ABHP EXAMINATION 29, PART II

May 31, 1985

(Comprehensive)

Name: ______________________________

Identification Number: ______________

Signature: _________________________

Mark the questions you are submitting for grading.

1. X
2. X
3. X
4. X
5. X
6. X

7. ___
8. ___
9. ___
10. ___
11. ___
12. ___
13. ___

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

Question 4, page 2 of 3

Question 6, page 1 of 1

ABHP EXAMINATION #29, PART II
COMPREHENSIVE
MAY 31, 1985

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 fundamentals questions. You must answer all six.
   - The second section (questions 7-13) 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 5 points. Questions 7-13 are each worth 10 points. The maximum possible score is 70 points. The relative weight of each part of a question is given.

3. You have four 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 material 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.

American Board of Health Physics
Examination 29, Part II
Comprehensive Certification
May 31, 1985

FUNDAMENTALS

QUESTION 1

For each of the radiation exposures shown in the table, describe the expected biological effects that would be observable within the first few weeks after the exposure. Assume that the exposures are acute, no recent exposure history, and that reasonable medical care is provided.

Point		Exposure	Exposure Site
1	A.	25 rad gamma	Whole body
1	B.	300 rad gamma	Whole body
1	C.	300 rad gamma	Hand
1	D.	300 rad beta	Hand
1	E.	50 rad slow neutrons 10 rad fast neutrons 100 rad gamma	Whole body - mixed field

Briefly explain the uncertainties in Part E.

QUESTION 2

The classical definition of the roentgen is that amount of x or gamma radiation which will produce 1 e.s.u. of charge of either sign in 1 cm^3 of dry air at S.T.P. under conditions of charged particle equilibrium. In the SI system of units, the roentgen is defined as equal to 2.58×10^{-4} C/kg (exactly).

POINTS

2 A. Using one of these two definitions, calculate the absorbed dose in air from an exposure of 1 R. Show your work. No credit for answer alone without showing how it was calculated.

3 B. Calculate the specific gamma-ray constant, Γ, for ^{137}Cs in units of R m^2 Ci^{-1} hr^{-1}. Show your work.

GIVEN

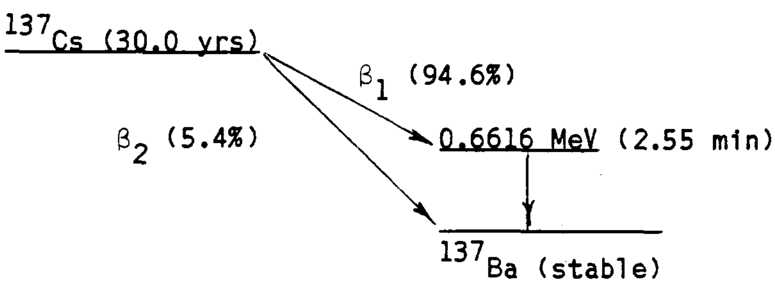
W_{air} = 34.0 eV/ip = 34.0 joules/coulomb

μ_{en}/ρ_{air} = 0.0271 cm^2/g

electronic charge = 4.8×10^{-10} e.s.u

1 MeV = 1.6×10^{-6} ergs = 1.6×10^{-13} joules

$\rho_{air} = 1.293 \times 10^{-3}$ g/cm^3 @ S.T.P.



QUESTION 3

You are to monitor a radioactive effluent in a stack. The effluent includes beta and gamma emitters on dust as well as radioiodine. You can adjust your air sampler and its collection device to obtain representative samples of stack gas.

Points

1 A. Is it necessary that sampling for each of these radionuclides in the effluent be isokinetic? Explain.

2 B. When sampling for beta and gamma emitters on dust:

(1) What collection device would you use?

(2) What would be the effect if the sampling velocity from the stack was significantly higher than the velocity of the gas in the stack? Explain.

2 C. When sampling for radioiodine:

(1) What collection device would you use?

(2) What would be the effect if the sampling velocity from the stack was significantly lower than the velocity of the gas in the stack? Explain.

QUESTION 4

An environmental sample has been collected for determination of ^{210}Po content. The sample is chemically separated and counted in an instrument with the following results sixty days after sampling:

Chemical yield	80%
Counting efficiency	20%
Sample counts (gross)	20
Sample count time	30 min.
Background counts	10
Background count time	30 min.
Half-life of ^{210}Po	138 days

POINTS

2 A. What was the sample ^{210}Po content in disintegrations/minute (dpm) at the time of sampling?

1 B. What is the standard deviation of the value determined in part A?

1 C. The lower limit of detection (LLD) at the 95% confidence level has been defined by Pasternack as:

$$LLD = (1.645)\ (2\ \sqrt{2}\ S_b)$$

where S_b is the standard deviation of the background. Calculate the LLD for this determination.

