Part I CHP Exam Prep

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(Q&A layout provided by Aaron Miaullis and Brian Livingston from the Army Public Health Center)

Exam Layout

150 multiple choice questions

- 5 possible answers

3 hours

- Answer about 1/3 of the questions each hour.
- Begin at the beginning and go through the whole exam, answering questions you are sure of *in order*.
- Pass over difficult/uncertain questions, saving them until the end. Do not lose time getting bogged down on a few difficult questions.
  - No penalty for guessing.

Passing score ≥ 95 correct answers

Domains and Sub-Areas

1. Measurements and Instrumentation (25% of total)

Covers the selection and use of measuring instruments, the interpretation and reporting of the values obtained from the instruments, data quality objectives and quality control, and the calibration, maintenance and performance testing of instrumentation. Includes sample collection devices.

- 1.1 Types of Measurements
- 1.2 Selection of Instruments
- 1.3 Analytical Techniques for Sampling
- 1.4 Measurement Methods
- 1.5 Interpretation and Reporting of Results
- 1.6 Quality Control and Data Quality Objectives
- 1.7 Instrument Calibration, Maintenance, and Performance Testing

Domains and Sub-Areas

2. Standards and Requirements (20% of total)

Covers the standards and guidelines of groups such as ICRP, NCRP, ANSI, ASTM, and the requirements of various regulatory agencies such as NRC, DOE, EPA, DOT, OSHA, FEMA, the Postal Service, and state agencies; these regulatory agencies also provide regulatory guidance. Guidance is also provided by industry oversight groups such as ANI and INPO.

- 2.2 History and Development
- 2.3 Use and Application
- 2.4 Types of Regulations
- 2.5 Interpretation and Knowledge

Domains and Sub-Areas

3. Hazards Analysis and Controls (20% of total)

Covers the identification of hazards, the use of engineered controls to eliminate or mitigate the hazard, analysis of potential failures of protective control systems and the radiological consequences of failure, types of controls and assessment of the control effectiveness.

3.1 Hazard Identification
3.2 Evaluate and Assess Significance/Consequence
3.3 Devise and Implement Controls
3.4 Types of Engineered Controls
3.5 Designs and Specifications
3.6 Selection and Evaluations
3.7 Use and Operations
3.8 Document and Communicate

Domains and Sub-Areas

4. Operations and Procedures (20% of total)

Covers the application or incorporation of radiation protection considerations into an operating program.

- 4.1 Standard Operating Practices and Procedures
- 4.2 Emergency Response
- 4.3 Basis for Operations and Program
- 4.4 Program Types
- 4.5 Records

Domains and Sub-Areas

5. Fundamentals and Education (15% of total)

Covers the content of training the health physicist receives and the training the health physicist prepares, reviews, and presents

- 5.1 Skills of the Trade - explain
- 5.2 Types

The candidate should be familiar with fundamental characteristics of those radionuclides commonly encountered in the radiation protection field including:

H-3	Sr-90
C-14	Tc-99m
F-18	I-125 & I-131
P-32	Cs-137
S-35	Ra-226
Co-60	Am-241

Fundamental characteristics include basics such as the mode of decay, principal type(s) of radiation emitted, energies of radiation emitted, and half-life.

Practice! Practice! Practice!

Sample Tests

- From ABHP site (25 Q&A)
- From NRRPT site (25 Q&A)
- NRRPT flash cards
  - http://www.cram.com/flashcards/nrrpt-radiation-protection-technologist-general-exam-study-set-2247261

Practice! Practice! Practice!

The CHP exam recycles questions

- Know the **practice questions** cold, several often show up verbatim!
- Review all old **CHP Part II exams** for multiple choice questions, you can bet a few will show up on Part I.

Comfort

Bring food & drinks!!

- your brain runs on carbohydrates and your brain will become exhausted.
- the food should be able to be eaten one-handed.
- avoid annoying others with smelly foods.
- fiber and lots of soda are not your friends. A ten minute bathroom break means 10 test minutes.

NRRPT Q1

In general, the body cells most susceptible to damage by radiation are those found in:

a. rigid or semi rigid tissues

b. muscle tissues

c. rapidly dividing tissues

d. highly specialized tissues

e. nerve tissues

NRRPT Q1

ANSWER: C

As stated by the the Law of Bergonie and Tribondeau (based on an early observation about the difference in radiosensitivity of cells in rats' testes) "the radiosensitivity of a tissue is directly proportional to the reproductive activity and inversely proportional to the degree of differentiation," and "tissues consisting of rapidly dividing stem cells are quite sensitive to radiation whereas cells that do not divide or only rarely divide are considerably more resistant."

NRRPT Q2

In a picocurie of any radioactive substance, the disintegration rate is:

a. 2.22 dpm

b. 2.22 x 10 E 6 dpm

c. 37,000,000 dpm

d. 3.7 x 10 E 4 dps

e. 3.7 x 10 E 10 dps

NRRPT Q2

ANSWER: A

This question requires some math, but the answers are in dpm (decays per minute) and dps (decays per second, also called becquerel (Bq)) so the student can "divide and conquer" on this question by finding out if the answer should be in dpm or dps. In addition note that all the answers but A are in orders of magnitude. So let's do the math!

$$(1\ pCi)\left(\frac{Ci}{10^{12}\ pCi}\right)\left(\frac{3.7\times 10^{10}\ dps}{Ci}\right)=3.7\times 10^{-2}\ dps$$

The exponent is negative, therefore answers b, c, d and e are not valid, leaving the answer to be a. But to prove that we have the right answer, convert to dpm:

$$(3.7\times 10^{-2}\ dps)\left(\frac{60\ seconds}{minute}\right)=2.22\ \frac{decays}{minute}$$

NRRPT Q3

Which of the following radionuclides cannot be detected by gamma spectrometry pulse height analysis?

a. Hydrogen-3
b. Iodine-131
c. Cerium-144
d. Ruthenium-106
e. Cesium-137

NRRPT Q3

ANSWER: A.

