Part I – Short Answer

Choose a letter to fill in the blanks. Use choices as many times as you wish. Only one choice is needed per blank. All are 3 points each.

1. First set.

A.hydrogen-1
B.hydrogen-2 (deuterium)
C.hydrogen-3 (tritium)
D. all of these
E. none of these

__C__Which of these isotopes has the greatest mass?

__E__Which of these isotopes also is a type of electromagnetic radiation?

__E__ Which of these isotopes has an atomic number of 2?

__D__Which of these isotopes is naturally occurring?

2. Next set, and again there is only one correct choice.

A. carbon-14
B. cesium-137
C. strontium-90
D. plutonium-239
E. uranium-235
F. None of these

_F__Which of these has 14 protons?

_A__Which one of these is not a metal?

_F__ Which of these mimics iodine in the body?

_B__Which of these occurs as a +1 ion?

_F__Which of these is a product in the natural decay series of uranium?

3. Final set. **HINT: see Table 5.6 of ions on page 7**

A. $CaCO_3$
B. $Ca(OH)_2$
C. KNO_3
D. Na_2O
E. Na_2OH
F. O_2
G. All of these
H. None of these

_E__ Which chemical formula is incorrectly written?

_F__ Which chemical formula represents an element?

_D__ Which of these contains the oxide ion?

_C_ Which of these contains the potassium ion?

Part II – Radioactivity!

Here is a table from your textbook

Table 7.2 Types of Nuclear Radiation

Type	Symbol	Composition	Charge	Change to the Nucleus That Emits It
Alpha	$^{4}_{2}He$	2 protons 2 neutrons	2+	Mass number decreases by 4. Atomic number decreases by 2.
Beta	$^{0}_{-1}e$	an electron	1−	Mass number does not change. Atomic number increases by 1.
Gamma	$^{0}_{0}\gamma$	a photon	0	No change in either the mass number or the atomic number.

1. (4 points) This table states that an alpha particle is made of neutrons and protons. Neutrons and protons are similar in that **__they are both found in the nucleus___.**
(or they are similar in their mass).
One way in which they differ is **_in their charges (p is + and n is neutral).**

2. (4 points) The table uses these terms. Explain each in 10 words or less.

atomic number - the # of p in the nucleus

mass number - the # of p and n in the nucleus.

3. (4 points) With beta particle emission, the table reports that "the atomic number increases by one." Offer an explanation as to what might be occurring.

$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e$ **If the mass # increases, a proton must be formed.**
A possible explanation is that a neutron is "converted" to a proton.

4. (4 points) Speaking of beta emission, cobalt-60 (Co-60) is a beta emitter with an accompanying gamma ray. Write the nuclear equation. No partial credit here.

$$^{60}_{27}Co \longrightarrow {}^{60}_{28}Ni + {}^{0}_{-1}e + {}^{0}_{0}\gamma$$

5. (4 points) Speaking of Co-60, this radioisotope is used in the gamma knife. Explain why 200 beams of radiation are used rather than a single beam.

With multiple beams, each can go along a different pathway to hit the tumor. This minimizes damage to healthy tissue and maximizes damage to the tumor.

Part III – The Priscilla Shot

Here is Figure 7.5 from Chemistry in Context. The nuclear test "Priscilla" was exploded on a dry lake bed northwest of Las Vegas in 1957

1. (2 points) The nuclear process that released the energy shown here is called _____**fission**_____.

2. (3 points) The most abundant isotope of uranium in nature is U-238.
This radioisotope could NOT have fueled this nuclear explosion because:

This isotope is not fissionable (under the conditions of an atomic bomb).

3. (6 points) Actually Priscilla was fueled with an isotope of plutonium. Humans produced plutonium on our planet using U-238 as a starting material. The first step was to make neptunium. Explain with an equation how humans can produce neptunium from U-238. No gamma rays are produced.
Hint: you did something analogous in the lab.

$$ {}^{1}_{0}\mathrm{n} + {}^{238}_{92}\mathrm{U} \longrightarrow [{}^{239}_{92}\mathrm{U}] \longrightarrow {}^{239}_{93}\mathrm{Np} + {}^{0}_{-1}\mathrm{e} $$

4. (7 points) Neptunium-239 has a half-life of 2.4 days. Construct a graph that shows the decay of Np-239 over time. Start with 100 atoms of Np-239, and let the time run about 10 days. Label your axes!

