COMPREHENSIVE EXAMINATION INSTRUCTIONS

READ THESE INSTRUCTIONS CAREFULLY AND FOLLOW THEM CLOSELY.

1. Part II of this examination consists of two sections:
   - The first section (questions 1-6) consists of six core questions. All six will be graded.
   - The second section (questions 7-14) consists of seven specialty questions. Answer any four. The proctor can accept only four answers from this section.

2. Questions 1-6 are each worth 50 points. Questions 7-14 are each worth 100 points. The maximum possible score is 700 points. The relative weight of each part of a question is given.

3. You have six hours in which to complete the examination.

4. On the cover sheet:
   a. Print your name;
   b. Write your identification number;
   c. Sign your name;
   d. When you have finished the examination, mark the questions you have answered.

5. On the answer sheets:
   a. Identify yourself with each sheet by writing your number (not your name) in the upper right corner. The graders can be objective when names do not appear.
   b. Write the question number in the upper left corner.
   c. When you have completed the answer to a question, go back and write beside the question number the number of pages in your answer: Page 1 of __, Page 2 of __, etc., so that the grader knows that all answer sheets are present.
   d. Write on only one side of the sheets.
   e. Begin each new question on a separate sheet.

6. This is a closed-book examination, so no texts or reference materials are permitted. Standard slide rules may be used, but not the so-called "Health Physics" slide rules. Non-programmable electronic calculators are permissible. Only those programmable calculators which have been previously approved by the Board are allowed. All calculators must be checked by the proctor prior to the start of the examination.

7. If the information given in a particular question appears to be inadequate, list any assumptions you make in developing your solution.

8. If you find you are running short of time, simply set up an outline showing clearly how you would complete the solution without working out the actual numerical answer. Appropriate partial credit will be given.

9. Return the completed cover sheet and your answer sheets to the proctor when you have completed the examination. You may keep the copy of the examination.

ABHP PART II EXAMINATION COVER SHEET

June 28, 1999

Name: ____

Identification Number: _______________________________

Signature: ____

Mark (X) the questions you have answered and are submitting for grading.

1. __X__
2. __X__
3. __X__
4. __X__
5. __X__
6. __X__

7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____

Remember to indicate on each answer sheet your identification number, the question number, and the number of pages for each, e.g.,

ID #1859, Question 4, page 2 of 3

ID #1859, Question 6, page 1 of 1

Have you taken a certification preparation or refresher course prior to taking this examination?

__ Y __ N

If so, which format was involved?

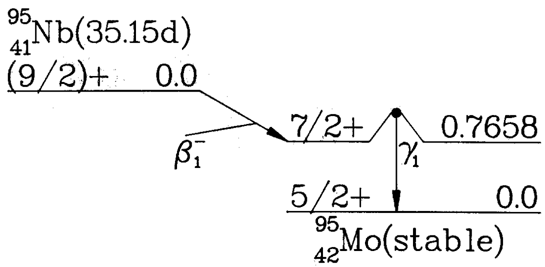
intensive, one or two weeks ___ multi-week, one or two classes per week ___

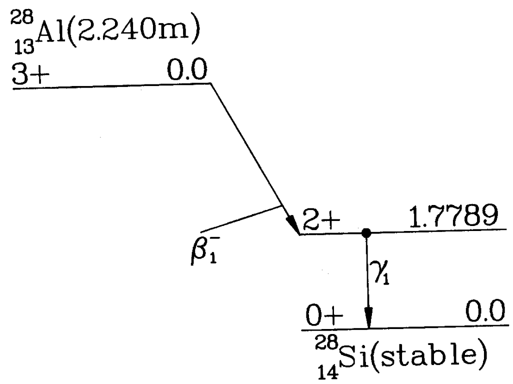
QUESTION 1

Answer the following questions related to gamma spectroscopy.

GIVEN

Decay Schemes:





β^-_1 = 0.04332 MeV (100%)
γ_1 = 0.7657 MeV (100%)

β^-_1 = 1.212 MeV (100%)
γ_1 = 1.779 MeV (100%)