Hydrogen-3 (tritium) is a pure beta (β -) emitter with a half-life of 12.3 years and a maximum energy of 18.6 keV. Beta particles have an average energy of about one third of their maximum energy, in this case 6.2 keV. The only way to detect hydrogen-3 is to swipe (100 cm^2 for surveys and 300 cm^2 for transportation) and count in a liquid scintillation counter (LSC).

NRRPT Q4

The elemental symbols for Boron, Beryllium, Cadmium, and Calcium are:

a. Bo, B, Ca, C

b. B, By, Cd, Ca

c. Bo, Be, Cd, Ca

d. B, Be, Cd, Ca

e. B, Br, Ca, Cl

NRRPT Q4

ANSWER: D

You may not know all of these, but you should know a few:

the last element on the list is calcium which has the elemental symbol Ca. Therefore A and E are out (carbon (C) and chlorine (Cl)). Bo and By aren't elemenst so we can eliminated c and b, which leaves us with d.

NRRPT Q5

Which of the following radionuclides is most suited to in-vivo measurements?

a. Hydrogen-3
b. Carbon-14
c. Strontium-90
d. Iodine-131
e. Plutonium-239

NRRPT Q5

ANSWER: D

Easy points here for knowing that “in vivo” means “performed or taking place in a living organism.” As weak pure beta (β -) emitters, hydrogen-3 and carbon-14 can only be seen through liquid scintillation analysis of urine (outside of the body). Strontinum-90 is also a pure beta emitter (fecal-analysis or urinalysis). Plutonium-239 has a very weak x-ray which is shielded by the body (lung lavage has been used in the past). Iodine-131 (a mixed β -/γ emitter) can be seen with a sodium-iodine probe held to the body (usually measuring on the thyroid).

NRRPT Q6

How long must a sample with a count rate of 300 cpm be counted to give a total count rate standard deviation of 1%?

a. 3.5 min
b. 17 min
c. 30 min
d. 33 min
e. 65 min

NRRPT Q6

ANSWER: D

To solve this question you need to know that the standard deviation (σ) is equal to the square root of the number of counts (n). But we are given a rate (r) and the counts are equal to the rate (r) divided by the time (t).

$$\sigma = \sqrt{n} = \sqrt{r/t}$$

To solve for time, we need to rearrange the equation. First square both sides, then switch the σ^2 with time, finally solve for time.

$$\sigma^2 = \sqrt{r/t}^{\,2} = r/t \qquad t = r/\sigma^2$$

One percent of 300 cpm (r) is 3 cpm (σ).

$$t = 300\ cpm/(3\ cpm)^2 = 33/cpm = 33\ minutes$$

NRRPT Q7

At what radius would you post a radiation area around an 8 curie Cesium-137 (662 keV photon, photon yield 0.85 photons/disintegration) point source?

a. 10 feet
b. 74 feet
c. 145 feet
d. 53 feet
e. 101 feet

NRRPT Q7

ANSWER: B

You need to know:

1. A radiation area boundary is any area with radiation levels greater than 5 mrem (0.05 mSv) in one hour at 30 cm from the source or from any surface through which the radiation penetrates.
2. For photons 1R is essentially 1 rem
3. The gamma constant (Γ) for Cs-137 is 0.345 $R\ m^2/hours\ Ci$
4. There are 3.28 feet per meter.

Rearrange the point source equation to solve for distance

$Dose\ Rate = \Gamma A/d^2$ $\quad d=\sqrt{\Gamma A/Dose\ Rate}$ $\quad d=\sqrt{(0.345\ R\ m^2/hours\ Ci)(8\ \mathrm{Ci})/5\ mR\ (R/10^3\ mR)}=23.5\ m$ $\quad 23.5\ m(3.28\ ft/m)=77.1\ ft$

Could also use $I'd'^2=I''d''^2$ where I' is exposure rate at 1m from 8Ci (0.345X8) and I" is desired exposure rate (0.005 mR/h), solve for d"

NRRPT Q8

An air filter with a collection efficiency of 99.97% is being used in a decontamination effort. Calculate the decontamination factor for this filter.

a. 9997
b. 0.9997
c. 3000
d. 10,000
e. 3333

NRRPT Q8

ANSWER: E

If 0.9997 is collected on the filter, 0.0003 is not collected (contamination).

$1/0.0003 = 3333$ *decontamination factor*

NRRPT Q9

During an emergency in a DOE regulated facility, with known or potential high radiation fields, exposure to personnel must be voluntary if it is anticipated that such exposure may exceed a whole body exposure of:

a. 5 rem
b. 10 rem
c. 25 rem
d. 75 rem
e. 100 rem

NRRPT Q9

ANSWER: A

5 rem is the DOE (and NRC) annual dose limit for normal work. Therefore if an emergency were happening they would ask for volunteers for the emergency (not normal) work. The distractions are 10 rem (***EPA*** limit for emergencies) and 25 rem (***EPA*** limit for lifesaving).

