Unit
13
Lesson
1

AIM
- What are the different modes of nuclear decay?

AGENDA
- U13L1 Lesson video
- Nuclear decay modes notes

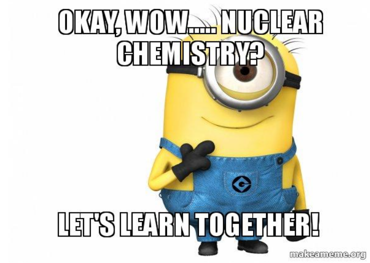
YOYO
- Watch the lesson video on YouTube (U13L1)

HOMEWORK
- Nothing Tonight
- Follow calendar

1

What is nuclear chemistry?

- Nuclear Chemistry deals with changes in or transformations of the **atomic nucleus**.
- Four types of decay
  - **Alpha particle**
  - **Beta particle**
  - **Positron particle**
  - **Gamma rays**



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Nuclear Reactions vs. Chemical Reactions

Chemical Reactions
1. Atoms are rearranged by the **breaking and formation of bonds**.
2. Only **electrons** are involved in the breaking or forming of bonds.
3. **Small** amounts of energy are absorbed or released
4. Rates of reaction **are** influenced by temperature, concentration , pressure, and catalysts.

Nuclear Reactions
1. **Elements are converted** from one type to another.
2. **Protons, neutrons, electrons, and other subatomic particles are involved.**
3. **Large** amounts of energy are absorbed or released.
4. Rates **are not** affected by temperature, pressure, or catalysts.

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Radioisotopes

- The nuclei of some unstable isotopes, called **radioactive isotopes** or **radioisotopes**, split up forming atoms with a different number of protons and releasing radiation.
- This process is called **radioactive decay**.
- **Radioactivity** is the release of energy and matter that results from changes in the nucleus of an atom

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Alpha Radiation

- An **alpha particle** is a positively charged particle identical to the helium nucleus
- Alpha decay occurs when the nucleus of an atom gives off an alpha particle—**two protons** and **two neutrons**.

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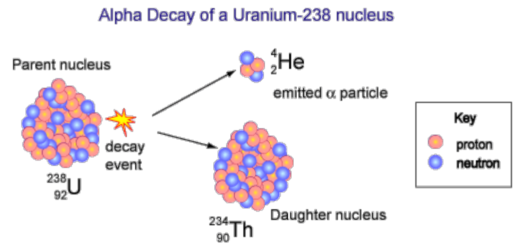
Alpha Radiation



$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$$

- Note: when an atom loses an alpha particle, the atomic number is lowered by two and the mass number is lowered by **four**.

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Beta Radiation

- Beta-minus decay occurs when a **neutron** is converted to a **proton**, and in the process, emits an **electron**.
- **Beta particles** are high-energy electrons whose source is an atomic nucleus

$$^1_0n \rightarrow {}^1_1H + {}^{0}_{-1}e$$

Neutron Proton electron

• (beta particle)

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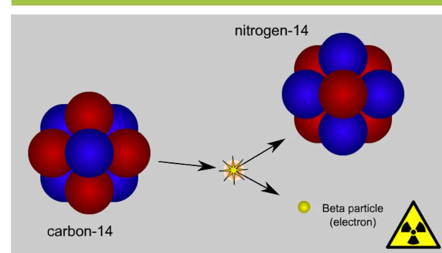
Beta Radiation



- Note: The atomic mass stays the same, and the **atomic number** increases by **one**.

$$^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}^-$$

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Positron Radiation

- Beta-plus decay (also called positron emission) occurs when a proton is converted to a neutron, and in the process, emits a positively charged electron (a positron).
- A positron is a particle identical to an electron except that it has a positive charge

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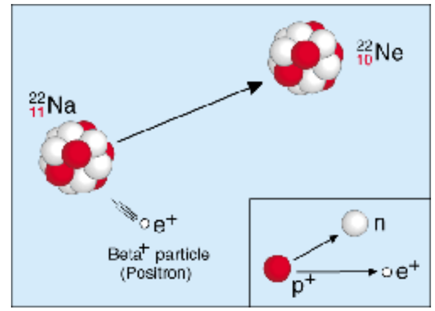
Positron Radiation



- Note: atomic number decreases by one and mass number remains the same

$$^{15}_{8}O \longrightarrow ^{15}_{7}N + ^{0}_{+1}\beta$$

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Gamma Radiation

- A gamma ray is a high-energy photon emitted by a radioisotope. Often are emitted along with alpha and beta particles.
- Gamma radiation doesn't have a positive or negative charge. Gamma rays are similar to X-rays, but they have even greater energy. Gamma radiation can only be stopped by a thick layer of lead or concrete.

