroid from the ^{131}I intake? **Show all work.**

20 B. What is the approximate Committed Effective Dose Equivalent (CEDE) from the internally deposited radionuclides? **State any assumptions. Show all work.**

20 C. Assume you have calculated a CEDE from radionuclide intake of 1.2 rem and a CDE to the thyroid of 26 rem. What is the Total Effective Dose Equivalent (TEDE)? Have any of the occupational dose equivalent limit recommendations in NCRP Report No.116 (1993) been exceeded**? State which recommendation(s). Justify your answer.**

QUESTION 7

You are a consultant RSO for two manufacturing companies. The Alpha Company uses Plutonium-239 in a nitrate solution. The Beta Company uses I-131 for medical research. Your contract stipulates that you use ICRP-30/26 concepts and models. Spills occur at each of these facilities and result in the data given below.

GIVEN

	Alpha Company- Pu-239	Beta Company- I-131
Inhalation intake amount	5 ALI (non-stochastic)	5 ALI (non-stochastic)
Approximate effective half-life	50 years	8 days
Organ that the non-stochastic ALI is based on:	Bone surfaces	Thyroid
Organ tissue weighting factor:	0.03	0.03

POINTS

10 A. Calculate the Committed Dose Equivalent(CDE) to the following organs and their contribution to the respective Committed Effective Dose Equivalents (CEDE). **Show all work.**

1. The Alpha Company worker's bone surface.
2. The Beta Company worker's thyroid.

20 B. The physician treating the worker from the Beta Company proposes to remove the workers thyroid to preclude the likelihood of thyroid cancer later in life. Is removal of the thyroid a prudent action? **Justify your answer.**

15 C. Both workers develop solid tumor cancer 1 year later and are suing the respective companies, claiming the cancers were caused by the spill. In court, the respective attorneys claim that, the worker received a dose that is 5 times the annual limit, therefore it is likely that the cancer was caused by the spill. Provide 3 arguments to challenge the validity of this statement. **Number your responses. Only the first three will be graded.**

D. The day that the spill occurs in the Alpha Company, the worker's physician administers the chelating agent DPTA.

25 1. Why is the chelation appropriate for one of the exposures and not the other?

15 2. List 3 factors that most determine the effectiveness of DTPA. **Number your responses. Only the first three will be graded.**

15 E. For calculating doses resulting from inhalation of transuranics, the ICRP 66 respiratory tract model is more sophisticated than the ICRP 30 model. Name three (3) of the changes in the transuranic ICRP 66 lung model (relative to ICRP 30). **Number your responses. Only the first three will be graded.**

QUESTION 8

You are asked to design the shielding for an electron accelerator facility with the facility information given below. Use the figures copied from the NCRP Report No. 51 (1977), “Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities, attached.

GIVEN

Electron beam kinetic energy = 20 MeV
Peak current = 1 A
Beam pulse length = 1 microsecond
Beam pulse frequency = 10 Hz

The target is a <u>thick</u>, tungsten beam dump.
Z, tungsten = 74
Z, copper = 29

Five figures from NCRP Report No. 51 (attached).

POINTS

30 A. Assume that the dose equivalent rate in an office, which is at 90 degrees from the beam line and five (5) meters from the target (perpendicular distance from the beam line), can be no greater than 0.5 mrem hr^{-1}. Calculate the minimum thickness required for the concrete wall (density is 2.35 g cm^{-3}) between the target and the office. **State any assumptions. Show all work.**

20 B. Assume that in part A the required transmission factor is 1×10^{-4} and the existing concrete wall is 30 inches thick. Calculate the additional lead thickness required to complement the concrete wall. **State any assumptions. Show all work.**