NRRPT Q10

A worker is to perform maintenance on a reactor coolant pump under the following radiological conditions: dose rate on contact with the pump is 350 mrem/hr, dose rate at 30 cm from the pump (working area dose rate) is 85 mrem/hr, and there is an airborne concentration of 0.45 DAC. She will spend a maximum of 14 hours in this area during the week. According to 10CFR20, how is this area to be posted?

a. Danger High Radiation Area, Airborne Radioactivity Area
b. Caution Radiation Area, Airborne Radioactivity Area
c. Caution High Radiation Area, Airborne Radioactivity Area
d. Caution Airborne Radioactivity Area
e. Caution Radiation Area

NRRPT Q10

ANSWER: E

Airborne Radioactivity Area: A room, enclosure, or area in which airborne radioactive materials, composed wholly or partially of licensed material, exist in concentrations that (1) exceed the derived air concentration limits (DACs), or (2) would result in an individual present in the area without respiratory protection exceeding, during those hours, 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

Radiation area: Any area with radiation levels greater than 5 mrem in one hour at 30 cm from the source or from any surface through which the radiation penetrates.

High Radiation Area: Any area with dose rates greater than 100 mrem in one hour 30 cm from the source or from any surface through which the ionizing radiation penetrates.

The worker will be in the area 14 hours at 0.45 DAC. Multiply the two values together and she will get 6.3 DAC-hours, which doesn't meet the definition for airborne radioactivity area.

NRRPT Q11

For an exclusive use vehicle that is transporting radioactive materials, radiation levels on contact with any external surface of the vehicle must not exceed:

a. 0.01 mSv/hour
b. 0.02 mSv/hour
c. 0.1 mSv/hour
d. 2.0 mSv/hour
e. 10.00 mSv/hour

NRRPT Q11

ANSWER: D

From DOT regs:
200 mrem/h at any point on the outer surface of the vehicle, including the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load or enclosure, if used, and on the lower external surface of the vehicle; and

10 mrem/h at any point 2 meters from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 meters from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle); and

2 mrem/h in any normally occupied space, except that this provision does not apply to private carriers, if exposed personnel under their control wear radiation dosimetry devices in conformance with 10 CFR 20.1502.

For shipments made under the provisions of paragraph (b) of this section, the shipper shall provide specific written instructions to the carrier for maintenance of the exclusive use shipment controls. The instructions must be included with the shipping paper information.

The written instructions required for exclusive use shipments must be sufficient so that, when followed, they will cause the carrier to avoid actions that will unnecessarily delay delivery or unnecessarily result in increased radiation levels or radiation exposures to transport workers or members of the general public.

NRRPT Q12

Two categories of ionization are:

a. alpha and beta
b. direct and indirect
c. microwave and infrared
d. charged and uncharged
e. molecular and atomic

NRRPT Q12

ANSWER: B

Answer A neglects gamma, x-rays, neutrons, etc.
Answer C covers nonionizing radiation
Answer D describes ionizing radiation, but not ionization.
Answer E covers chemistry (molecular and atomic),not physics.
Atoms are ionized either directly or indirectly.

NRRPT Q13

Intrinsic efficiency of a detector expresses the:

a. probability that a count will be recorded if radiation enters the sensitive volume.

b. ability of an instrument to count different energies.

c. percent of gamma energy producing ion pairs.

d. total detector counts minus the background.

e. total beta/gamma counts by a tissue equivalent detector

NRRPT Q13

ANSWER: A

Efficiency is what the detector reads (cpm) divided by what the detector could see (dpm). The only answer that covers probability is A.

NRRPT Q14

The antiparticle of a positron is a:

a. proton
b. neutrino
c. electron
d. meson
e. neutron

NRRPT Q14

ANSWER: C

A positron (β +) is a positive beta particle (β -). A beta particle is the same as an electron, therefore an anti-positron would be a beta particle, or electron.

NRRPT Q15

Forms of the same chemical element that contain different numbers of neutrons are called:

a. isobars
b. isomers
c. radionuclides
d. isotones
e. isotopes

NRRPT Q15

ANSWER: E

^Z↑A↓X↓N

A= mass number (Z+N)

Z= atomic number (no of protons)

N= number of neutrons

Isotopes: nuclei with constant number of **protons** but different number of neutrons. For example, isotopes of hydrogen are H-1, H-2 and H-3.

Isotones: nuclei with constant number of **neutrons.**

Isobars: nuclei with constant mass number A but different atomic number Z and neutron number N.

Isomers: Same A, N and Z, but different energies. For example, Tc-99m and Tc-99 are isomers of each other.. The metastable form has more energy to give up.

NRRPT Q16

An atom of a radionuclide that has a low neutron to proton ratio, and an atomic rest mass energy that is 1.02 MeV greater than the product atom's rest mass energy may decay by which of the following?

a. Either positron emission or electron capture
b. Annihilation
c. Beta minus emission
d. Isomeric transition
e. Internal conversion

NRRPT Q16

ANSWER: A

The big clue is the 1.02 MeV statement. An atom needs 1.02 MeV (the energy of two electrons) to give up to produce a positron. The other clue is the neutron to proton ratio is low. The atom must either eject a positive charge (positron) or negate a positive charge by capturing an electron and converting the proton into a neutron.

NRRPT Q17

Which radioactive decay series includes Ra-226 as one of its decay products?

a. Thorium
b. Uranium
c. Actinium
d. Neptunium
e. Polonium

NRRPT Q17

ANSWER: B

The easy way is to remember natural decay chains is the AUNT rule:

Divide the atomic number (226 in this case) by four. Whatever is left over as the remainder will help you decide which decay chain the isotope is in.