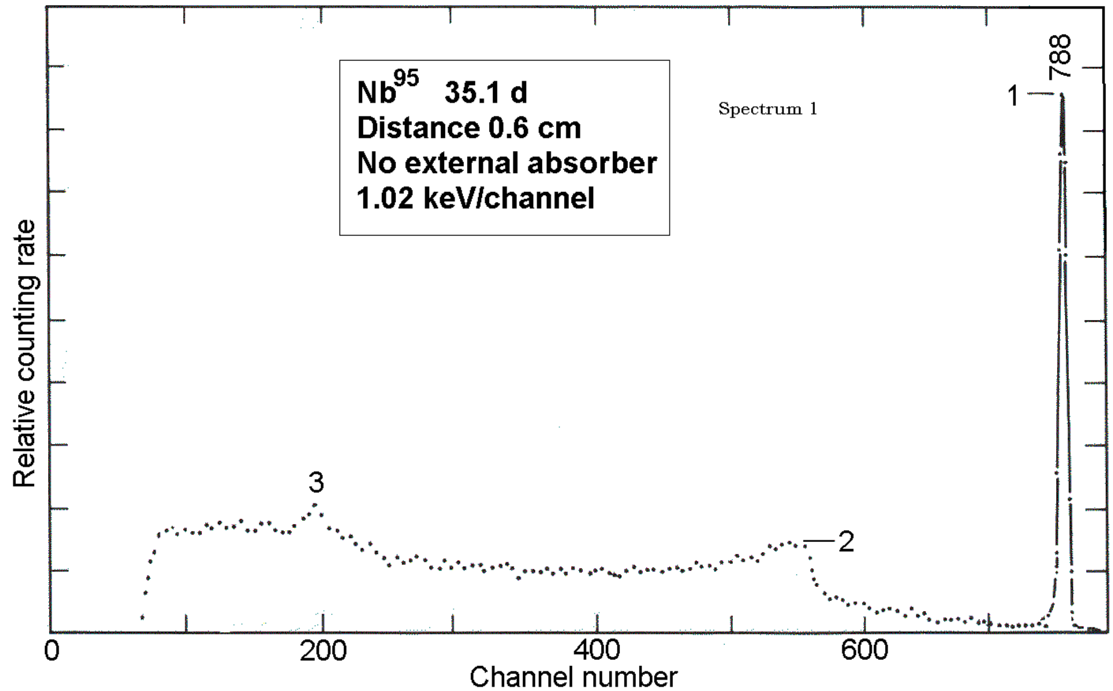
POINTS

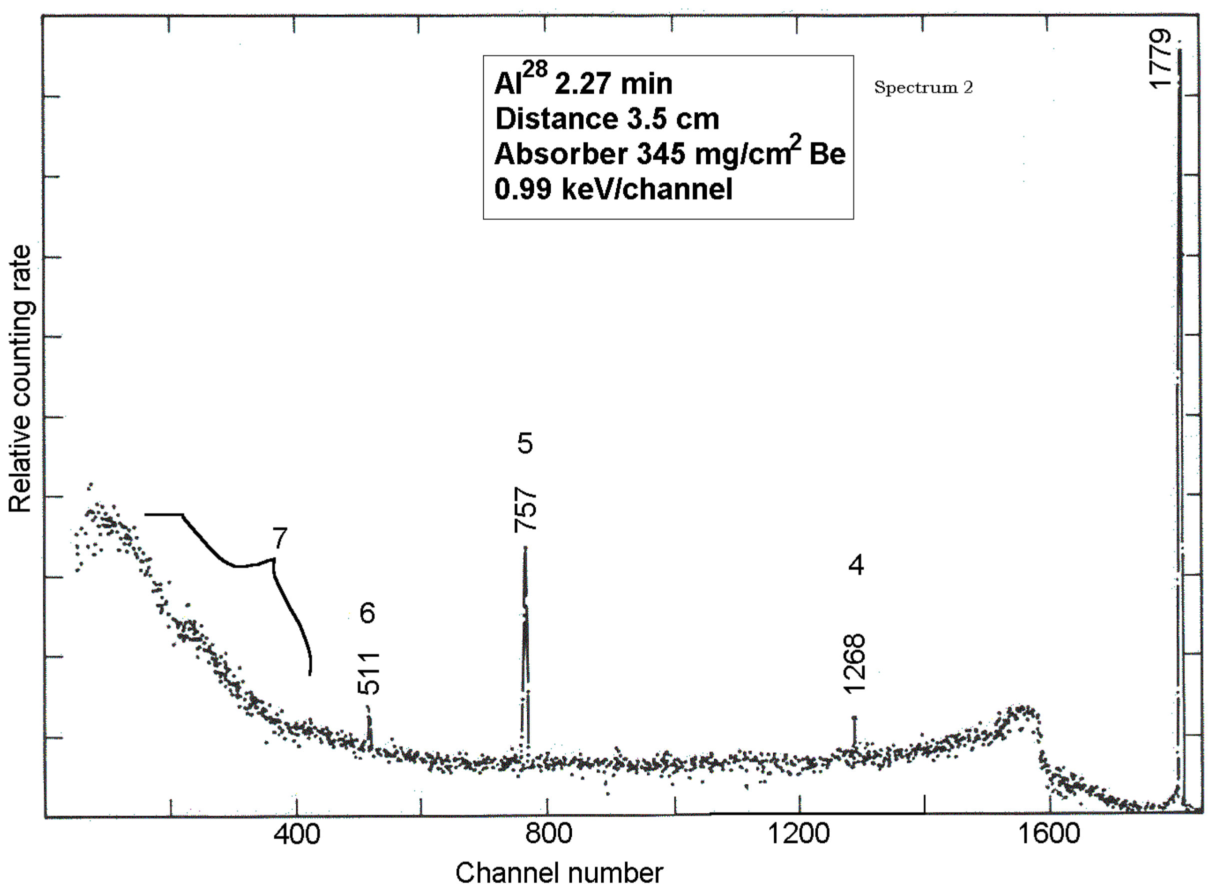
28 A In the gamma spectra taken with an HPGe detector shown on the next page, identify features 1 through 7. Briefly describe the origin of each feature.

8 B If the HPGe detector crystal was increased in size, would the height of the photopeak in relation to the height of the Compton edge be higher or lower? Why?

10 C Define FWHM. Is the FWHM of an HPGe detector greater or smaller than that of a NaI(Tl) detector? Why?

4 D Why are escape peaks generally more prominent in HPGe detectors in comparison with NaI(Tl) detectors?


Nb95 35.1 d
Distance 0.6 cm
No external absorber
1.02 keV/channel
Spectrum 1
788
1
2
3
Relative counting rate
0
200
400
600
Channel number


Al28 2.27 min
Distance 3.5 cm
Absorber 345 mg/cm2 Be
0.99 keV/channel
Spectrum 2
1779
5
757
4
1268
6
511
7
Relative counting rate
400
800
1200
1600
Channel number

QUESTION 2

A worker in your nuclear power plant was suspected of having an inhalation intake of Co-60 during a routine maintenance outage. A whole body count of the worker confirmed the intake.