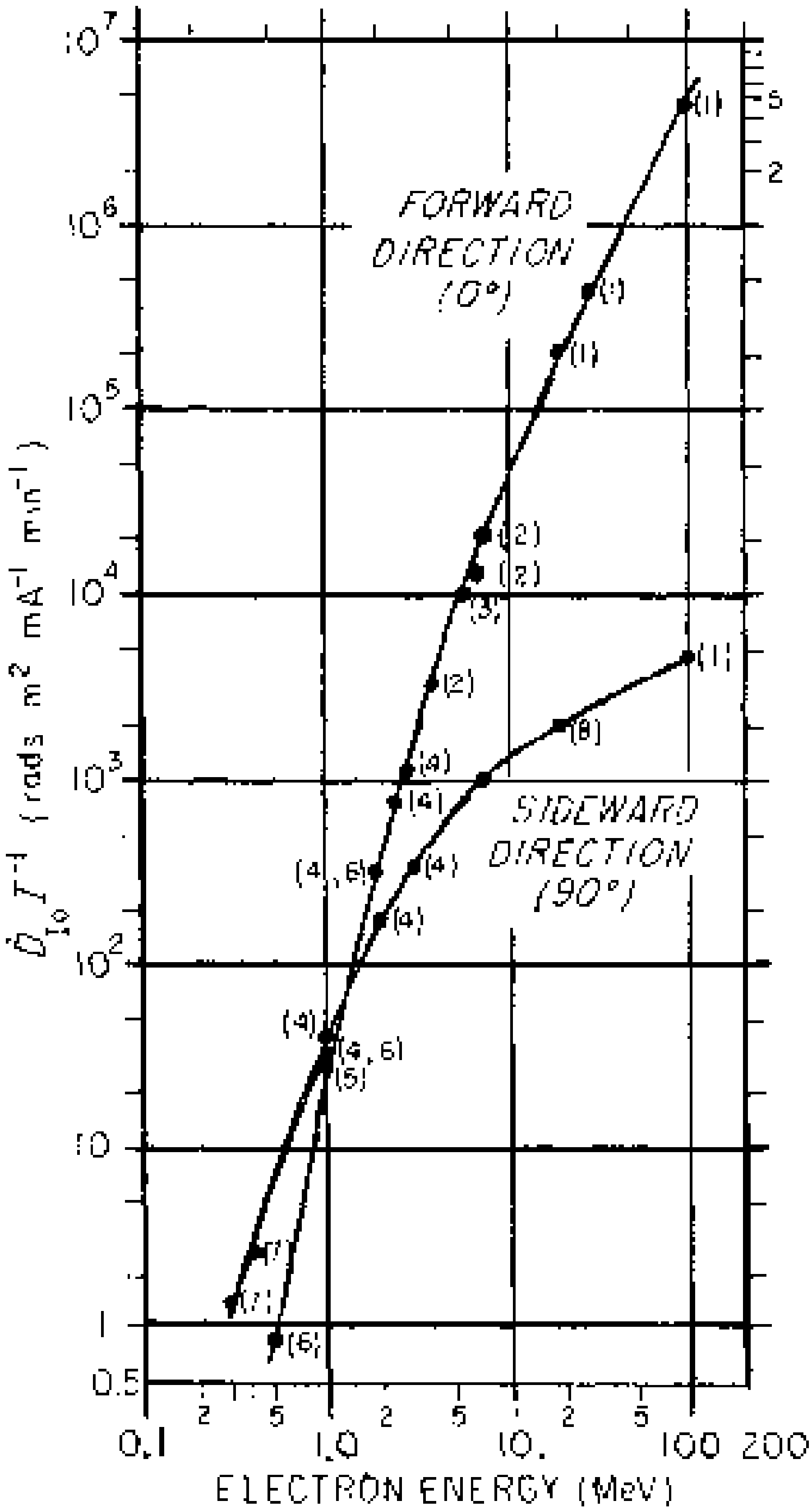
20 C. List and describe five (5) parameters of significant importance to estimate the emission of radiation from an accelerator. **Number your responses. Only the first five responses will be graded.**

20 D. List five (5) considerations for selecting shielding materials for an accelerator. **Number your responses. Only the first five responses will be graded.**

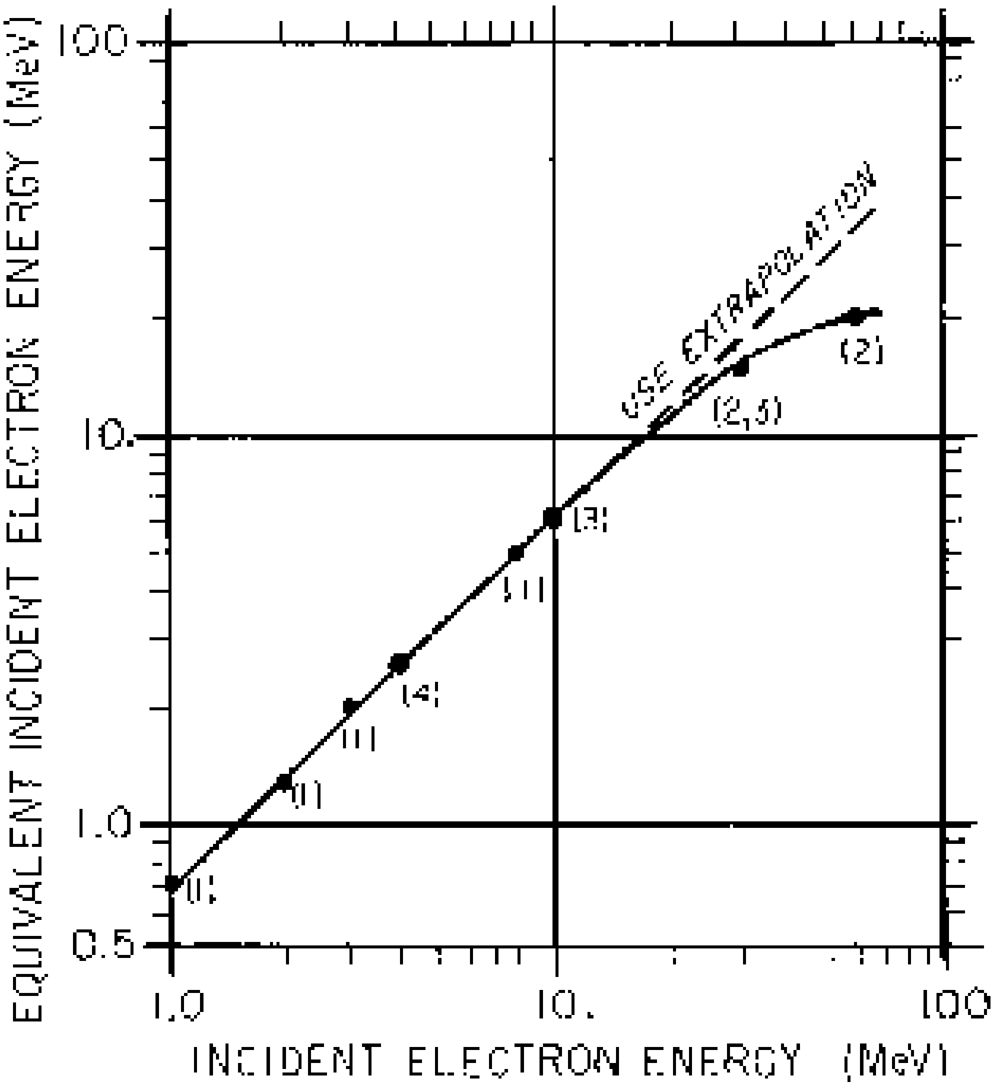
10 E. For each of the following accelerator types, complete the table by identifying the two principle radiations of concern for occupied areas.