Actinium	4N + 3
Uranium	4N + 2
Neptunium	4N + 1
Thorium	4N + 0

NRRPT Q18

An individual who receives an acute, whole body radiation exposure (DDE) of approximately 8 Gy will likely suffer symptoms of up to which level of the Acute Radiation Syndrome?

a. Subclinical
b. Hemopoietic
c. Gastrointestinal
d. Central Nervous System
e. Not enough exposure to classify

NRRPT Q18

ANSWER C

Dose (Gy)		Borne Marrow Suppression		
	12 and above		Neurovascular syndrome onset	Multiple organ failure Probable death
	11			
	10			Consider stem cell transplants
	9			
	8			
	7			LD50/60 with supportive care
	6		GI syndrome onset	
	5			LD50/60 without treatment
	4			
	3			
	2		Hematopoietic syndrome onset	~100% survival without treatment
	1			
	0			

NRRPT Q19

The term "isokinetic sampling" refers to the procedure of using sampling velocity that is <u>exactly equal</u> to the:

a. velocity of the gas stream at the point of sampling

b. velocity at the center of the main gas stream corrected for temperature and pressure

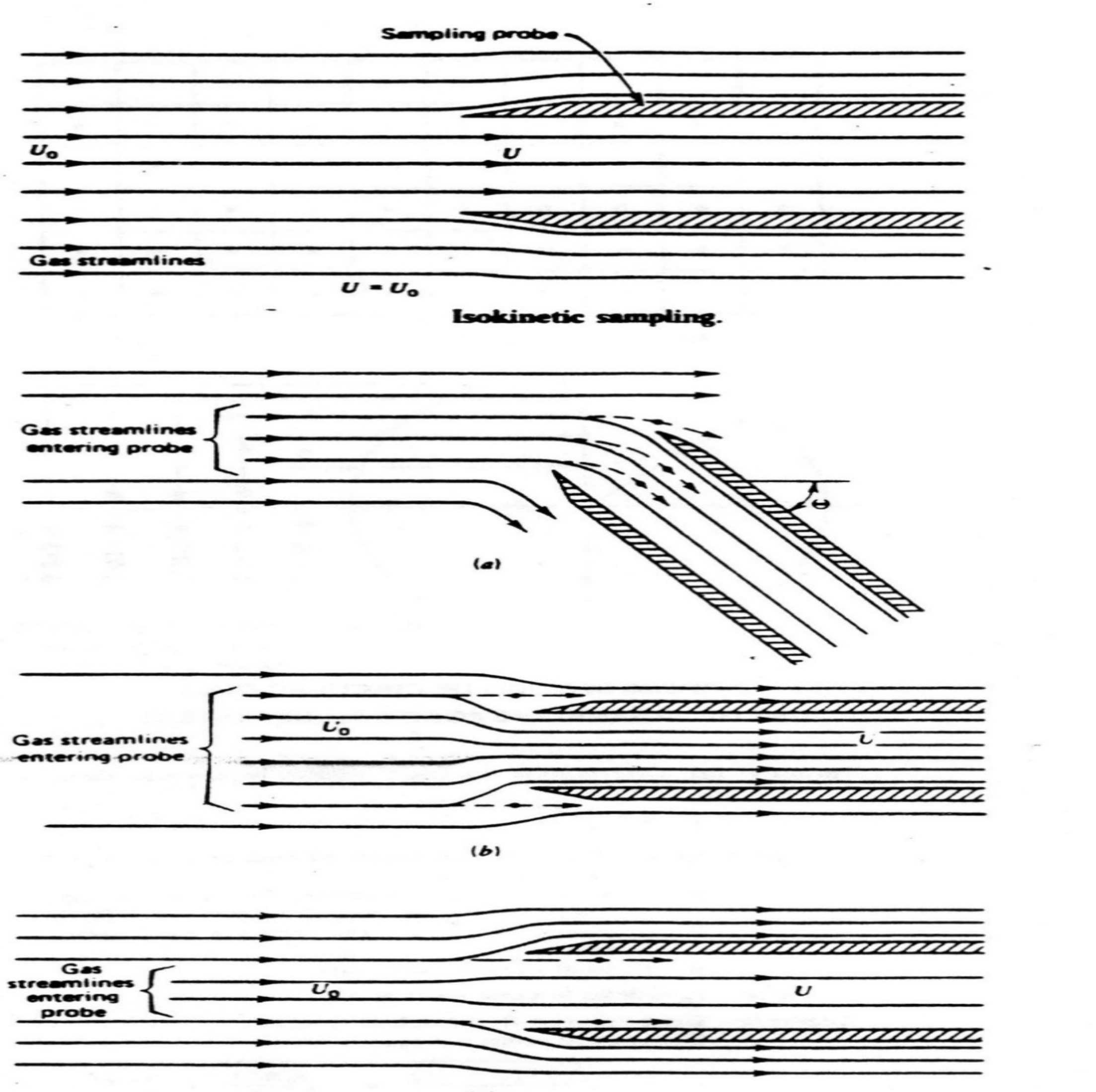
c. velocity at the center of the main gas stream

d. velocity of the gas stream adjacent to the duct wall

e. average velocity of the main gas stream

NRRPT Q19

ANSWER: A



Anisokinetic sampling. (*a*) Misalignment, $\Theta \neq 0$. (*b*) $U > U_0$. (*c*) $U < U_0$.

NRRPT Q20

In which of the following radioactive decays will the daughter product be an <u>isobar</u> of the parent?

a. alpha decay
b. gamma decay
c. neutron decay (elastic scatter)
d. positron decay
e. neutron decay (inelastic scatter)

NRRPT Q20

ANSWER: D

See earlier question.

