Cabrillo College
Physics 10L

Name____________________________

LAB 5
Radioactivity

Read Hewitt Chapter 33

What to explore and learn

An amazing discovery was made about 100 years ago: that some kind of "rays" came out of matter which could penetrate through solid materials and make images on film. The first to be discovered were X-rays, then three other forms of "rays" were found, which were named **alpha α, beta β, and gamma γ**, after the "A, B,C" of the Greek alphabet. The materials that produce these rays are called **radioactive.**

We, on our planet Earth, are continually bombarded by these rays, coming from outer space and from the interior of the Earth itself. We will make some of them visible in a Cloud Chamber – one of the little magic tools that physicists use to study these tiny particles.

Objects on Earth are composed of **atoms**, as we visualized last week in the Fluids lab. Most of these atoms are "stable," meaning that they will remain unchanged for millions or billions of years. But some of them are "unstable," and they will literally turn into something else in a while. Such atoms change themselves by changing their **nucleus.**

We will observe **alpha α, beta β, and gamma γ** rays. These are produced in the **nucleus** of the atom: the unimaginably dense, unbelievably tiny center of the atom, composed of **protons** and **neutrons**. The nucleus is highly energetic, so the energies of this radiation are well above those of visible or even ultraviolet light. None of these rays can be detected by our human senses. Since they can be dangerous in large quantities, it is important to learn about them.

We will use a tool called a **Geiger counter** to detect this nuclear radiation. We will show you how it works and let you experiment with **alpha α, beta β, and gamma γ** radiation.

We have very low-level commercial radioactive samples that are made for teaching about radioactivity. We also have some seemingly normal objects that emit nuclear radiation, and we have various materials that you can use to experiment with **shielding**—that is, to see if the rays can pass through them.

CAUTION — even the low activity radioactive samples we will use in this lab can be dangerous if handled carelessly or improperly. Please pay strict attention to the following special rules and procedures:

- ***Do not eat, drink, smoke or use cosmetics.***
- ***Use gloves when handling liquid radioisotopes.***
- ***Wash your hands thoroughly before leaving.***
- ***Report spills or wounds immediately.***
- ***Return all samples to the instructor at the end of lab.***

Safety concerns

With all these warnings, you might be smart enough to wonder if perhaps you just ought to stay away from this lab! On the other hand, knowledge is a very good thing. So let's address the risk.

First of all, we have calculated the dose you will receive when working with these samples, holding them one meter from your body for a **week.** This dose is less than you would get taking a half-hour plane ride.

Secondly, have you ever noticed the little badges that people wear when they work with radioactivity, to measure the dose they receive? Well, the people who wrote the manual for use with our radioactive samples wore those badges for the entire two years while they did every experiment they could think of. They received **absolutely no measurable dose** on their badges. So don't worry, be happy, and get educated!

Mandatory Comments

Please give us feedback on this lab. Use the last page. Thank you!

1) **Cloud Chamber** This is set up on the front desk. The gas inside is kept really close to the dew point so it is itching to form a cloud. The tip of the needle in the chamber contains a tiny speck of lead 210, which emits alpha particles. When an energetic particle flies through the gas, tiny water droplets form along the path, making it visible. The droplets fall toward the bottom of the chamber.
Spend some time just staring at this little box.

2) **Estimate your annual radiation dose from background radiation.**

Use the program on the computer. Write down your annual dose: ____________ mrem/year

https://www.epa.gov/radiation/calculate-your-radiation-dose

Is there anything you can do to reduce your dose?

3) **Portable Geiger Counter ("quick-checks") (do this at any time during the lab)**
Use the hand-held, portable Geiger counter to see if any of the objects on the side counter are radioactive. Also test any objects you or others may have brought to lab. Remember that something must give noticeably more counts than the background to be labeled as 'radioactive'.

Item	Radioactivity level – How much more than background? (circle one)
Cell phone	none – low – med - high
banana	none – low – med - high
Mystery box	none – low – med - high
Orange plate	none – low – med - high
Coleman lantern wick	none – low – med - high
	none – low – med - high
	none – low – med - high

4) **Measure the Background Radiation**
Radiation is all around you, day and night, wherever you may be. In this activity, we'll use a **Geiger counter** to measure this **background radiation**. To do this, you first need to remove all radioactive sources from your table. Push **stop, reset,** and **count.** The counter will count the background radiation for 30 seconds and stop itself automatically.

a) Record the activity (counts in 30 seconds). Do this five times. Record your numbers.