GIVEN

The stochastic annual limit on intake for Class W Co-60 is 200 μCi. The stochastic annual limit on intake for Class Y Co-60 is 30 μCi. The worker's whole body count results, over a period of two-hundred days, are given below:

Time post intake, days	Co-60 activity, μCi
0.1	86.0
1	76.7
2	57.3
5	27.9
10	22.1
20	19.0
50	13.3
100	7.8
200	3.2

It is not known if the intake was from Class W or Class Y Co-60. The intake retention fractions (IRFs) for Co-60 are given below:

Time post intake, days	IRF Co-60, W	IRF Co-60, Y
0.1	0.635	0.635
1	0.566	0.583
2	0.423	0.424
5	0.206	0.190
10	0.163	0.157
20	0.140	0.152
50	0.098	0.144
100	0.058	0.134
200	0.024	0.117

POINTS

10 A What is the difference between an intake and an uptake?

20 B What class of Co-60 (W or Y) did the worker inhale? (5 pts). **Justify your answer** (15 pts).

20 C Assume that the intake was Class W.

1) What is your estimate of the intake (10 pts). **Show all work.**

2) What is the worker's committed effective dose equivalent (10 pts)? **Show all work.**

QUESTION 3

A woman who is 10 weeks pregnant has been experiencing extreme chronic hip pain and her physician wants to conduct an x-ray study to aid in the diagnosis. The x-ray procedure is expected to result in a dose of approximately 2 rem to her abdominal area. As the health physicist at a large medical center you have been asked for your professional opinion.

POINTS

12 A The physician is trying to weigh the risks versus benefit of the procedure. Provide two reasons that support the decision to conduct the x-ray study, and two reasons that support the decision not to conduct the study. **Number your responses. Only the first two for each will be graded.**

8 B What would you recommend to the physician? Why?

15 C The physician has asked you to counsel the patient, who wants to know what the possible effects on the fetus are, and whether or not she should have a therapeutic abortion if she has the x-ray procedure.

1. List 3 possible effects of in-utero exposure at this stage of gestation, and whether these effects would be expected at this dose level. **Number your responses. Only the first three will be graded.**
2. On the basis of the potential for health effects in the developing fetus, would you recommend a therapeutic abortion? Why or why not?

15 D What are the dose limits for the fetus that are recommended by the NCRP? Is the NCRP recommendation pertinent to this case?

QUESTION 4

You are the Health Physicist on the staff of a custom isotope production facility. A customer has inquired about the production of Na-24 sources. You are required to calculate information regarding the production, build-up, decay, and shielding of the proposed product.

GIVEN

^{24}Na Data:
$T_{1/2}$ = 14.96 hours
$E(\gamma_1)$ = 1.4 MeV; $Y(\gamma_1)$ = 1.0
$E(\gamma_2)$ = 2.8 MeV; $Y(\gamma_2)$ = 1.0

Thermal neutron capture cross section, σ_c, for ^{23}Na (n,γ) ^{24}Na = 0.534 barns

Fraction of Target, by weight, which is ^{23}Na = 0.20
Air mass energy absorption coefficient = 0.03 cm^2/g
Lead mass attenuation coefficient = 4.6×10^{-2} cm^2/g
Density of lead = 11.3 g/cm^3
Assume there is no initial ^{24}Na activity at the start of any irradiation

POINTS

15 A What is the thermal neutron flux, in neutrons per cm^2 per second, required to produce 3.7×10^{10} Bq of ^{24}Na at saturation in a 5 gram target? **Show all work.**

15 B What is the estimated unshielded absorbed dose rate in rad/hr on the surface of a shipping drum of 30 cm radius containing the target (3.7×10^{10} Bq of ^{24}Na) in the center of the drum? Assume a point source. Neglect air attenuation. **Show all work.**

20 C Assume 35 rem/hr on contact with the surface of the unshielded shipping container. Will the addition of 10 cm of lead shielding allow shipment of this container with a Radioactive II transport shipping label? **Show all work.**

QUESTION 5

You are the Radiation Safety Officer at a decommissioning project where Sr-90 was used to manufacture radioisotopic thermoelectric generators (RTG) for offshore buoys. During the project, a worker inadvertently handles and is exposed to a high-activity component. Exposure readings are taken with an ionization chamber instrument.

GIVEN

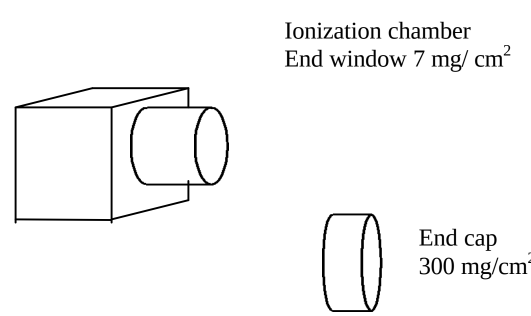
- The component is a moisture trap about the size of a baseball.
- The beta reading is 800 rad per hour on contact and 200 rad per hour at 18 inches. The instrument used had a 7 mg/cm^2 window.
- Gamma readings are 3 R/hr at contact and 2 R/hr at 18 inches. The instrument used had a 300 mg/cm^2 window.
- The monitoring instrument used for contact readings was protected by a plastic bag.
- The worker hand-carried the trap for 2 minutes at 18 inches from the body.
- The worker was wearing 2 pairs of rubber gloves, a set of coveralls, and a respirator with a hood.