Accelerator	Particle Accelerated	Beam Energy (MeV)	Principle Radiations
a. Potential Drop	Protons/ deuterons	1- 10	1. _______________ 2. _______________
b. Electron linear	Electrons	1- 10	3. _______________ 4. _______________
c. Electron linear	Electrons	> 10	5. _______________ 6. _______________
d. Cyclotron	Protons/ deuterons	10 - 50	7. _______________ 8. _______________
e. Betatron	Electrons	1- 50	9. _______________ 10. _______________

E.1. X-Ray Emission Rates from High-Z Targets



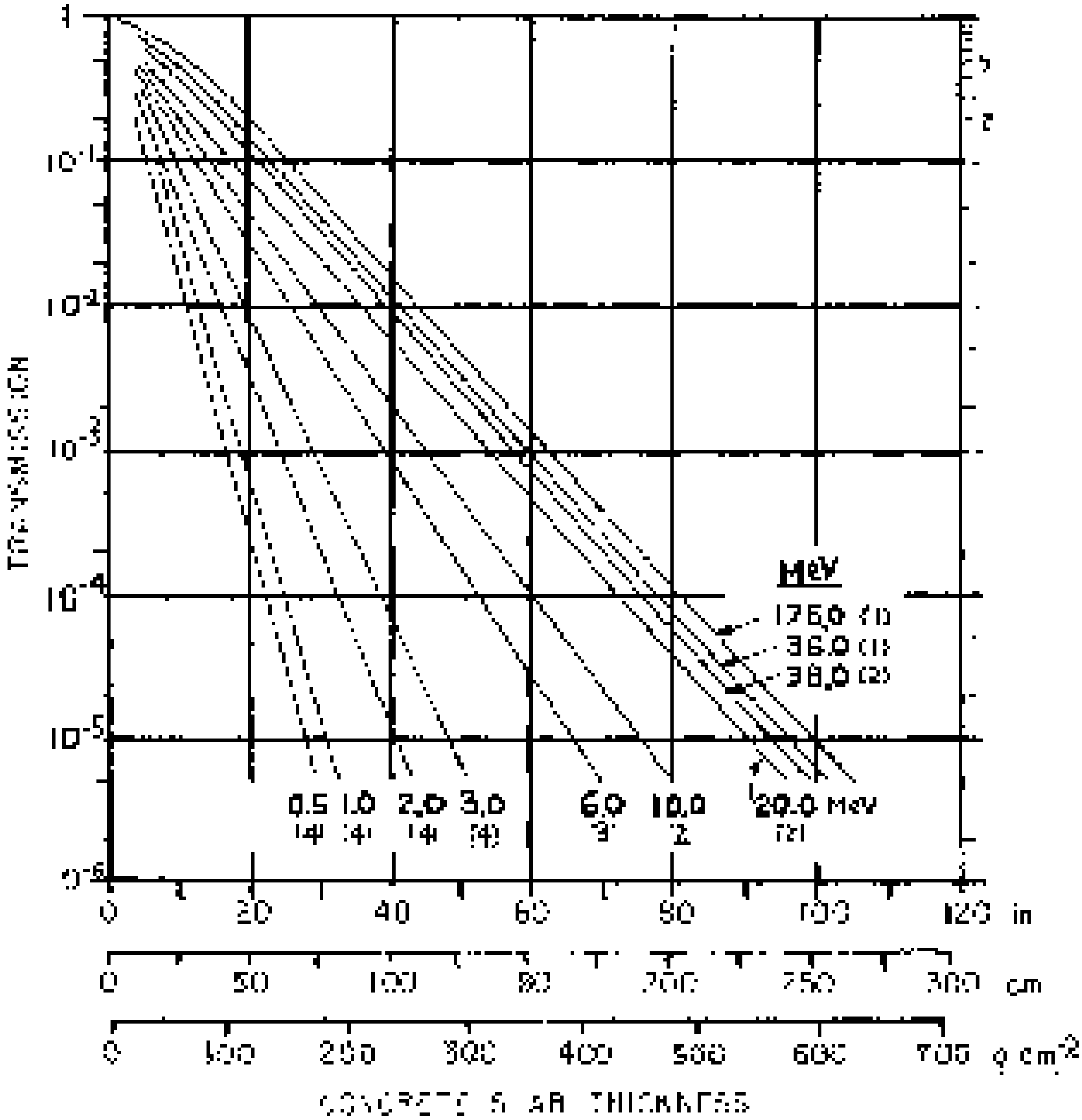
E.6 Equivalent Incident Electron Energies



Equivalent electron energy for analysis of transmission of x-rays emitted in the 90° direction from very thick high-Z targets, as a function of the incident electron energy. The x-ray spectrum at 90° is lower in energy than the spectrum at 90°. This lower-energy radiation can be described in terms of an incident electron energy that would in effect produce x-rays with similar transmission characteristics in the 0° direction. Transmission curves or tenth-value layer curves applicable to the lower energy selected from this graph may be used in the calculation of shielding thicknesses for the 90° beam. The same procedure would be a conservative approach for x-rays from low-Z targets, and for x-rays emitted in the 190° direction.