____________ ____________ ____________ ____________ ____________

Does the activity change very much from one trial to the next? Note your highest and lowest values, and compare them to others around you. Typically, your values will seem quite random—they are the result of a random, chaotic process.

b) What is your average background activity? (round off to ±1 count) __________

c) Write your average on the whiteboard. How does yours compare with those of the other lab groups?

e) What do you think is the source of this background radiation?

5) Experiment with a Beta Source $_{-1}\beta^{0}$

Note: A **Beta** is an energetic electron that is ejected from the nucleus when a neutron decays into a proton. When this happens, the nucleus becomes a different element and the electron shoots out with high energy (it goes fast!) The element now has one more proton, so it becomes the element with the next higher **Atomic Number.**

a) Get the **beta** source and read the label to identify the **isotope** and its **half-life**.
Write the name of the isotope, its symbol, and its half-life below. (Example: Carbon $_{6}C^{14}$ 5730 years)

b) Put your sample on the second shelf below the Geiger tube. (Put the 'x' side up.) Push **stop, reset, and count** to measure the activity of your sample for 30 seconds. Repeat the measurement two more times. Record your measurements:

________________ ______________ ______________.

Are you surprised to see how much chaotic variation there is from one measurement to the next?

c) Now you are going to investigate how hard it is to 'block' these beta particles. For each blocker type, count how many particles pass through it. Remember to account for the natural background radiation.

Blocker type	Count	Count minus the background
Paper		
Thin Plastic		
Lead		

Based on your measurements, answer these questions (circle the best answer):

Paper blocks (most – some – not many) of the beta particles.

Thin plastic blocks (most- some- not many) of the beta particles.

A piece of lead blocks (most – some – not many) of the beta particles.

Conclusion: **Beta particles** are (very easy – kind of easy – hard) to block

d) What did your element become when it spit out the beta particle? Hint: Since the new element has one more proton than the original element, it will be one space to the right on the periodic table.

6) Experiment with a Gamma Source $_{0}\gamma^{0}$

Note: A **gamma** is a tight little bundle of electromagnetic energy. It has no measurable mass and no charge. It does NOT change the element into something else; it only lets the nucleus settle into a lower energy state. You'll meet this process in the last part of this lab when you measure the half-life of an excited isotope.

a) Get the **gamma** source and read the label to identify the **isotope** and its **half-life**. Write the isotope and half-life below.

b) Put your sample on the second shelf below the Geiger tube. (Put the 'x' side up.) Push **stop, reset, and count** to measure the activity of your sample for 30 seconds. Repeat the measurement two more times. Record your measurements:

________________ ______________ ______________.

c) Now you are going to investigate how hard it is to 'block' gamma radiation. For each blocker type, count how many particles pass through it. Remember to account for the natural background radiation.

Blocker type	Count	Count minus the background
Paper		
Thin Plastic		
Lead		

Based on your measurements, answer these questions (circle the best answer):

Paper blocks (most – some – not much) of the gamma radiation

Thin plastic blocks (most- some- not much) of the gamma radiation.

A piece of lead blocks (most – some – not much) of the gamma radiation.

Conclusion: **Gamma radiation** is (very easy – kind of easy – hard) to block.

7) Experiment with an Alpha Source $_2\alpha^4$

Note: An alpha is a little chunk of the nucleus itself. It is a stable little group of two protons and two neutrons—actually the same as the nucleus of a helium atom. Its charge is +2 and mass is 4. It flies out at a great speed so it can be damaging, but you'll see it doesn't go far…..

a) Get the **alpha** source and read the label to identify the **isotope** and its **half-life**.
Write the isotope and half-life below.

b) Put your sample **on the top shelf (*not the second shelf*)** below the Geiger tube. (Put the 'x' side up.) Push **stop, reset, and count** to measure the activity of your sample for 30 seconds. Repeat the measurement two more times. Record your measurements:

_____________ _____________ _____________.

c) Now you are going to investigate how hard it is to 'block' these alpha particles. For each blocker type, count how many particles pass through it. Remember to account for the natural background radiation.