1 D. Does the activity level of this sample exceed the LLD for this determination?

QUESTION 5

An existing room at your licensed facility is being converted to a calibration room for the TLD program. The room dimensions and existing shielding are shown below. A 25 Ci ^{137}Cs source will be located in the room as shown. Your management wants the restricted area on the other side of the primary shield wall to have radiation levels less than that which would require the area to be posted and controlled as a radiation area.

POINTS

4 A. Is the existing primary shield wall adequate? Show your calculations.

1 B. If the area on the other side of the primary wall was an unrestricted area (e.g., public parking lot), what are the exposure limits which would apply for protecting the public from radiation exposure?

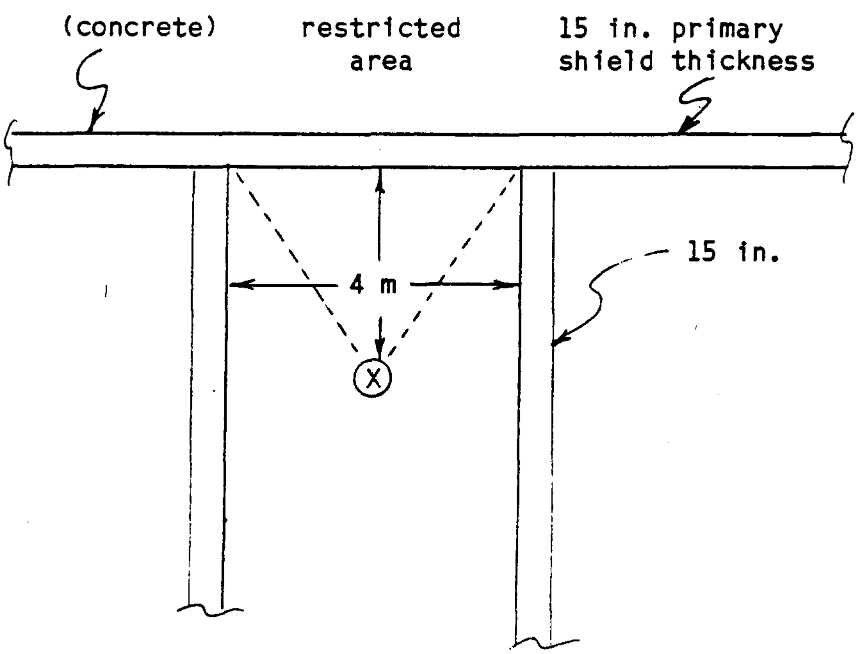
GIVEN

Mass attenuation coefficient for concrete = 0.078 cm^2/g

density, concrete = 2.35 g/cm^3

buildup table - attached

Γ for ^{137}Cs = 0.33 R m^2 hr^{-1} Ci^{-1}



Beam is incident only on primary shield wall.

QUESTION 5 (continued)

GIVEN (continued)

Dose Buildup Factor (B) for a Point Isotropic Source

Material	MeV	μx						
		1	2	4	7	10	15	20
Water	0.255	3.09	7.14	23.0	72.9	166	456	982
	0.5	2.52	5.14	14.3	38.8	77.6	178	334
	1.0	2.13	3.71	7.68	16.2	27.1	50.4	82.2
	2.0	1.83	2.77	4.88	8.46	12.4	19.5	27.7
	3.0	1.69	2.42	3.91	6.23	8.63	12.8	17.0
	4.0	1.58	2.17	3.34	5.13	6.94	9.97	12.9
	6.0	1.46	1.91	2.76	3.99	5.18	7.09	8.85
	8.0	1.38	1.74	2.40	3.34	4.25	5.66	6.95
	10.0	1.33	1.63	2.19	2.97	3.72	4.90	5.98
Aluminum	0.5	2.37	4.24	9.47	21.5	38.9	80.8	141
	1.0	2.02	3.31	6.57	13.1	21.2	37.9	58.5
	2.0	1.75	2.61	4.62	8.05	11.9	18.7	26.3
	3.0	1.64	2.32	3.78	6.14	8.65	13.0	17.7
	4.0	1.53	2.08	3.22	5.01	6.88	10.1	13.4
	6.0	1.42	1.85	2.70	4.06	5.49	7.97	10.4
	8.0	1.34	1.68	2.37	3.45	4.58	6.56	8.52
	10.0	1.28	1.55	2.12	3.01	3.96	5.63	7.32
Iron	0.5	1.98	3.09	5.98	11.7	19.2	35.4	55.6
	1.0	1.87	2.89	5.39	10.2	16.2	28.3	42.7
	2.0	1.76	2.43	4.13	7.25	10.9	17.6	25.1
	3.0	1.55	2.15	3.51	5.85	8.51	13.5	19.1
	4.0	1.45	1.94	3.03	4.91	7.11	11.2	16.0
	6.0	1.34	1.72	2.58	4.14	6.02	9.89	14.7
	8.0	1.27	1.56	2.23	3.49	5.07	8.50	13.0
	10.0	1.20	1.42	1.95	2.99	4.35	7.54	12.4