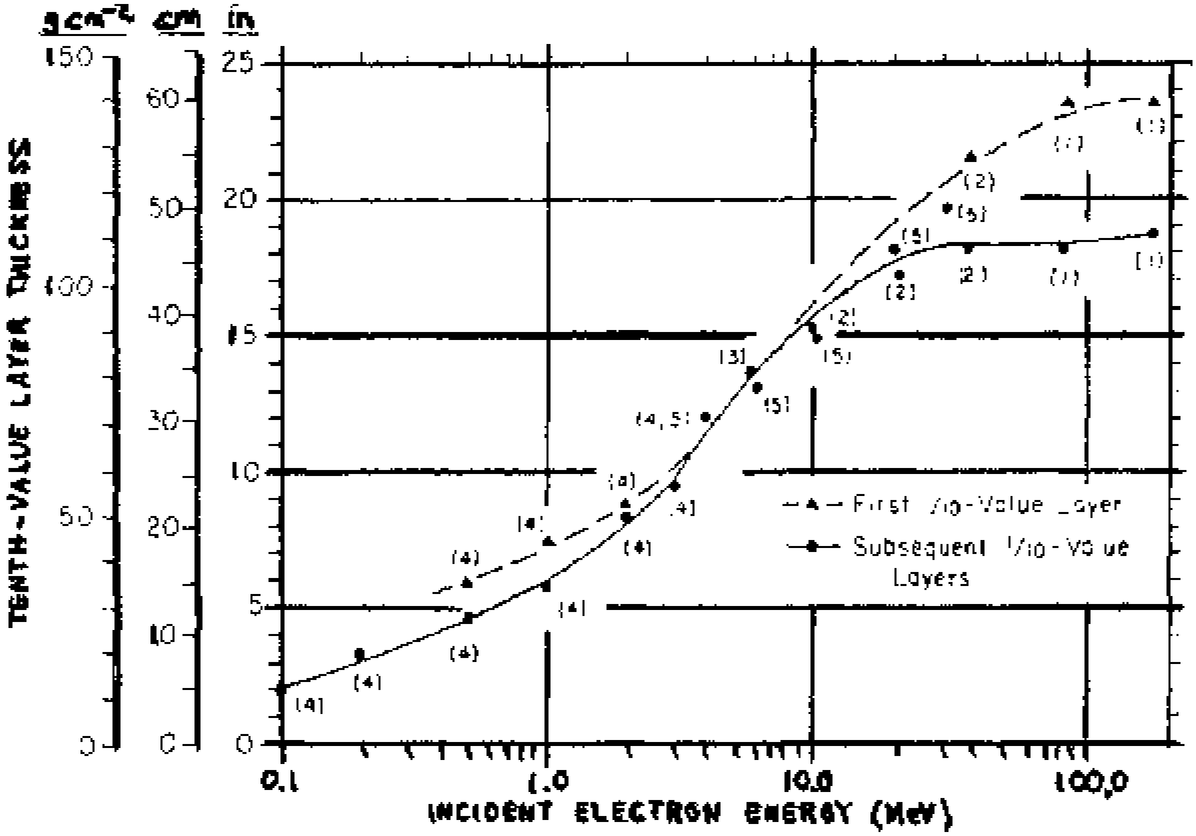
References: (1) Burrill (1968); (2) and Seltzer (1970); (3) McCall and Nelson (1974); and (4) Saxon (1964).

E.8 Broad-Beam Transmission Through Concrete of X Rays Produced by 0.5- to 176-Mev Electrons