NRRPT Q21

The respiratory protection device of choice for entry into an atmosphere immediately dangerous to life and health is a (an):

a. supplied air hood

b. air-purifying respirator equipped with a high efficiency filter

c. air-purifying respirator, full face piece, equipped with organic vapor canister

d. self-contained breathing apparatus equipped with a pressure demand regulator

e. self-contained breathing apparatus equipped with a demand type regulator

NRRPT Q21

ANSWER: D

Positive-pressure respirators maintain a positive pressure in the face piece during both inhalation and exhalation. The two main types of positive-pressure respirators are pressure-demand and continuous flow. In pressure-demand respirators, a pressure regulator and an exhalation valve on the mask maintain the mask's positive pressure except during high breathing rates. If a leak develops in a pressure-demand respirator, the regulator sends a continuous flow of clean air into the face piece, preventing penetration by contaminated ambient air. Continuous flow respirators (including some SARs and all powered air-purifying respirators [PAPRs]) send a continuous stream of air into the face piece at all times.

NRRPT Q22

The average distance of travel in a medium between interactions, describes a photon's:

a. mass energy absorption coefficient
b. mean free path
c. linear attenuation coefficient
d. Compton cross section
e. linear energy transfer

NRRPT Q22

ANSWER: B

The trick is the word "distance" and the only answer with distance is B (mean free **path**). Similar to the mean life ($1/\lambda$), for radioactive decay, $1/\mu$ is the average distance that incident photons travel before interacting. For uncollided radiation, it is numerically equal to the relaxation length (distance for which the exposure decreases by a factor of e).

NRRPT Q23

The Bragg-Gray principal is based upon the relationship of:

a. secondary charged particle equilibrium requirements and the thickness of the wall material of the chamber.

b. ionization in an air-filled ionization chamber to the dose in air

c. ionization of the gas in an ionization chamber to the dose in the wall material

d. ionization in a gas-filled ionization chamber to the dose in the gas

e. scatter of low energy photons to the probability of ionization in the chamber

NRRPT Q23

ANSWER C:

When you see the words "Bragg-Gray principle" go for the answer with "wall" in it. The Bragg-Gray principle is the foundation for much of dosimetry and relates the ionization in one component of a test system (cavity) to the energy absorbed in another component (wall).

NRRPT Q24

Given a gamma-energy value of 0.662 Mev, and a photon yield of 0.85 per decay, the exposure rate at 2 yards from an unshielded 10 mCi Cs-137 point source is:

a. 1.10 R/hour
b. 0.55 R/hour
c. 5.50 R/hour
d. 0.55 mR/hour
e. 0.94 mR/hour

NRRPT Q24

ANSWER: E

Again, you need to know the gamma constant ($\Gamma = 0.345\ R\ m^2 / hours\ Ci$) and that there are 3.28 feet per meter.

$$Dose\ Rate = \Gamma A/d^2$$

$$DoseRate = (0.345\ R\ m^2 / hours\ Ci)(10\ \mathrm{mCi})(Ci/10^3\ mCi)/((2\ yards)(3\ feet/yards)(meter/3.28\ feet))^2 = 1.03\times 10^{-3}\ R/hour = 1.03\ mR/hr$$

NRRPT Q25

A radionuclide has a decay constant of 0.1314 $years^{-1}$, a gamma energy (per disintegration) of 2.50 MeV, and will produce a dose rate of approximately 30 R/hour at one foot from a 2 Curie source. Calculate the radiological half-life of this nuclide:

a. 5.27 years
b. 229 years
c. 3.93 years
d. 30.1 years
e. 0.0231 years

NRRPT Q25

ANSWER: A

Everything after the decay constant (λ) is a distraction. All you need is the decay constant to solve this one.

$\lambda = (0.693/t_{1/2})$ $\quad t_{1/2} = (0.693/\lambda)$ $\quad t_{1/2} = (0.693/0.1314\ years^{-1}) = 5.27\ years$

(remember 0.693 = ln2)

CHP Part 1 Q1

For a **narrow** beam of photons, the **relaxation length** is that thickness of absorber that will result in a reduction of in the initial beam intensity.

1. 1/10.
2. 1/2.
3. 1/log 2.
4. 1/1n2.
5. 1/e.

CHP Part 1 Q1

ANSWER: 5

One relaxation length is the thickness (t) of shield that will attenuate a narrow beam to 1/e of its original intensity. One relaxation length, therefore, is numerically equal to the reciprocal of the absorption coefficient.

$(I_2 / I_1) = e^{-ut}$ $\qquad 1/e = e^{-1} = e^{-ut}$

$-1 = -ut$ $\qquad 1/u = t$

CHP Part 1 Q2

If the total beta count rate is 250 cpm based on a 25-minute count and the beta background is 60 cpm based on a 10-minute count, how should the sample count rate be reported at the 95 percent confidence level?

1. (190 ±4) cpm
2. (190±8) cpm
3. (190± 14) cpm
4. (190± 16) cpm
5. (190±23) cpm

CHP Part 1 Q2

ANSWER: 2

$(Count\ Rate) - (Background\ Rate) = (Sample\ Count\ Rate)$

$(250\ cpm) - (60\ cpm) = (190\ cpm)$

$\sigma = \sqrt{(r_g/t_g) + (r_b/t_b)} = \sqrt{(250\ cpm/25\ minute) + (60\ cpm/10\ minute)} = \sqrt{10+6} = \sqrt{16} = 4$

95% Confidence Interval is 1.96 σ. Therefore 1.96 X 4 = 8 cpm

CHP Part 1 Q3

To avoid criticality when processing waste fissionable material, the size and shape of the container and the concentration are most important for:

1. a liquid slurry
2. small, dry solid pieces
3. dry powder
4. large solid pieces
5. an alloy of less dense material