And,

$$f_b = e^{-0.00435\ (x)}$$

Where f_b is the beta reduction factor for Sr/Y-90 energies, and "x" is the density thickness of the material in mg/cm^2

Material	**Density thickness (mg/cm^2)**
Coveralls	29
1 pair rubber gloves	39
Respirator facepiece	250
Plastic bag	15



POINTS

22 A Calculate the dose to the lens of the eye. Disregard any field reduction by air. **Show all work.**

8 B What are the annual limits for the skin, lens of the eye, whole body, and extremity?

4 C At what tissue depth is skin dose evaluated?

4 D At what tissue depth is deep dose equivalent evaluated?

12 E A whole-body TLD with filters for skin and eye dose was worn on the chest under the coveralls during the incident. List 4 factors to consider when comparing the TLD dose to the calculated dose. **Number your responses. Only the first four responses will be graded.**

QUESTION 6

Your university conducts a wide variety of medical and clinical research and, as the newly appointed Radiation Safety Manager, you have been asked to determine work controls for radiological work by declared pregnant staff workers, none of whom are minors.

GIVEN

- P-32: Beta E(max) = 1.7 MeV
- I-131: Beta E(max) = 0.606 MeV; gamma exposure rate = 0.21 R-m^2/hr-Ci

POINTS

For each of the work descriptions below, state whether you would recommend to

(a) prohibit the work,
(b) allow the work to continue, but with additional specific work controls, or,
(c) allow the work to continue without any additional work controls.

Provide the technical basis for your recommendations, including any assumptions. If (b) is selected, state which specific work controls you would implement.

10 A Work consists of cell labeling starting with a 1 ml stock solution of 10 mCi of P-32-labeled nucleotides. The stock solution is diluted by a factor of 1,000 prior to use. Dilutions are done on a weekly basis, and require about a half hour of hands-on work. Work with the diluted material requires about 10 hours of hand-on work per week. Normal controls include a fume hood, Plexiglas shield, and use of gloves, labcoat, and tongs.

10 B Work consists of interventional radiology with a variable monthly work load. A TLD is worn outside of a lead apron that provides 2 half-value layers (HVL) of attenuation. A typical 9-month dosimeter history is shown below:

TLD reading (rem):

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.050	0.100	0.285	0.115	0.075	0.110	0.185	0.230	0.175

10 C Work consists of performing iodinations using a stock solution of 30 mCi of I-131 as Sodium Iodide. Iodinations are performed on a weekly basis, and require about a half-hour of hands-on work. Work with the iodinated protein requires about 10 hours of hands on work per week. Normal controls include use of a a fume hood, shields, gloves, labcoat, and tongs. Work history indicates that the average worker is exposed to one DAC - hour per week as a result of performing iodinations.

10 D Work consists of performing maintenance on an 18 MeV electron accelerator. The accelerator is typically operated continuously from Tuesday through Saturday and routine maintenance is conducted on Monday. Maintenance takes about 4 hours in areas where the dose rate averages 4.5 mrem/hr.

10 E Work consists of conducting x-ray fluorescence analysis on a variety of materials. Although the exposure rate outside the machine is not detectable above background, the machine is capable of producing a severe overexposure of the fingers, should the interlocks fail or be bypassed.

QUESTION 7

Five accident scenarios are presented below.

Accident 1) A worker's hand is severely lacerated by a grossly contaminated saw blade while cutting a drain line containing Pu-239.
Accident 2) A diver is pulled from a spent fuel pool after a leak in the divesuit is detected. The pool water is heavily contaminated with tritium (H-3).
Accident 3) A worker is grossly contaminated upon the face, hair, neck, and upper torso with Cs-137 following work in a highly contaminated area.
Accident 4) A researcher swallows a quantity of S-35 during a pipetting operation.
Accident 5) A worker's respiratory protective equipment fails during work in a high I-131 airborne area.

POINTS

25 A List five (5) actions which should be taken immediately in response to a radiological accident involving personal injury. Order the actions by priority (1=first action, highest priority). **Only the first five responses will be graded**.

20 B For each of the five accident scenarios presented above, give the preferred bioassay monitoring technique. Justify your answer. Assume your resources are not limited.

20 C Medical intervention techniques used to minimize internal dose following an intake/uptake of radioactive material are divided into several general categories based upon their protective actions. List 4 of these categories and give a brief description of the dose-savings principles of each. **Number your responses. Only the first four will be graded.**

10 D A physician working with an accident response team recommends the following intervention actions. Do you agree? Explain your answer.

1) Chelation therapy following the inhalation intake of 5 ALI of Am-241.
2) Lung lavage following the inhalation of 10 ALI of mixed fission products.

25 E Assume that the intakes associated with the five accident scenarios given above are sufficiently high to warrant medical intervention. Give a specific intervention technique that is available for each accident and discuss any special concerns or necessary precautions.

QUESTION 8

A toxicology professor is using highly toxic di-methyl-mercury in an experiment. The experiment and the apparatus, as designed, result in a steady-state air concentration of 0.005 mg/m^3 for organic mercury. The professor now wishes to include a tracer study in her research using Hg-203 tagged $Hg(CH_3)_2$. The specific activity used is 5-microcurie per milligram of the $Hg(CH_3)_2$ compound.

GIVEN

- DAC for organic Hg-203 is 7×10^{-5} μCi/ml
- Permissible Exposure Limit (PEL) for organic Hg compounds is 0.01 mg/m^3
- Atomic weight of Hg = 200.6
- Atomic weight of C = 12
- Atomic weight of H = 1
- The half-life of Hg-203 is 47 days
- Assume the presence of the radioactive mercury has an insignificant effect on the molecular weight of the tagged $Hg(CH_3)_2$.

POINTS

30 A Calculate the fraction of Hg atoms that are tagged? **Show all work**.

40 B What is the activity concentration, $\mu Ci/m^3$, corresponding to the PEL? Is this concentration below the DAC? **Show why or why not.**

30 C Assume OSHA requires that the fraction of DAC and the fraction of PEL is additive and should be less than or equal to one. i.e.:

$$f(DAC) + f(PEL) \leq 1$$

What is the highest specific activity of the tagged compound that can be used to assure compliance with the requirement?