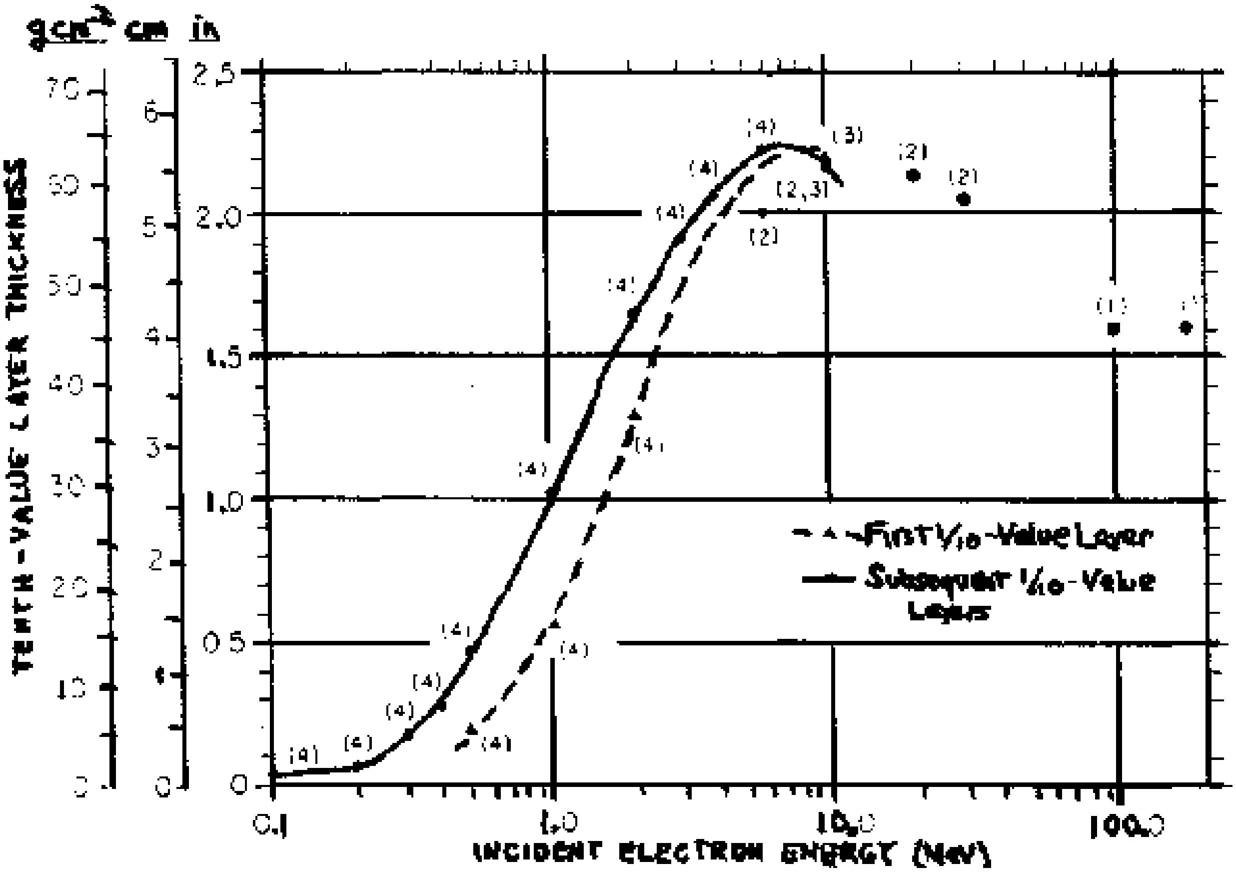
Transmission of thick-target x rays through ordinary concrete (density 2.35 g/cm^{-3}), under broad-beam conditions. Energy designations on each curve (0.5 to 176 MeV) refer to the monoenergetic electron energy incident on the thick x-ray producing target. Curves represent transmission in dose-equivalent index ration. (See Appendix E-12 for basis for interpolating between curves.) Curves derived from (1) Miller and Kennedy (1956); (2) Kirn and Kennedy (1954); (3) Karzmark and Capone (1968); and (4) NCRP Report No. 34 (NCRP, 1970a) and NCRP Report No. 49 (NCRP, 1976).

E.12 Dose-Equivalent Index Tenth-Value Layers for Broad-Beam X-rays in concrete



Dose-equivalent index tenth-value layers in ordinary concrete (density 2.35g/cm^{-3}) for thick target x-rays under broad-beam conditions, as a function of the energy of electrons incident on the thick target. The dotted curve refers to the first tenth-value layer; the solid curve refers to subsequent or "equilibrium" tenth-value layers. Both curves are empirically drawn through data points derived from the following references: (1) Miller and Kennedy (1956); (2) Kirn and Kennedy (1954); (3) Karzmark and Capone (1968); and (4) NCRP Report No. 34 (NCRP, 1970a), (5) Maruyama et al. (1971). Studies by Lokan et al. (1972) on light Ilmenite-loaded concrete (density 2.89 g/cm^{-3}) are in reasonable agreement with the solid curve above, on a mass thickness basis (g cm^{-2}).

E.14 Dose-Equivalent Index Tenth-Value Layers for Broad-Beam X Rays in Lead



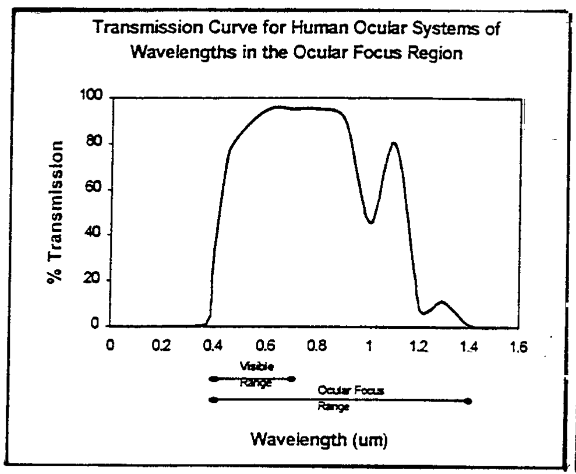
Dose-equivalent index tenth-value layers in ordinary lead (density 11.3 g/cm^{-3}) for thick target x-rays under broad-beam conditions, as a function of the energy of electrons incident on the thick target. The dotted curve refers to the first tenth-value layer; the solid curve refers to subsequent or "equilibrium" tenth-value layers. Both curves are empirically drawn through data points derived from the following references: (1) Miller and Kennedy (1956); (2) Maruyama et al. (1971); (3) ICRP Publication No. 4 (ICRP, 1964); and (4) NCRP Report No. 34 (NCRP, 1970a). The empirical curve is not extended into the 10- to 100-MeV region because of uncertainties in the available data.