CHP Part 1 Q3

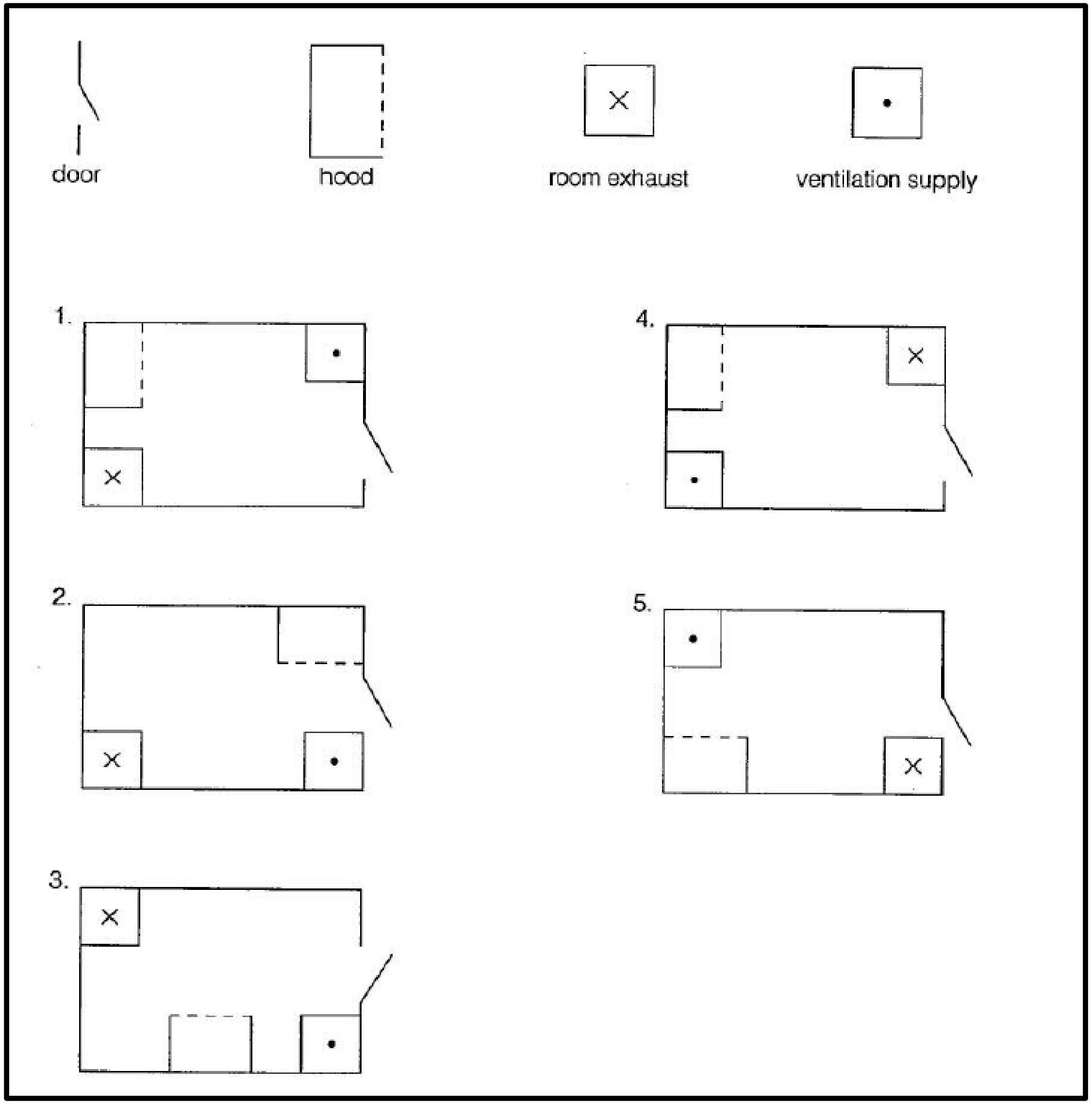
ANSWER: 1

In a liquid slurry the geometry can change and cause a critical mass. In addition all the other answers are dry (no water) and therefore lack a moderator to induce a criticality effectively.

CHP Part 1 Q4

A laboratory is being designed for performing iodine labeling experiments with activities on the order of a few millicuries. A radioisotope hood will be used for this work. Which one of the following arrangements is best?

(see next page for diagrams)


door
hood
room exhaust
ventilation supply
1.
2.
3.
4.
5.

CHP Part 1 Q4

ANSWER: 1

Clean air near door, exhaust air near hazard.

CHP Part 1 Q5

An ionization chamber was exposed to 10^{-2} C kg^{-1} of x-rays at a rate of 10^{-4} C kg^{-1} s^{-1}. The same chamber was then exposed to 10^{-2} C kg^{-1} at the rate of 10^{-2} C kg^{-1} s^{-1}. If the second exposure reading was **less** than the **first** reading, the most likely cause is:

1. recombination
2. leakage
3. resolving time
4. a decrease of energy absorption
5. an increase in absorption coefficients

CHP Part 1 Q5

ANSWER: 1

Knoll: “Collisions between positive ions and free electrons may result in **recombination** in which the electron is captured by the positive ion and returns it to a state of charge neutrality. Alternatively, the positive ion may undergo a collision with a negative ion in which the extra electron is transferred to the positive ion and both ions are neutralized.”

CHP Part 1 Q6

A certain radioisotope has a **biological half-life** in the human body which is **three times as long** as its **physical half-life**. Its **effective half- life** would be taken as equal to:

1. three-fourths of the physical half-life.
2. four-thirds of its physical half- life.
3. four times its physical half- life.
4. one-third of its biological half- life.
5. its biological half-life.