QUESTION 9

Part of the reactor coolant clean-up system of a pressurized water reactor includes demineralizers that are loaded with resin to reduce the concentration of radioactive material in the reactor coolant system (RCS). Assume that only ^{60}Co is present in the reactor coolant system and that the clean-up system has been operating continuously for the 200 consecutive days of reactor operation.

GIVEN

Vertical Demineralizer:

- Composition material: Stainless steel
- Diameter: 4 ft
- Top thickness: 0.1 inches (neglect attenuation and build-up in steel top)

Operational Data:

- Flow rate through demineralizer: 480 lpm
- Demineralizer efficiency: 100%
- Concentration of ^{60}Co in RCS: 8.0×10^{-5} μCi/ml

Radiological Data for ^{60}Co:

- Gamma constant (Γ): 1.3 R-m^2/hr-Ci
- Half-life: 5.26 y
- Gamma emissions: 1.173, 1.332 MeV each at 100%
- Beta emissions: 1.480 MeV @ 0.12 %
  0.314 MeV @ 99.0 %

Additional data:

- Assume dose rate in air equals dose rate in tissue
- Attenuation Coefficients for Lead:

E(MeV)	0.60	0.70	0.80	1.0	1.25	1.50	2.75
μ(cm^{-1})	1.36	1.12	0.97	0.78	0.65	0.58	0.47

- Dose Build-up Factors for an Isotropic Point Source:

MeV	1(μx)	2(μx)	4(mx)	7(mx)	10(mx)	15(mx)	20(mx)
0.5	1.24	1.42	1.69	2.00	2.27	2.65	2.73
1.0	1.37	1.69	2.26	3.02	3.74	4.81	5.86
2.0	1.39	1.76	2.51	3.66	4.84	6.87	9.00
3.0	1.34	1.68	2.43	2.75	5.30	8.44	12.30

POINTS

40 A Calculate the gamma dose equivalent rate in rem/hour at a point 1 foot above the centerline of the surface of the demineralizer bed immediately after the 200 day run. Assume that the demineralizer contains no water above the resin bed and that all radioactive material is distributed uniformly over the top of the demineralizer bed. Also assume that the dose rate in the bed can be approximated by a thin disc source. Account for decay in your answer. **Show all work.**

60 B A valve located on the centerline, nine feet above the end of the demineralizer bed requires lapping. When isolated six months ago, the demineralizer contained 60 Ci of ^{60}Co. There is no water above the resin bed.

The lapping operation requires 30 minutes and is to be performed by a mechanic who has 300 mrem remaining on his annual administrative exposure limit. Because of physical limitations, a mat equivalent to 2 inches of lead is all the shielding that can be used. Is the shielding sufficient to prevent the worker from exceeding the administrative exposure limit? This is the mechanic’s only source of exposure. **State all assumptions. Show all work.**

QUESTION 10

You are the designated laser safety officer (LSO) of a major research facility that operates a continuous wave (CW) neon gas laser. The laser is operated from the center of a laboratory that is 20-meters square. The beam is directed towards the center of one wall where it terminates on a diffusely reflecting target that is mounted to the wall. The target reflectively factor, ρ_λ, is 0.90. The laser has the following operating parameters:

GIVEN

Power:	20 W
Beam diameter (1/e):	2 mm
Beam divergence:	1 mrad
Wavelength:	540 nm

Maximum Permissible Exposure for Direct Ocular Exposure Intra-beam Viewing from a Laser Beam*

Wavelength λ (μm)	Exposure Time t(s)	MPE
0.400 to 0.700	10^{-9} to 1.8×10^{-5}	5×10^{-7} J cm^{-2}
0.400 to 0.700	1.8×10^{-5} to 10	$1.8t^{3/4} \times 10^{-3}$ J cm^{-2}
0.400 to 0.550	10 to 10^4	1×10^{-2} J cm^{-2}
0.550 to 0.700	10 to T_1	$1.8t^{3/4} \times 10^{-3}$ J cm^{-2}
0.550 to 0.700	T_1 to 10^4	$10C_B \times 10^{-3}$ J cm^{-2}
0.400 to 0.600	10^4 to 3×10^4	$C_B \times 10^{-6}$ W cm^{-2}

* C_B=1 for λ = 0.400 to 0.550 μm; $C_B = 10^{(15[\lambda-0.550])}$ for λ = 0.550 to 0.700 μm;
$T_1 = 10 \times 10^{[20(\lambda-0.550)]}$ second for λ = 0.550 to 0.700 μm. [From ANSI Z136.1 (1986)].

POINTS

20 A Match the following radiometric quantities to their appropriate units.

1.	Radiant energy	a.	W cm^{-2}
2.	Radiant power	b.	W sr^{-1}
3.	Radiant intensity	c.	J
4.	Radiance	d.	W sr^{-1} cm^{-2}
5.	Radiant exposure	e.	J cm^{-2}
		f.	W
		g.	J sr^{-1} cm^{-2}

12 B Briefly define and describe each of following terms. Why is the specification of a NHZ more appropriate for indoor laser laboratories?