NOTE: For concrete use an average of aluminum and iron; e.g., B(conc) = [B(iron) + B(Al)] ÷ 2.

QUESTION 6

In the United States there are about 440,000 deaths each year due to cancers of all types in a population of about 220 million. It has been projected that if each member of a population of a million people were to receive a whole-body absorbed dose of 10 rem, there would be 1000 additional annual cancer deaths. Use these data in the calculations below.

Points

1 A. Define absolute risk.

1 B. Calculate the absolute risk of death per year due to cancer in the U.S.

1 C. Define relative risk.

2 D. Calculate the relative risk of death due to cancer for a radiation worker with a lifetime whole-body radiation equivalent dose of 35 rem.

American Board of Health Physics
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SPECIALTY QUESTIONS

QUESTION 7

You are the health physics consultant retained by a firm planning to develop and operate a low-level radioactive waste disposal facility. In addition to the shallow land burial operation, the facility will also include some waste processing operations, such as an incinerator, compactor or other state-of-the-art systems.

POINTS

3 A. Discuss the climatic, geographic and demographic characteristics to be considered in siting such a facility.

4 B. Discuss the preoperational environmental data necessary to support the licensing and design effort, the monitoring program required to obtain this information, and how long it would take to collect.

3 C. Discuss the routine environmental monitoring program necessary once operation begins to evaluate the impact of the proposed operations on the environment.

QUESTION 8

Significant concentrations of radon and its daughter products in the home air have recently been identified as a health concern. As a health physicist, you may be asked to sample for and quantify radon and its daughter products.

POINTS

POINTS		
1	A.	Define the Working Level (WL) which is the special unit used to describe airborne concentrations of radon daughters.
1	B.	Define the Working Level month (WLM) which is the special unit used to describe cumulative exposure to radon daughters.
1	C.	What is the drawback of using the Working Level month (WLM) in assessing or estimating the dose to the lung?
2	D.	What is the difference between the special unit for radon daughter concentration discussed in Question A and the activity concentration limit (typically called MPC) discussed in ICRP-2?
2	E.	Estimate the lung dose equivalent received by a uranium miner who sustains a cumulative annual exposure of 4 WLM; compare this estimate with the annual lung dose limit specified in ICRP 2.
1	F.	What is a method or technique for estimating long-term radon concentrations?
2	G.	Two grab-sample methods used to determine radon daughter concentrations are the Kusnetz method and the Tsivoglou method. How is the sample collected in each method? Which of the two methods would you use to make accurate indoor radon daughter measurements and why?

QUESTION 9

A patient treated for a special thyroid condition received an oral dose of 90 mCi of iodine-131 in a hospital in Louisville, Kentucky. The following day the patient was discharged to join his family in New York City. Because of the Air Traffic Controllers Strike, he took a public transportation bus and reached his destination 18 hours later. The passenger seated next to him for the entire trip was a pregnant woman. Assume the iodine-131 activity in the thyroid gland of the patient to be a point source and the distance between the thyroid gland containing iodine-131 and the fetus to be 30 inches.

Points		
2	A.	What is the iodine-131 body burden in the patient? What consideration(s) should be given in discharging the patient?
1	B.	List two radiation precautions or instructions that should be given to the patient upon release from the hospital.
3	C.	Calculate the radiation exposure to the fetus assuming no attenuation of the gamma photons between the source and the target?
2	D.	What is the guidance of the NCRP with regard to radiation exposure to the fetus?
2	E.	Estimate the radiation dose to the thyroid gland of the patient?

GIVEN

Physical half-life of iodine-131 = 8.0 days

Biological half-time of iodine-131 in the thyroid gland = 13.2 days

Specific Gamma-ray Constant of iodine-131 $\Gamma = 2.2 \times 10^3$ R cm^2/Ci hr

24-hour uptake in the thyroid gland at the time of discharge = 30%

Assume instantaneous uptake and uniform distribution of the activity in the thyroid gland and that it is eliminated exponentially with a single effective half-time.