CHP Part 1 Q6

ANSWER: 1

$T_E = ((T_B)(T_R)/T_B + T_R) = ((3T_R)(T_R)/3T_R + T_R) = 3T_R/4$

CHP Part 1 Q7

An investigator has received some ^{95}Zr (half-life = 65 days) for use in a long-term study. He finds the ^{95}Zr to be contaminated with ^{60}Co (half-life = 5.24 years) such that the ratio of ^{60}Co activity to the ^{95}Zr activity is 0.012. After the initial assay, the activities of the two emitters will become **equal** in:

1. 280 days.
2. 290 days.
3. 340 days.
4. 360 days.
5. 430 days.

CHP Part 1 Q7

ANSWER: 5

$$A_2 = A_1 e^{-\lambda t}$$

$$1 = \left(\frac{A_{Co-60}}{A_{Zr-95}}\right)_2 = \left(\frac{A_{Co-60}}{A_{Zr-95}}\right)_1 \left(\frac{e^{-\lambda_{Co-60} t}}{e^{-\lambda_{Zr-95} t}}\right)$$

$$1 = (0.012)_1 e^{(\lambda_{Zr} - \lambda_{Co})t} \qquad \frac{\ln(1/0.012)}{\lambda_{Zr} - \lambda_{Co}} = t$$

$$\frac{\ln(1/0.012)}{(0.693/65\ days) - (0.693/(5.24\ years)(365\ days/year))} = 429.4\ days = t$$

CHP Part 1 Q8

All of the following are common causes of **significant radiation exposure** in the use of **x-ray diffraction equipment** except:

1. alteration or removal of shielding in order to perform a specialized analysis
2. visual alignment of the beam without using a leaded glass shield.
3. placement of fingers in the primary beam while changing samples.
4. failure to incorporate shielding in the walls of the room in which the unit is housed.
5. failure to realize that x-ray beams are emitted from exit ports other than the one of immediate concern.

CHP Part 1 Q8

Answer: 4

The assumption here is that the engineers who designed the facility put the shielding in.

CHP Part 1 Q9

Disccs or foils of copper, cadmium, or aluminum are often incorporated into thermoluminescent dosimeters (TLDs) in order to:

1. measure neutrons via the n-alpha reaction
2. facilitate the annealing process.
3. filter out high-energy cosmic radiation.
4. filter out low-energy background radiation.
5. provide information on the energy of the photon.

CHP Part 1 Q9

ANSWER: 5

The various materials in the TLD help identify the energy.

CHP Part 1 Q10

If an airborne release occurs because of a loss of coolant accident at a light-water power reactor in which no core melt occurs, the first radioisotope of concern through the food chain is:

1. ^{90}Sr.
2. ^{137}Cs.
3. ^{3}H.
4. ^{135}Xe.
5. ^{131}I.

CHP Part 1 Q10

ANSWER: 5

Both ^{90}Sr and ^{137}Cs have a 30 year half-life, and they don't go far. These are later concerns that will be around for a long time.

^{3}H is a gas, and becomes THO, and then evaporates. If you inhaled a lot, the cure would be two weeks of beer, tea and IVs.

^{135}Xe is a noble gas and therefore doesn't interact much. It also dissipates over a large area.

^{131}I has an 8 day half-life, and can be incorporated into the thyroid if you don't wash your vegetables. Cows don't wash the grass before they eat, so ^{131}I is a concern for beef and milk.

However after about 80 days (ten half-lives) the ^{131}I is effectively gone. So ^{131}I is an early concern.

CHP Part 1 Q11

In branching decay, a substance may decay by two or more modes. If a radioisotope has only two modes of decay (l and 2), the formula for its half-life $T_{1/2}$ would be:

1. $T_{1/2} = (\lambda_1 + \lambda_2)/\ln 2$
2. $T_{1/2} = (T_{1/2})_1 + (T_{1/2})_2$
3. $T_{1/2} = 1/\lambda_1 + 1/\lambda_2$
4. $T_{1/2} = \ln 2/\lambda_1 + \ln 2/\lambda_2$
5. $T_{1/2} = \ln 2/(\lambda_1 + \lambda_2)$

CHP Part 1 Q11

ANSWER: 5

$$\lambda_T = \lambda_1 + \lambda_1$$

$$\lambda_T = \ln 2 / T_{1/2} = \lambda_1 + \lambda_1$$

$$T_{1/2} = \ln 2 / \lambda_1 + \lambda_1$$

CHP Part 1 Q12

In a satisfactory "air-walled" ionization chamber, the ionization per unit volume would be:

1. inversely proportional to the density of the gas in the chamber.
2. inversely proportional to the gamma-ray energy absorbed per cubic centimeter of wall material.
3. directly proportional to the stopping power of the walls for electrons.
4. independent of the density of the gas in the chamber.
5. independent of the volume of the chamber.

CHP Part 1 Q12

ANSWER: 5

CHP Part 1 Q13

When air is sampled by being pulled through a filter paper, the radioactivity at equilibrium on the filter paper due to naturally occurring radon daughters is:

1. proportional to the flow rate of the sampler.
2. dependent only on the total volume of air sampled.
3. dependent on the time required for radioactive equilibrium on the filter paper to be established.
4. dependent on the volume of air sampled after radioactive equilibrium on the filter paper has been established.
5. independent of the flow rate of the sampler.

CHP Part 1 Q13

ANSWER: 1

CHP Part 1 Q14

When UF6 is released to the atmosphere, hydrolysis results in the production of hydrofluoric acid and uranyl fluoride. The primary health hazard associated with such a release is:

1. chemical toxicity of uranium.
2. radiotoxicity of uranium.
3. chemical toxicity of UF_6.
4. chemical toxicity of HF.
5. chemical toxicity of F_2.

CHP Part 1 Q14

ANSWER: 4

Hydrofluoric acid is bad for the lungs immediately. The radiation hazard is really minor in comparison.