ANSWER KEY – POINTS ARE NOT IN EXACT PLACES

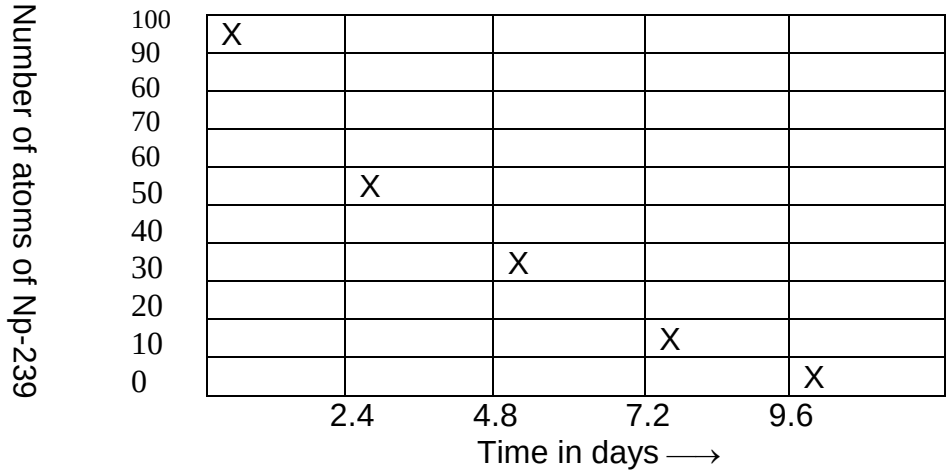


Table 7.4 Physiological Effects of a Single Dose of Radiation

Dose (rem)	Dose (Sv)	Likely Effect
0–25	0–0.25	No observable effect
25–50	0.25–0.50	White blood cell count decreases slightly
50–100	0.50–1.00	Significant drop in white blood cell count, lesions
100–200	1.00–2.00	Nausea, vomiting, loss of hair
200–500	2.00–5.00	Hemorrhaging, ulcers, possible death
>500	>5.00	Death

Part IV – Radiation and people

Here is another table.

1. (6 points)
This table uses the unit of **rem**.
We also used the unit **curie** in class.

Fill in the blanks:
The **curie** and **rem** are units that both relate to radioisotopes, but are VERY different.

The **curie** focuses on the radioisotope and is a measure of **__how fast the sample is decaying ("disintegrating"); that is, emitting alpha or beta particles _____**

In contrast, the **rem** focuses on what happens when ionizing radiation hits tissue, and **rems** = **Q x rads**, where a **rad** measures the dose of energy deposited in a tissue.

The factor **Q** takes into account the fact that **different types of radiation cause different amounts of tissue damage.**

2. (6 points) A dose of ionizing radiation >100 rem can cause radiation sickness. Mark true statements with an **X**:

___ Muscle cells, such as those in your heart, are especially sensitive to radiation.

_X_ If damaged, your DNA usually repairs itself within a few hours.

_X_ Radiation sickness primarily is caused by damaged cells that live and reproduce, rather than the damaged cells that die.

3. (4 points) After Hiroshima, radiation sickness was most acute approximately 2 weeks after the large dose of radiation received from the atomic explosion. Explain the delay in 25 words or less.

The radiation killed the growing cells (the baby cells). These cells would be needed to replace dying adult cells 2-3 weeks later. So people were not sick until the adult cells died (and had no replacements).

4. (6 points) In addition to these two, list 3 more questions that you need answers to in order to assess the hazard of a radioisotope.

NOTE: "Is it dangerous?" or "Is it toxic?" are both too vague.