Dose to the thyroid gland per μCi-hr of cumulative activity in the thyroid gland, $S = 2.2 \times 10^{-2}$ rads.

QUESTION 10

You are the RSO in a large university where investigators use many radioisotopes. Three radiochemicals of concern are inorganic P-32, NaI-125 to label biological compounds and tritiated water (HTO). All are used in millicurie quantities.

Points

5 A. In each of the following categories, assess the relative hazards of these three radiochemicals by indicating in each case:

High
Moderate
Low
Not applicable

	^{32}P	^{125}I	HTO
Skin Dose Potential			
Bioassay Requirement			
Eye Hazard			
Personnel Dosimetry Requirement			
Air Sampling Requirement			

1 B. Discuss how you would shield 10 mCi phosphorus-32 in terms of choice of shielding material to protect the torso when working on a benchtop with phosphorus-32 for 3 hr/wk. Justify your choice of shielding material and thickness required to protect the body.

1 C. If the activity of phosphorus-32 being handled is increased to 100 mCi, why does the shielding thickness remain the same?

1 D. Describe how you would handle phosphorus-32 radwaste given the economic constraints of a reduced RSO budget for fiscal year 1985. Be specific.

1 E. A researcher asks for your advice on whether he should take prophylactically 100 mg of potassium iodide before iodinating proteins with 2 mCi iodine-125. What would you advise? List two reasons for your decision.

1 F. You wipe test an area where hydrogen-3 and iodine-125 are both used. If you could only afford one instrument to detect this mixed contamination, what would it be? Explain.

QUESTION 11

Points

There is a debate currently going on among some health physicists over the question of how to assign dose limits: on an annual or on a committed dose basis.

2 A. Briefly describe the differences between the two systems of assigning dose and controls.

4 B. Briefly describe two benefits of each system of accounting for and controlling dose.

4 C. Briefly describe two problems of each system of accounting for and controlling dose.

Use an outline format as shown below or brief paragraphs to prepare your answers.

Basic Differences:

ANNUAL COMMITTED

Advantages:

1)

2)

Problems:

1)

2)

QUESTION 12

You are the Health Physicist providing health physics coverage for a radwaste shipment from an operating BWR nuclear power station. You have 1 liner containing 25 cubic feet of resin, solidified in cement, 3000 pounds net weight, to ship. The radiation level at 1 foot from the unshielded liner is 10 R/hr.

You will place the liner inside of 1 of 2 available shipping casks: Cask A or Cask B. Cask A, a DOT-certified Type A cask, has 5 cm of lead shielding; Cask B, a DOT-certified Type B cask, has 10 cm of lead shielding. The cask selected will be shipped on an exclusive use, unenclosed, flatbed trailer.

Radiochemistry has analyzed the resin, with the following results:

	^{60}Co	^{54}Mn	^{90}Sr
Concentration ($\mu Ci/cm^3$):	5.2	10.	8.7

The LSA concentration limits are shown below:

	^{60}Co	^{54}Mn	^{90}Sr
LSA Concentration Limit (mCi/g):	0.3	0.3	0.005

Points

2 A. What is the activity of each radionuclide to be shipped in Ci?

2 B. Can this be an LSA shipment? Justify your answer with calculations.

2 C. What would be the transmitted gamma dose rate at the exterior wall of each cask if used for the resin? Show all calculations.

2 D. Are there any DOT radiation level restrictions which apply to this shipment? If so, specify the applicable restriction(s).