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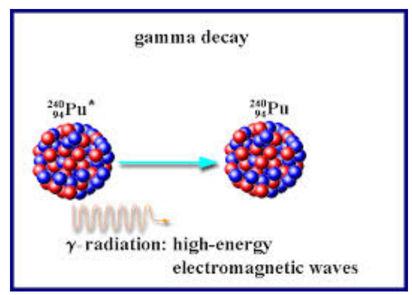
Gamma Radiation



$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}\alpha$$

$$^{234}_{90}Th \rightarrow ^{234}_{91}Pa + ^{0}_{-1}\beta + ^{0}_{0}\gamma$$

$$^{234}_{91}Pa \rightarrow ^{234}_{92}U + ^{0}_{-1}\beta + ^{0}_{0}\gamma$$

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Gamma Radiation

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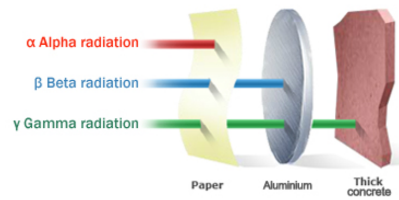
Penetrating Power



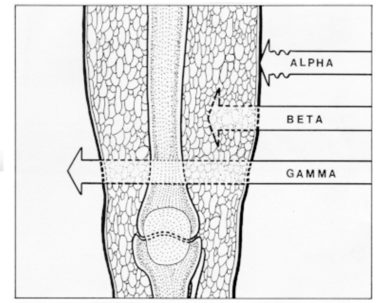


Figure 3. Radiation travelling through human tissue

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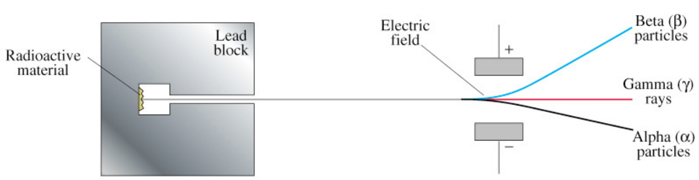
Separating Alpha, Beta, and Gamma Particles

- Alpha and beta particles are deflected in opposite directions- alpha particles toward the negative plate and beta particles toward the positive plate. Gamma rays are undeflected.



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Balancing Nuclear Equations

What particle is represented by X in the following equation?

$$^{27}_{13}Al \; + \; ^{1}_{0}n \; \rightarrow \; ^{24}_{11}Na \; + \; X$$

- Step 1: Label known and unknown
  - Known- charge and mass numbers for Al, neutron, and Na
  - Unknown- X=?
- Step 2: Balance charge on both sides of the equation
  - The sum of the charges on the left is 13; therefore, the sum on the right must also be 13. Na accounts for 11, so X must have a charge of 2.
- Step 3: Balance mass numbers on both sides
  - The sum of mass numbers on the right is 28; therefore, the sum on the left should also be 28. Na accounts for 24, so X must have a mass of 4.

X is an alpha particle. It has an atomic number of 2 and a mass number of 4

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Table O

Table O
Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	$^{4}_{2}He$ or $^{4}_{2}\alpha$	α
beta particle	$^{0}_{-1}e$ or $^{0}_{-1}\beta$	β^-
gamma radiation	$^{0}_{0}\gamma$	γ
neutron	$^{1}_{0}n$	n
proton	$^{1}_{1}H$ or $^{1}_{1}p$	p
positron	$^{0}_{+1}e$ or $^{0}_{+1}\beta$	β^+

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Balancing Nuclear Reaction Practice

1. $^{210}_{84}Po \rightarrow$ ________ $+ ^{4}_{2}He$ ____________________
2. $^{8}_{5}B \rightarrow ^{8}_{4}Be +$ ________ ____________________
3. $^{14}_{6}C \rightarrow$ ________ $+ ^{0}_{-1}e$ ____________________
4. $^{15}_{8}O \rightarrow ^{15}_{7}N +$ ________ ____________________
5. $^{238}_{92}U \rightarrow$ ________ $+ ^{4}_{2}He$ ____________________

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Summary

Property	Alpha Radiation	Beta Radiation	Gamma Radiation	Positron Radiation
Composition	Alpha particle (helium nucleus)	Beta particle (electron)	High-energy electromagnetic radiation	Positron particle
Symbol	$^{4}_{2}He$, $^{4}_{2}\alpha$,	β, $^{0}_{-1}e$	γ	$^{0}_{+1}e$
Charge	2+	1-	0	1+
Mass (amu)	4	1/1837	0	1/1837
Common Source	Radium-226	Carbon-14	Cobalt-60	
Penetrating Power	Low	Moderate	Very High	Very low
Shielding	Paper, clothing	Metal foil	Lead, concrete	

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Nuclear Decay Regents Practice
Hint: Use Table N and O to help you!

Question 1: A sample of which radioisotope emits particles having the greatest mass

a. ^{137}Cs
b. ^{53}Fe
c. ^{220}Fr
d. ^{3}H

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Nuclear Decay Regents Practice
Hint: Use Table N and O to help you!

Question 2: Given the equation representing a nuclear reaction in which X represents a nuclide:

$$^{232}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + X$$

Which nuclide is represented by X?

a. $^{236}_{92}\text{Ra}$ b. $^{228}_{88}\text{Ra}$ c. $^{236}_{92}\text{U}$ d. $^{228}_{88}\text{U}$

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Nuclear Decay Regents Practice
Hint: Use Table N and O to help you!

Question 3: Positrons and beta particles have

a. The same charge and the same mass
b. The same charge and different masses
c. Different charges and the same mass
d. Different charges and different masses

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Nuclear Decay Regents Practice
Hint: Use Table N and O to help you!

Question 4: Which two radioisoptes have the same decay mode

a. ^{37}Ca and ^{53}Fe
b. ^{220}Fr and ^{60}Co
c. ^{37}K and ^{42}K
d. ^{99}Tc and ^{19}Ne

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Nuclear Decay Regents Practice
Hint: Use Table N and O to help you!

Question 5: Which nuclear emission has the greatest penetrating power?

a. Proton
b. Beta particle
c. Gamma radiation
d. Positron

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