Blocker type	Count	Count minus the background
Paper		
Thin Plastic		
Lead		

Based on your measurements, answer these questions (circle the best answer):

Paper blocks (most – some – not many) of the alpha particles.

Thin plastic blocks (most- some- not many) of the alpha particles.

A piece of lead blocks (most – some – not many) of the alpha particles.

Conclusion: **Alpha particles** are (very easy – kind of easy – hard) to block

d) Can alpha particles be stopped by just passing through the air? Try putting the source on the second or third shelf. What happens to the counts?

8) Compare Alpha, Beta and Gamma Particles

a) Which type of radiation is best at passing through materials?

b) Which type is most easily absorbed? Does this mean it is less dangerous?

c) Which type would be the most dangerous if you breathed particles that emitted it?

d) Which type would be the most dangerous if stored in a box under your bed?

e) Smoke detectors use a tiny amount of radiation to detect smoke. They have a radioactive source that shoots across a little air gap. If there is smoke in the air, it blocks the particles and the detector goes off. What type of radiation (alpha, beta, or gamma) do you think they use in smoke detectors? Why?

9) Measure the Half-Life of a Short-lived Radioisotope

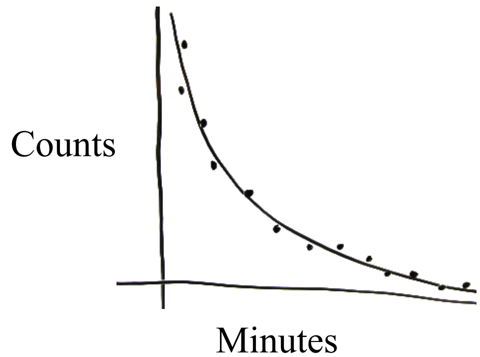
a) What are **isotopes?** Can you define them in words, with help from the instructor and/or the book? What are **radioisotopes?** (Hint: the letter *p* in the word refers to protons; the prefix *iso* means *equal)*

b) Find out what short-lived radioisotope we will be using and how we obtain it. Write it down.

c) Obtain a small sample of a short half-life radioisotope from the source on the front counter. Work quickly to start your measurements of the activity of your sample, and continue to measure its activity once every minute for 30 seconds at a time. Continue the measurements for 15 minutes, recording your results in the table below. Do you observe the activity decreasing?

total elapsed time (minutes)	time interval counted (mm:ss)	count
0	0:00 to 0:30	
1	1:00 to 1:30	
2	2:00 to 2:30	
3	3:00 to 3:30	
4	4:00 to 4:30	
5	5:00 to 5:30	
6	6:00 to 6:30	
7	7:00 to 7:30	
8	8:00 to 8:30	
9	9:00 to 9:30	
10	10:00 to 10:30	
11	11:00 to 11:30	
12	12:00 to 12:30	
13	13:00 to 13:30	
14	14:00 to 14:30	

d) Draw a **smooth** curve (not just a “dot-to-dot”) through the data points on your graph. (See example picture.)



e) Use your **curve** to estimate the half-life of the isotope (i.e., the time it takes for the activity to decrease from some amount to half that amount). Show **directly on the graph** just how you found the half-life.
Write your half-life directly on your graph.

f) Use your curve again, using different starting counts. (hint: pick nice round starting counts like 1000, 2000, or 4000). Is this time interval (half-life) approximately the same as the first one you measured?
Show this on the graph as well and be ready to explain how you got it.

g) Compare your result to the accepted value.

My measured half-life of ____________ is ______________________________. (**Drum Roll!)**
element symbol time

Show this result to the instructor, who will then (quietly) *show you* the accepted value of the half-life.

The half-life of this radioisotope is ________________________

My result is □ way off □ sort of close □ pretty darn close! □ right on the money ! ☺