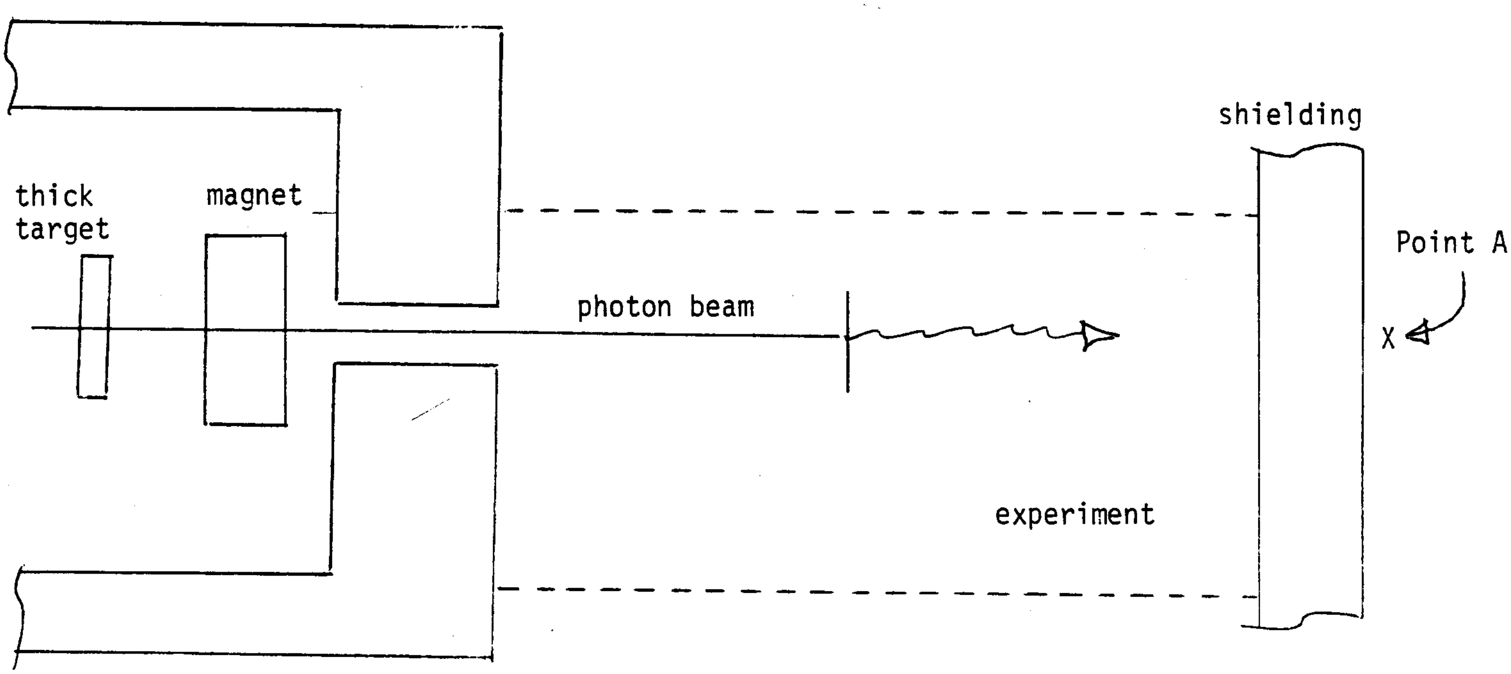
2 E. As a final check, you take a gamma radiation level measurement at the cask exterior wall, with 96 mR/hr as the result. What is the significance, if any, of this measurement? What actions, if any, should be taken?

GIVEN

1 ft^3 = 2.8 x 10^4 cm^3
1 lb = 454 g
Density of lead = 11.34 g/cm^3
Mass attenuation coefficient for 1 MeV gamma in lead = 0.0708 cm^2/g
Assume 1 gamma per disintegration with 1 MeV average energy.
Assume buildup factor, B, for 5 cm of lead at 1 MeV gamma = 2.
Assume buildup factor, B, for 10 cm of lead at 1 MeV gamma = 3.
Assume distance from outside of resin liner to outside of shipping cask (through the shielding) to be 1 ft.

QUESTION 13

A beamline is being set up to use photons from a thick target in a scattering experiment. The photon beam is produced by a 100 MeV electron beam striking a target as shown in the sketch below. The beamline components are interlocked so only a photon and neutron beam can enter the experimental area. The shielding at wide angles is adequate. Use the information given below to answer the following questions. State any assumptions.



Points

4 A. Calculate the unshielded photon and neutron dose rate at point A 30 meters from the target.

2 B. Calculate the photon and neutron dose rate at point A after the addition of one (1) meter of concrete.

2 C. Calculate the concrete shield thickness required to reduce the combined dose rate at point A to 100 mrem/hr.

2 D. An area monitoring system using GM detectors is proposed to monitor the dose rate after the concrete shield. Give your reason for accepting or rejecting this area monitoring system.

QUESTION 13 (continued)

GIVEN

Beam parameters: Electron beam energy = 100 MeV
Peak current = 5 mamp
Pulse duration = 2 microseconds
Pulse rate = 100 pulses/sec

D (photons) zero degrees = $3 \times 10^4 E_o \frac{\text{rad m}^2}{\text{kW hr}}$

Neutron yield (Giant Resonance) = $\frac{1 \times 10^{12} \text{ n/sec}}{\text{kW}}$

TVL for photons in concrete = 140 g/cm^2
TVL for GR neutrons in concrete = 100 g/cm^2
Flux to dose rate conversion for GR neutrons = 8 n/cm^2 sec = one (1) mrem/hr
Density of concrete = 2.35 g/cm^3
1 eV amp = 1 watt