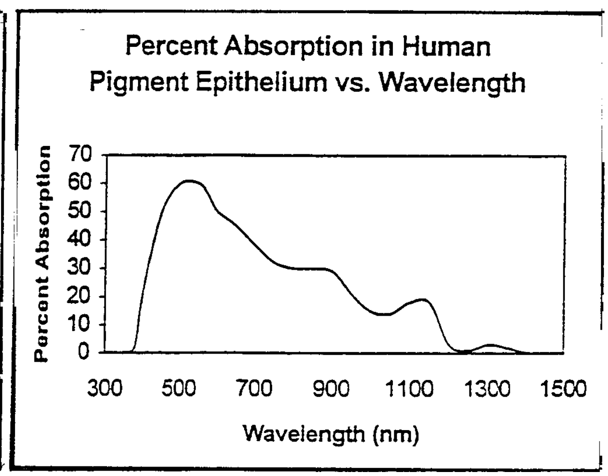
QUESTION 9

As Laser Safety Officer you are asked the following questions concerning laser hazards and safety.

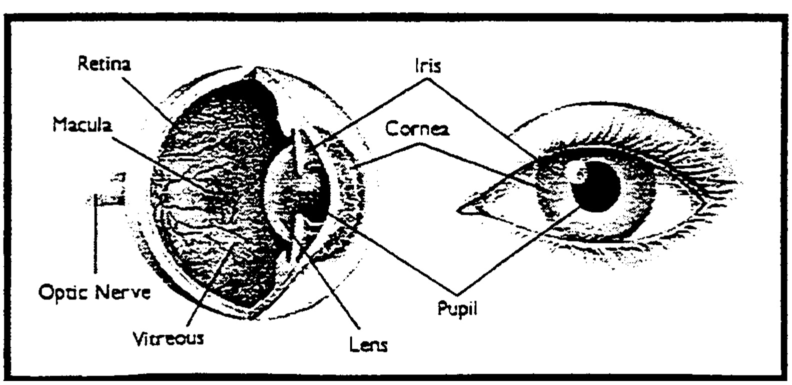
GIVEN

- Limiting aperture = 7 mm.
- Following transmission and absorption graphs:





- Anatomy of the eye:



POINTS

20 A. Preventing eye injury is a primary concern of laser safety programs. For the following four types of lasers, **IDENTIFY** the anatomical structure(s) of the eye that are the most sensitive to damage. **JUSTIFY** the selection of the anatomical structure(s).

1) Far infrared, carbon dioxide laser (10.6 µm).
2) Visible, gold vapor laser (0.628 µm).
3) UV-A, nitrogen laser (0.337 µm).
4) UV-C, krypton fluoride excimer laser (0.248 µm).

15 B Maximum Permissible Exposure Limits vary considerably within a narrow range of the visible spectrum. For example, MPEs of 2.5×10^{-3} W cm^{-2} and 1.7×10^{-5} W cm^{-2} apply respectively to quarter-second exposures for wavelengths of 0.647 µm (red) and 0.530 µm (green). Briefly **EXPLAIN** the source(s) of these differences.

15 C. Deleterious effects to the skin are associated with exposure to lasers with wavelengths in the ultraviolet region of the electromagnetic spectrum. **LIST** the skin effect(s) associated with the following UV bands:

1) UV-A (0.315 µm - 0.400 µm).
2) UV-B (0.280 µm - 0.315 µm).
3) UV-C (0.200 µm - 0.280 µm).

20 D. Lasers have gained wide acceptance for refractive eye surgery. Surgical units, such as LASIK (**La**ser In **Si**tu **K**eratomileusis) systems, are typically equipped with laser alignment devices which operate in the visible region. Assuming that beam divergence is negligible, calculate the maximum allowable power output (in units of mW) for the following alignment system:

Laser:	Continuous Wave Diode
Wavelength:	635 nm
MPE:	0.01 J cm^{-2}
Laser to eye distance	0.2 m
Beam diameter	3.5 mm
Blinking Reflex Time:	Inhibited for surgery
Maximum Alignment Time:	1.2 seconds per eye

30 E. A local sports team plans to add a laser show to their pre-game entertainment routine. The show will include figure tracing and direct audience scanning. The proposed laser array includes the following:

Laser:	Q-Switched 40W Nd:YAG
Wavelength:	532 nm
Pulse Width:	20 microseconds
Pulse Frequency:	25 kHz
Beam diameter	2 mm
Laser to audience distance:	25 m
Beam Divergence:	0.2 milliradians
Scanning Rate:	20,000 cm sec^{-1}
MPE:	$1.8\ t^{3/4} \times 10^{-3}$ J cm^{-2}

Using the MPE as your guide, is this equipment appropriate for use in such a show? Assume no optically aided viewing. **Justify your answer.**

QUESTION 10

You are the health physicist at a downwind location in response to a brush fire at the Smooth Peaks Weapons Facility. The facility handled weapons grade plutonium and some of the land surrounding the facility is contaminated with plutonium.