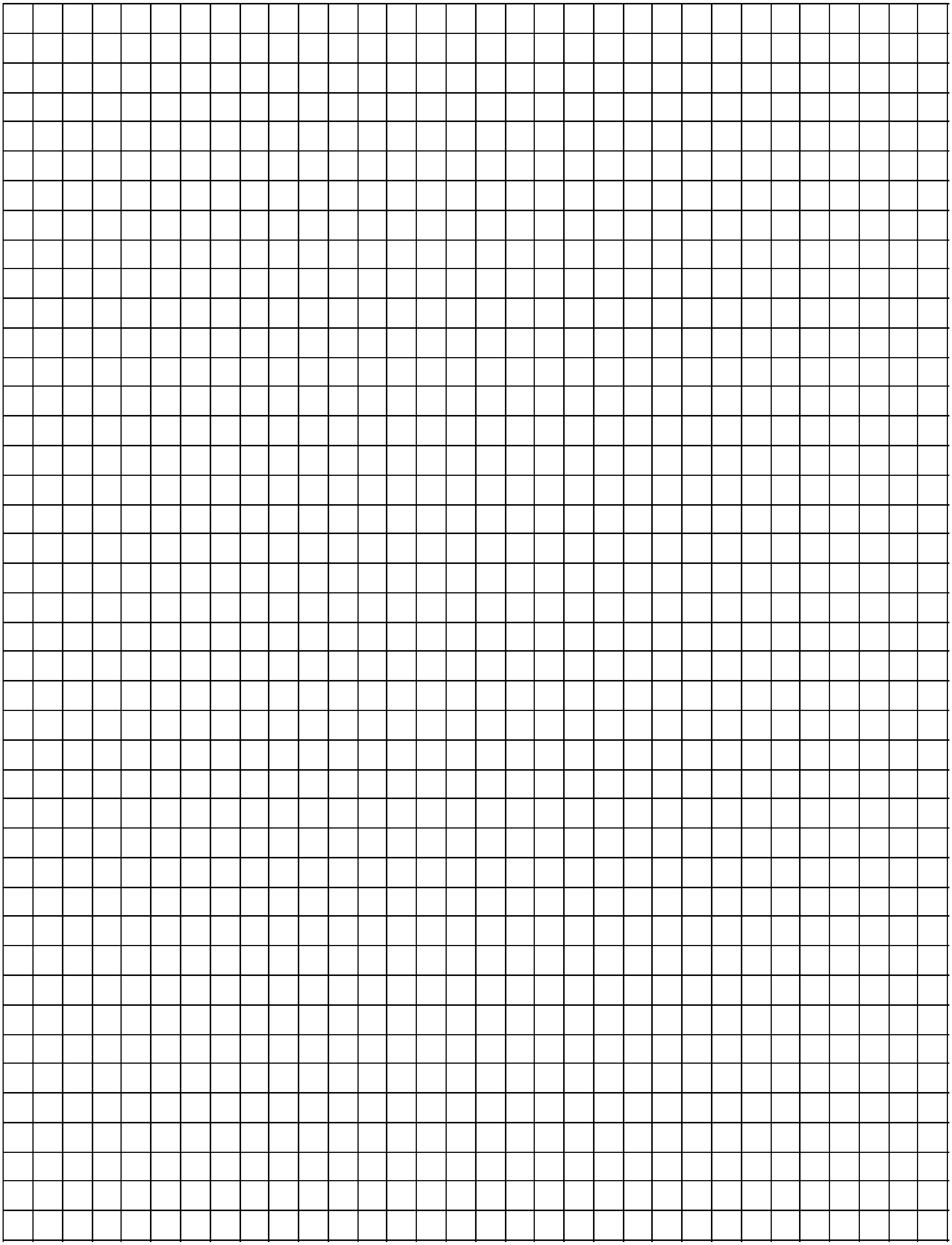
Suggestion: if you aren’t at least “pretty darn close,” ask the instructor to help figure out why.

Question: Radiation from Fukushima.

In the nuclear accident in Japan in 2011, one of the radioactive isotopes that leaked out was Iodine 131. Wind and water currents carried it all around the world. This isotope emits beta particles and has a half-life of 8 days. At this point in time, do you think there is much danger from this escaped iodine? (hint: think about how many of its half-lives have passed since then.)
Another substance that was released from Fukushima was Cesium 137, which we used in today’s lab to get our Barium for the half-life measurement. Its half-life is about 30 years. Is the Cesium 137 that was released in Japan still very active now?

Conclusion: Radioactivity is a valuable ally. Like fire and electricity, it can be dangerous.
Since it is also utterly undetectable by your senses, the more you learn about it, the better you can judge what is dangerous and what is not. Education is the answer here.
Look through Hewitt Chapter 33 for some more info on nuclear radiation.

Please write your Mandatory Comments on the back. Thank you.


counts
minutes