1. Nominal Hazard Zone (NHZ)
2. Nominal Ocular Hazard Distance (NOHD)

30 C Estimate and describe the nominal hazard zone (NHZ) for this laser laboratory? Assume the intrabeam MPE applies. **Show all work.**

20 D What is the minimum optical density (OD) of protective eyewear required to reduce the laser irradiance below the intrabeam MPE. Assume a 0.25-second accidental viewing time. **Show all work.**

10 E Assume a minimum OD of 5 is required for the protective eyewear. A researcher has obtained specifications from three proposed laser eyewear manufacturers. These eyewear have the following optical densities (OD) at the indicated wavelengths and luminous transmission values:

Specifications	**Brand X**	**Brand Y**	**Brand Z**
OD @ 400nm	3	5	5
OD @ 450 nm	4	7	7
OD @ 500 nm	5	7	8
OD @ 540 nm	5	7	8
OD @ 600 nm	3	4	7
OD @ 650 nm	1.5	3	6
Luminous Transmission	35 %	6 %	<1 %

Which manufacturer's eyewear (Brand X, Y, or Z) would you recommend as best to use in this laser laboratory and why? **Justify your answer.**

8 F Match the following FDA laser class with the appropriate characteristic that BEST describes the class.

1. Class I	a. can damage skin or eye from diffuse reflection
2. Class II	b. not an ocular hazard
3. Class III	c. 0.25 second exposure threshold
4. Class IV	d. momentary intrabeam viewing is hazardous

QUESTION 11

A 10 ton net weight (9071 kg) cylinder of 5% enriched UF_6 is punctured during heating inside a fuel fabrication facility. The facility building ventilation is released to the atmosphere via a 25 meter tall stack. The building has a volume of 10^6 cubic feet and a stack flow rate of 10^4 cfm.

GIVEN

$T_{1/2}$ $^{234}U = 2.5 \times 10^5$ y
$T_{1/2}$ $^{235}U = 7.1 \times 10^8$ y
$T_{1/2}$ $^{238}U = 4.5 \times 10^9$ y
The mass of the ^{234}U is 1% of the mass of the ^{235}U.
Atomic mass of Fluorine = 19 amu
Graphs of σ_y and σ_z with respect to distance are attached.

POINTS

20 A What is the specific activity of the UF_6? **Show all work.**

20 B For this part only, assume a specific activity of 10^{-5} Ci/g. Calculate the initial release rate (in activity units) for U_{Total} assuming instantaneous release of the contents of the UF_6 cylinder and instantaneous uniform mixing of the UF_6 within the building. **Show all work.**

25 C Using a constant release rate of 3.32×10^{-4} Ci/s, calculate the activity concentration of U_{Total} at 500 meters downwind at ground level at plume centerline for class D stability conditions and 5 m/s wind speed using the Gaussian plume model equation. **Show all work**.

20 D List five control measures that can be used to preclude a criticality accident from occurring. **Number your responses. Only the first five will be graded**.

15 E Preliminary analysis of the stack monitoring shows that apparent releases were considerably lower than predicted. Give three explanations for this**. Number your responses. Only the first three will be graded**.