GIVEN:

- Filter alpha self-absorption = 0.4 (i.e., 60% of alphas are absorbed in filter).
- Filter collection efficiency = 0.8
- Detector active detection area of 60 cm²
- Background count = 180 counts in 60 minutes
- First sample count = 500 counts in 10 minutes
- Second sample count 1 hour later = 360 counts in 10 minutes
- Detector efficiency for alpha is 0.3 cpm/dpm (assume uniform distribution over detector area).
- Active filter area = 500 cm²
- ^{239}Pu Committed Effective Dose Conversion Factor per unit of inhalation intake
- = 5 E-05 Sv/Bq.
- Active filter area = 500 cm^2 (assume uniform distribution).
- Breathing rate = 1.2 m^3/h

Assume:

Effective half-life for radon (Rn-222) progeny = 30 minutes

$$LLD = 3.29\sqrt{\left(r_b t_g\left(1+\frac{t_g}{t_b}\right)\right)}+3$$

POINTS

40 A. You take a 1-m^3 air sample at the downwind location. Calculate the ^{239}Pu airborne activity in Bq/m^3 correcting for the contribution from radon (Rn-222) progeny. Assume no thoron progeny are present and neglect decay correction during the counting. **Show all work**

10 B. Calculate the LLD for this counting system in cpm. **Show all work.**

10 C. Calculate the Committed Effective Dose Equivalent to a person standing at the sampler location. Assume the release takes place over a period of four hours and the average activity concentration is 20 Bq/m^3. **Show all work.**

20 D. Provide five (5) ways of improving the dose estimate for off-site individuals. **Number your responses**. **Only the first five responses will be graded.**

20 E. List five (5) possible methods to reduce the potential long term dose to individuals from brush fires or other high re-suspension events? **Number your responses**. **Only the first five responses will be graded.**

QUESTION 11

You have been asked to perform risk estimates for a large, proposed residential development in an area of higher than normal radon levels. Measured radon emanation at the soil surface is approximately 5 pCi $m^{-2}s^{-1}$. Predicted radon flux in the first floor of a slab foundation home without any radon mitigation is 2 pCi $m^{-2}s^{-1}$.

GIVEN

- J_i = radon flux into home = 2 pCi $m^{-2}s^{-1}$
- J_o = radon flux into soil surface = 5 pCi $m^{-2}s^{-1}$
- Equilibrium factor, F_{eq} = 0.4
- A = Building area = 200 m^2
- H = Building room height = 2.5 m
- K_v = ventilation removal constant (ventilation flow rate/room volume) = 0.5 hr^{-1}
- R = lifetime excess cancer mortality risk per WLM = 5.5 x 10^{-4}/WLM
- F = Occupancy factor = 0.7
- L = life expectancy = 70 years

Nuclide	Alpha Energy (MeV)	Half-life
Radon 222	5.49	3.82 days
Polonium 218	6.00	3.1 minutes
Lead 214		26.8 minutes
Bismuth 214		19.7 minutes
Polonium 214	7.68	1.6 x 10^{-4} s

POINTS

25 A. Calculate the steady state indoor radon concentration (in pCi L^{-1}) in the first floor living space.

10 B. Assume the answer to Part A was 14 pCi L^{-1}. What is the exposure to the short-lived radon progeny in Working Level Months (WLM) per year?

20 C. List four sources of uncertainty in the application of the results from epidemiological studies of populations of underground miners to health effects in the general population. **Number your responses. Only the first four numbered responses will be graded.**

20 D. The current radon risk model is based on empirical studies (i.e., developed from epidemiological studies of underground uranium miners). Another type of model could develop risk estimates based on radon's effects on the respiratory tract. List four sources of uncertainty in this dosimetric model for the respiratory tract as applied to risk estimates from radon exposures. **Number your responses. Only the first four numbered responses will be graded.**

20 E. List four methods to reduce the radon entry into a home or building. **Number your responses. Only the first four numbered responses will be graded.**

5 F. Of potential concern is the radon in the water supply to the homes. Which of the following statements represents the best estimate of the transfer factor for the reduction in concentration of radon in water (in pCi L^{-1}) to the indoor air concentration (in pCi L^{-1}).

A. 10 to 1 reduction (i.e., a 10 pCi L^{-1} water concentration results in a 1 pCi L^{-1} air concentration);
B. 100 to 1 reduction;
C. 1,000 to 1 reduction;
D. 10,000 to 1 reduction.

QUESTION 12

An endocrinologist has referred a patient to a nuclear medicine physician for treatment of Graves' disease. The nuclear medicine physician administers a small amount of ^{123}I to determine the 24 hour uptake and to perform imaging. The physician plans to treat the condition with ^{131}I .

GIVEN

- 24 hour thyroid uptake in the patient = 60%
- Thyroid mass in the patient = 100 g
- Thyroid mass in Reference Man = 20 g
- Absorbed Dose per Unit Cumulative Activity ('S' factor) for thyroid as source and target organ = 1.57×10^{-3} mGy MBq^{-1} s^{-1}
- Assume contribution from all other source organs, to the thyroid (target organ) is negligible
- Effective half-life in the patient's thyroid = 5 d
- Physical half-life of ^{131}I = 8.03 d

POINTS

40 A. The nuclear medicine physician has decided to give a dose of 70 Gy to the thyroid. Calculate the ^{131}I activity (MBq) that needs to be administered to the patient to deliver the prescribed dose.