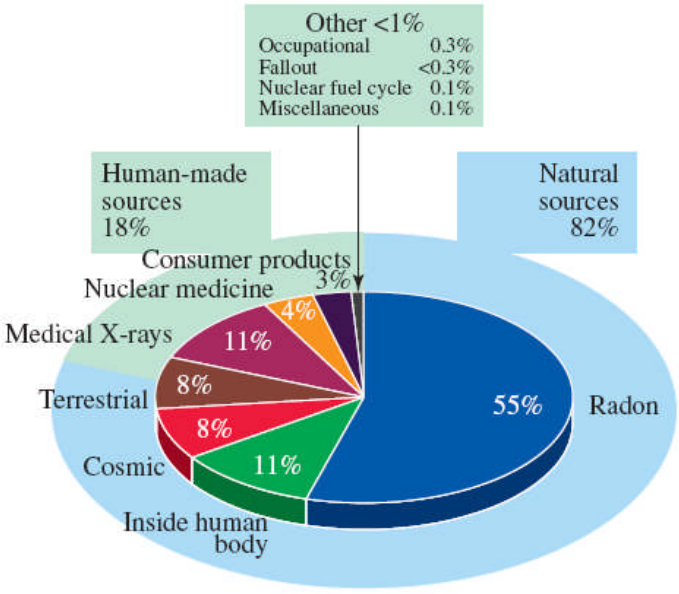
1. Is the radioisotope inside or outside of your body?
2. What is the chemical form of the radioisotope?
3. **What is the half-life?**

4 How much is present? Also: Is the form retained by your body?

5. What type of radioactive decay?

Part V – Radioactivity On Our Planet

Yep, our planet contains radioactive substances. The figure to the right is taken from Chemistry in Context.



1. (3 points) This figure is missing its caption. What should it be?

Sources of radiation
(U.S. average per year)

2. (12 points) In the pie chart, 11% refers to "inside human body."

a. Radioactive potassium (K-40) is found inside your body. Explain why (<15 words).
K-40 is naturally occurring, and your body takes up all K isotopes.

b. This potassium is not in the form of potassium metal. Explain why (<15 words).
It is K+; the metallic form is too reactive to exist

c. Eating bananas (potassium-rich) does not increase the amount of K-40 in your body. Explain why (<15 words).
Your intake of K+ is balanced by the out-take. K+ does not accumulate.

3. (9 points) In the pie chart, fallout is estimated at **<0.3%**

a. What is fallout?
Fission products released into the atmosphere that come down somewhere else on the planet.

b. Why isn't radon-222 included as a part of fallout?
The splitting of U-235 (fission into two roughly equal smaller nuclei) does not produce radon (it is too large of a nucleus).

c. If not from fallout, where does radon-222 come from?
The radioactive decay series of naturally occurring U-238.

Table 5.6 Common Polyatomic Ions

Name	Formula	Name	Formula
acetate	$C_2H_3O_2^-$	nitrite	NO_2^-
bicarbonate*	HCO_3^-	phosphate	PO_4^{3-}
carbonate	CO_3^{2-}	sulfate	SO_4^{2-}
hydroxide	OH^-	sulfite	SO_3^{2-}
hypochlorite	ClO^-	ammonium	NH_4^+
nitrate	NO_3^-		

Part VI – Ions and Ionizing Radiation

Here are the chemical formulas of some polyatomic ions, taken from your textbook.

If an ion is used below and not listed here, you are expected to know it.

1. (6 points) Circle the chemical formulas with errors and write the correct formula below. Assume that the polyatomic ions are only the ones listed in Table 5.6.

$NaCO_3$ $CaCl_2$ K_2O $Mg(OH)$ $NaNO_3$ NH_4SO_4

Na_2CO_3 **$Mg(OH)_2$** **$NaNO_3$** **$(NH_4)_2SO_4$**

2. Students in past years have had trouble with the term **"ionizing radiation."**

a. (6 points) Part of the confusion is the word "radiation." First explain these 2 terms.

nuclear radiation: Alpha, beta, gamma emissions from the nucleus.

electromagnetic radiation: Photons of light of different wavelength and energy (X-rays, UV, visible, IR, radiowaves). The origin varies.

b. (3 points) Now explain **ionizing radiation**. You may have 15 words.

Radiation (nuclear or electromagnetic) that produces ions when It hits.

3. (4 points) The early radiologists lost their hands (and sometimes their lives) while doing their job.

a. Their skin cells were damaged by **nuclear** **electromagnetic** radiation.

b. The name of the type of radiation involved was ____**X-Rays**_____.

4. Here is an equation that we discussed in lecture.

$$[H_2O\bullet]^+ + H_2O \longrightarrow H_3O^+ + HO\bullet$$

a. (3 points) Two species in this equation have "dots." What does the dot mean?

The dot indicates an unpaired electron (highly reactive species)

b. (4 points) In the context of nuclear radiation, explain the implications of this equation at the cellular level.

It shows that the H_2O^+ ion produced from ionizing radiation can in turn produce MORE species that can react with your DNA and can damage it.