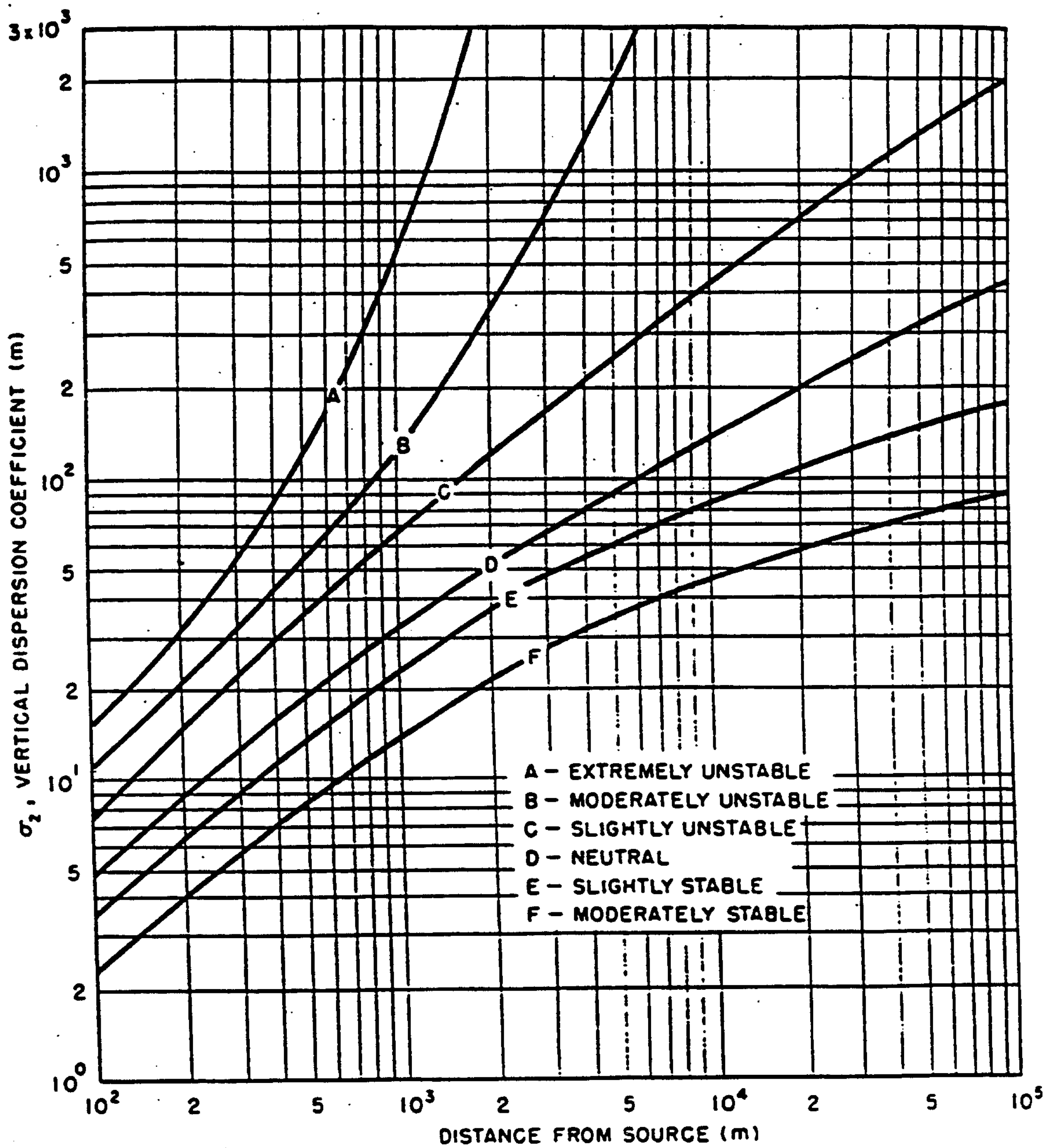


Figure 1: Meteorology and Atomic Energy: σ_z versus distance

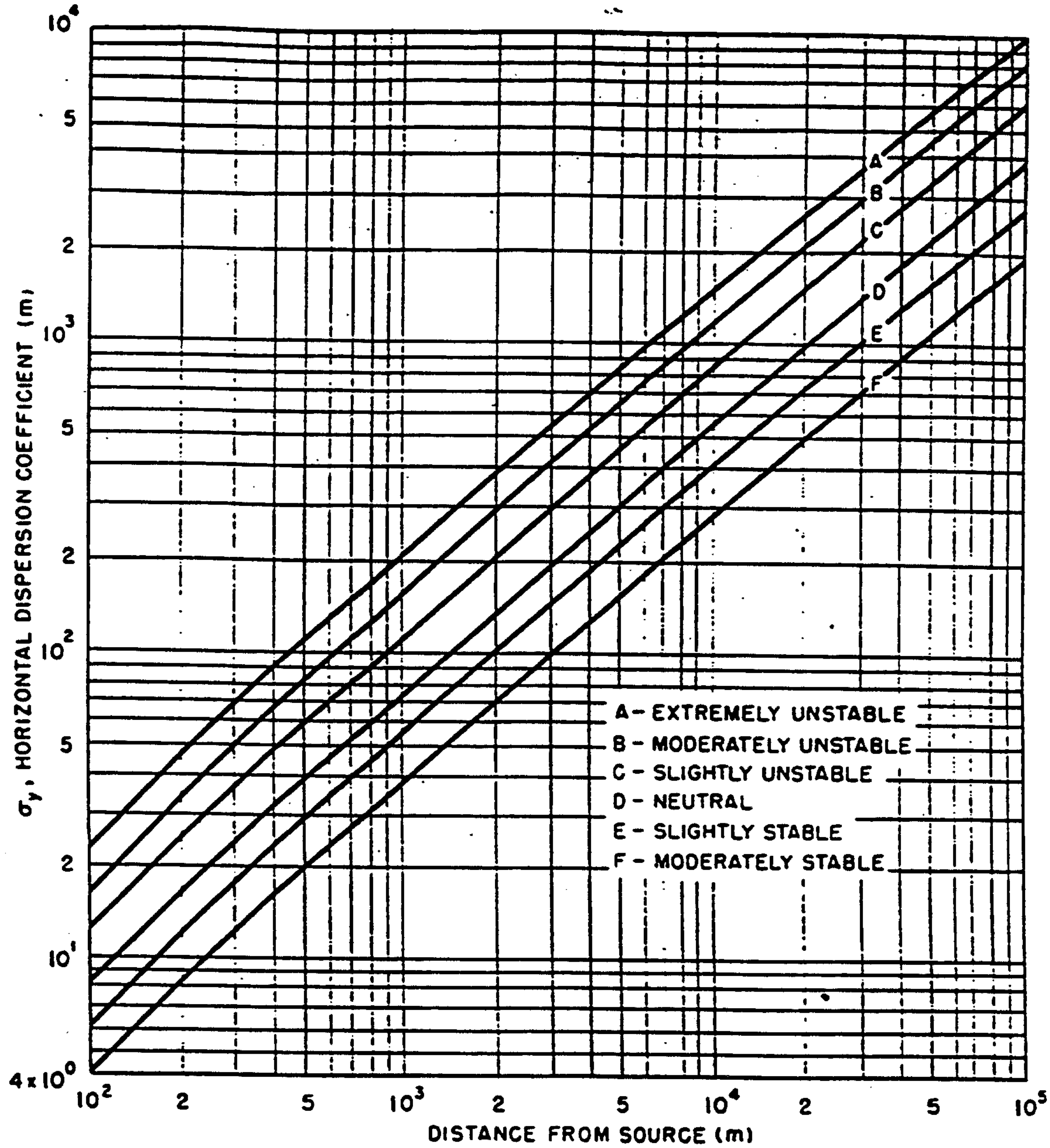


Figure 2: Meteorology and Atomic Energy: σ_y versus distance

QUESTION 12

You are the Health Physicist at an electron linear accelerator with a beam of up to 120 MeV and 50 kW used to strike a Tantalum target for the production of neutrons for research.

POINTS

10 A In reviewing the dose records for accelerator personnel, you notice that researchers and operators show low levels of neutron and β/γ exposures while maintenance workers show much higher levels of β/γ exposure only. How would you account for this difference?

10 B The accelerator needs to operate for approximately 96 hours per week and normally will require a block of about 8 hrs per week for scheduled maintenance. As the H. P., how would you recommend setting up the schedule? **Justify your answer.**

15 C At about what electron energy would one need to begin worrying about neutron production in most materials? Why this energy? What are the implications of higher energies?