30 B. Suppose the patient above, was administered 1480 MBq. Calculate the cumulative external dose to his spouse under the following conditions:

- Sleeping arrangements: distance is 1 meter;
- The thyroid is the only source of exposure;
- Time spent in the vicinity (1 meter) of the spouse, over a period of 24 hours = 8 hours;
- Specific Gamma-ray Dose Equivalent Constant at 1 meter = 7.647×10^{-5} mSv h^{-1} MBq^{-1}.

10 C. Assume the dose equivalent to the patient's spouse is 2.5 mSv. Is the licensee in compliance with the radiation limits of 10CFR35 if the patient is released from the hospital immediately after administration? **Justify your answer**.

20 D. Give four general precautionary measures that you would suggest to a patient treated for the condition of Graves' disease upon release from the hospital. **Number your responses. Only the first four will be graded.**

QUESTION 13

You are the health physicist at a power reactor facility that uses continuous air monitors (CAMs) to measure airborne, beta-emitting particles near work activities that present some potential of generating airborne activity. The monitor uses a fixed-filter sample and a pancake-type GM detector contained inside a lead shield. The monitor reads out in counts per minute (cpm) and uses a strip chart to record data for historical purposes.

A maintenance job is to be performed within a contaminated area. Prior to performing work in the area, the filter paper on the monitor is replaced and the monitor is moved into place and turned on at 0800.

GIVEN

- Monitor flow rate: $1\ ft^3\ min^{-1}$
- Filter collection efficiency: 90%
- Counting efficiency: $0.30\ c\ d^{-1}$ per beta disintegration
- Detector background (with fresh filter paper): $70\ c\ min^{-1}$
- DACs are based on ICRP 26 methodologies
- Radon progeny $T_{1/2}$ (effective) = 30 minutes

Isotope	DAC ($\mu Ci/cm^3$)	Inhalation ALI (μCi)
Co-60	1×10^{-8}	30
I-131	2×10^{-8} (Thyroid)	50
Cs-137	6×10^{-8}	200

POINTS

30 A. Particulate radon daughters are known to be present in the room at a beta concentration of $3 \times 10^{-10}\ \mu Ci\ cm^{-3}$ with an effective half-life of approximately 27 minutes. At 0900 hours, what count rate should be observed on the monitor? **State all assumptions. Show all work.**

20 B. At 0900 hours, work begins in the room where the air monitor is located. At 0945, the air in the room suddenly becomes contaminated. Over the next 10 minutes, the strip chart recorder shows that the count rate has increased by 40,000 $c\ min^{-1}$. Based upon this information, what is the estimated airborne concentration in the room, assuming that the half-life of the measured activity is much greater than 10 minutes? **State all assumptions and show all work.**

20 C. The workers leave the room at 0955 and report the incident to the health physics office. You suspect that the workers were exposed to a mixture of ^{137}Cs and ^{60}Co. To confirm your suspicions, you send the workers to have a whole body count. What are four advantages of a whole body count <u>in this specific case</u> over urine bioassay? **Number your responses. Only the first four will be graded.**

10 D. A count of the filter on a gamma spectroscopy system shows that the airborne radioactivity is due to 25% ^{60}Co, and the remainder due to ^{137}Cs. What is the potential Committed Effective Dose Equivalent (CEDE) for each hour of exposure if the air concentration is measured to be 2×10^{-6} μCi cm^{-3}? **Show all work.**

20 E. Gamma spectroscopy screening of an air sample shows that ^{131}I and ^{137}Cs are present. The worker is exposed for 4 hours to the contaminated atmosphere, and inhales 2 ALI of ^{131}I and 0.5 ALI of ^{137}Cs. What are the Committed Effective Dose Equivalent and the Committed Dose Equivalent to the thyroid from this exposure? **Show all work.**

QUESTION 14

A researcher reported a spill of radioactive material in his laboratory. The lab is authorized for use of ^{32}P, ^{35}S, and ^{14}C. Subsequent surveys showed widespread contamination throughout a corridor with three outside entrances and 12 rooms. Further investigation shows that the spill occurred about 24 hours ago.

GIVEN

- ^{35}S maximum beta energy = 167.4 keV
- Sulfur biological half-life = 9.3 h
- ^{35}S physical half-life = 87.2 d

POINTS

20 A. List four actions you could take to ensure the extent of the spill is determined and contaminated areas properly isolated. **Number your responses. Only the first four will be graded.**

15 B. List three items (e.g., supplies, equipment) that you would take to the scene to assess and control the spill. **Number your responses. Only the first three will be graded.**

30 C. One laboratory technician reported a possible uptake of ^{35}S. A subsequent urinalysis indicated 1500 dpm ml^{-1} of ^{35}S in a urine sample. Assume this concentration reflects the average ^{35}S concentration in the body. Calculate the CEDE received by this worker assuming that the intake occurred 48 hours ago**. State your assumptions. Show all work.**

15 D. It is possible that multiple nuclides were spilled. Describe how you would determine the nuclides present at this location.

20 E. Further investigations revealed that:

1. personnel were using radioactive materials prior to completing radiation safety training;
2. a centrifuge was contaminated to 1500 dpm/100 cm^2;
3. some laboratory personnel were found to not be wearing radiation dosimetry;
4. one (1) millicurie of ^{14}C was used in un-posted rooms.

For each of these items, indicate if it violates federal/ agreement state regulations, violates good work practices, or is not of concern. You DO NOT have to cite the regulation.