CHP Part 1 Q15

A mono-energetic photon beam is measured to have an exposure rate of l00 mR h^{-1} at 1 meter. An absorber of 0.2 m thickness (μ= 6.93 m^{-1}) is placed in the beam. What is the shielded exposure rate at 5 meters from this source?

1. 1 mR h^{-1}
2. 4 mR h^{-1}
3. 5 mR h^{-1}
4. 20 mR h^{-1}
5. 25 mR h^{-1}

CHP Part 1 Q15

ANSWER: 1

$$I_2 = I_1 e^{-\mu t} = (100\ mR/h) e^{-(6.93/m)(0.2m)} = 25\ mR/h$$

$$I_3 = I_2 (d_2/d_3)^2 = (25\ mR/h)(1\ m/5\ m)^2 = 1\ mR/h$$

CHP Part 1 Q16

The biologically most significant type of interaction of thermal neutrons with atoms in tissue is:

1. ionization.
2. elastic scattering.
3. inelastic scattering.
4. hydrolization.
5. capture.

CHP Part 1 Q16

ANSWER: 5

The big clue is that we are interesting in the biology and the neutrons are thermal. Thermal neutrons are slow enough that they can be captured.

To determine the dose to someone who has captured neutrons in them after a neutron criticality, put a meter into their armpit and measure the Na-24. Na-23 captured a neutron and became Na-24 with a 15 hour half-life.

CHP Part 1 Q17

Right-angle scattered x-ray radiation exposure measured one meter from the beam of a fluoroscope will be

1. about 0.01% of the incident beam at the scatterer.
2. about 0.1% of the incident beam at the scatterer.
3. about 1% of the incident beam at the scatterer.
4. about 10% of the incident beam at the scatterer.
5. of little significance and can be ignored for all practical purposes

CHP Part 1 Q17

ANSWER: 2

The scatter is 1000 fold less (0.1%) than the primary beam at a 90 degree angle.

CHP Part 1 Q18

A solution contaminated with plutonium has spilled on the ground near a facility. There are no other radioactive materials in the solution. Which one of the following is the most appropriate primary survey instrument to assess the extent of the contamination?

1. Portable thin NaI(TI) scintillator (FIDLER).
2. Portable high purity Ge spectrometer.
3. End-window GM survey meter.
4. Air-proportional alpha survey meter.
5. Gas-proportional alpha survey meter.

CHP Part 1 Q18

ANSWER: 1

A FIDLER (4 inches x 1 mm. NaI [T1]) probe, in good condition, mated to a Ludlum 2220 electronics package, may detect **60-keV** activity as low as 0.2 μCi/m^2. In a typical weapon grade mix for a medium-aged weapon, this mix should correspond to about **1 microcurie of plutonium per square meter**. Furthermore, since the X-rays are much less affected by overburden than are alpha particles, the radiation monitor has much better control of the factors that influence its meter readings. As a result, the monitor may make quantitative measurements of the amount of radiation and infer the actual amount of contamination with far greater confidence than with any other field technique.

CHP Part 1 Q19

According to ANSI Z136.1-1986 “For the Safe Use of Lasers”, what Class applies to a laser which emits light in the visible portion of the spectrum such that eye protection is normally afforded by the aversion response including the blink reflex?

1. Class 1
2. Class 2
3. Class 3a
4. Class 3b
5. Class 4

CHP Part 1 Q19

ANSWER: 2

Class 1 lasers are considered to be incapable of producing damaging radiation levels, and are therefore exempt from most control measures or other forms of surveillance. Example: laser printers.

Class 2 lasers emit radiation in the visible portion of the spectrum, and protection is normally afforded by the normal human aversion response (**blink reflex**) to bright radiant sources. They may be hazardous if viewed directly for extended periods of time. Example: laser pointers.

Class 3a lasers are those that normally would not produce injury if viewed only momentarily with the unaided eye. They may present a hazard if viewed using collecting optics, e.g., telescopes, microscopes, or binoculars. Example: HeNe lasers above 1 milliwatt but not exceeding 5 milliwatts radiant power.

Class 3b lasers can cause severe eye injuries if beams are viewed directly or specular reflections are viewed. A Class 3 laser is not normally a fire hazard. Example: visible HeNe lasers above 5 milliwatts but not exceeding 500 milliwatts radiant power.

Class 4 lasers are a hazard to the eye from the direct beam and specular reflections and sometimes even from diffuse reflections. Class 4 lasers can also start fires and can damage skin.

(Reference: LLNL Safety Manual, page 28-2)

NOTES: *Retinal injuries can occur instantaneously with Class 3b and Class 4 lasers; the damage may be irreparable. Corneal burns from far-IR and UV lasers may also be irreparable. Class 4 beams may be of sufficient power intensities to penetrate through the sclera (white) of the eye and damage the retina and other structures; thus, turning one's head or not looking directly at the laser offers little or no protection to high power lasers. Lenticular damage may also be caused by the beam and by photochemical reactions from exposure to UV and blue frequencies.*

Reference: Stanford University Laser Safety Manual

CHP Part 1 Q20

The count rate for an effluent particulate filter is measured in a proportional counter. Which of the following system calibration parameters is most crucial in converting the result to an activity for use in airborne concentration assessment?

1. FWHM resolution.
2. Fano factor.
3. Absolute efficiency.
4. Intrinsic efficiency.
5. Signal-to-noise ratio.

CHP Part 1 Q20

ANSWER: 3

Absolute efficiency takes into account all factors, therefore as a calibration parameter it is the most crucial parameter in converting the result to an activity for use in airborne concentration assessment