5 D Why is knowing the neutron spectrum in areas occupied by accelerator personnel so important?

30 E Describe three distinctly different ways to measure a neutron spectrum and a brief statement indicating the basis on which they operate. **Number your responses. Only the first three will be graded.**

20 F Identify two different types of routine personnel dosimetry useful for accelerator neutron dosimetry. Describe the principle of detection for each. **Number your responses. Only the first two will be graded.**

10 G List one radioactive and one non-radioactive contaminant commonly produced in the air around the target area, and describe how each is produced. **Number your respones. Only the first two responses will be graded**.

QUESTION 13

A patient was administered I-131 for a thyroid ablation in your medical center. The patient is incontinent for urine and will be on a catheter with a urine collection bag.

GIVEN

Quantity of I-131 administered: 7400 MBq of I-131 (200 mCi)

For most thyroid ablation patients, approximately ½ of the patient's administered activity will be gone within the first 24 hours due to biological elimination and radioactive decay.

I-131 physical half life: 8.04 days

For I-131, the Gamma Constant = 2.2 $R\text{-}cm^2/hr\text{-}mCi$

For 364 keV photons: 1.4×10^7 $photons/s\text{-}cm^2$ yields an exposure rate of 1 R/hr

I-131 Radiations: β with an average energy of 0.180 MeV 100 % emission rate.
0.08 MeV gamma; 2.6% emission rate
0.364 MeV gamma; 82% emission rate
0.723 MeV gamma; 1.6 % emission rate

I-131 biological half life in the thyroid: 138 Days
Mass of thyroid: 20 grams

Available survey instruments include a "Pancake" style GM survey meter and a thin window NaI(Tl) probe.

At the 24 hour mark, the patients urine output is 1000 ml.

POINTS

10 A The dose rate from the urine collection bag at 24 hours is 47 mR/hr at 1 foot as measured with an air ion chamber. The bag has not been emptied. What is the amount of I-131 in the urine?

20 B The patient became very combative and threw the urine collection bag against a wall. The bag burst and a nurse proceeded to clean up the spill. The nurse tells you about this event the next day. You decide to perform a field screening to determine if the nurse had an iodine uptake. For the two instruments listed in the "Given" section state one pro and one con of using each instrument to check the nurse's thyroid, and your recommendation for use.

10 C Field screening shows that the nurse did intake I-131. The nurses thyroid is counted for 10 minutes using a fixed germanium thyroid detector. The results incidate 1800 counts in the 0.364 MeV photon peak. The background count rate in this spectral region is 80 cpm. The detection efficiency for this photon is 1E-03 c/d. Estimate the amount of I-131 in the nurse's thyroid at the time of the count. Show all work. Give your result in units of nCi.

40 D For thyroid-to-thyroid irradiation, MIRD pamphlet #11 gives an absorbed dose per unit cumulative activity factor ($S_{(\text{Thyroid}<\text{Thyroid})}$) of 2.2 x 10^{-2} Rad/uCi-h . A 100 μCi deposition of I-131 was measured in the thyroid of a janitor that assisted in the cleanup of the spill.

1) Calculate the committed dose equivalent to the janitor's thyroid from the 100 μCi deposition. **Show all work.**

2) Calculate the committed effective dose equivalent received by the janitor from the 100 μCi depostion. **Show all work.**

3) Is intervention advisable? **Explain your answer**.

20 E The non-stochastic inhalation ALI for I-131 is 50 mCi. Will a simple ratio of the I-131 detected within the thyroid to the ALI given above provide a reasonably accurate estimate of the CEDE? **Explain your answer?**

QUESTION 14

The following questions pertain to environmental monitoring principles.

GIVEN

1 gallon = 3.785 liters

According to HPS N13.30-1996, when the background and sample count times are the same, the equation for Minimum Detectable Amount (MDA) can be represented by the following equation:

$$MDA = \frac{4.65 s_b}{KT} + \frac{3}{KT}$$

s_b = The standard deviation of the background count rate
T = Sample and Background Count Time
K = Calibration Constant, counts per time per disintigration

POINTS

20 A Assume that a Gaussian dispersion model applies to a gaseous release. For the following conditions, would the centerline airborne radioactivity concentration on the ground at the site boundary (1 km from the release point) increase, decrease, or remain the same? **Justify your answer for each.**

1. The effective release height is increased
2. The wind speed increases
3. The ground temperature, which initially exceeds the temperature at 100 meters above the ground at the beginning of the release, decreases below the temperature at 1000 meters.
4. The gaseous effluent is heated above the ambient temperature and ejected from a vertical stack with a velocity exceeding that of the existing wind speed.

20 B Assume a release through a pipe to the bottom and in the middle of a wide, shallow, straight river. For the following release conditions, will the downstream centerline radioactivity concentrations in the river increase, decrease or remain the same? Justify your answer for each.

1. What is the effect on liquid radioactivity concentration if the temperature of the discharge is increased?
2. What is the effect on liquid radioactivity concentration from an increased velocity of the discharge?

3. What is the effect on the liquid radioactivity concentration from an increase in the river current?
4. What effect does time have on the concentration of radioactive material in the sediment on the river bottom?

25 C A counting laboratory needs to establish the counting time of sediment samples for a given procedure and stated MDA:

Counting efficiency = 0.2 c/d
Background count rate = 85 cpm
Desired MDA = 0.1 pCi/g
Sample size = 500 g of sediment

If the counting time for both the background and the samples is the same, is a count time of 4 minutes sufficient to meet the desired MDA? **Show all work.**

35 D Laboratory analysis shows that a holding tank with 15,000 gallons of water contains Cs-137 at a concentration of 8.81×10^3 pCi/ml. It is to be released over a 2-day period to a stream with a flow rate of 200 cfs. Calculate the dose to a theoretical individual who consumes 250 g of fish from the stream after this release if the bioaccumulation factor is 2000 and the ingestion ALI, based on ICRP 30 guidance, is 100 mCi. **Show all work.**