Radioactive Decay

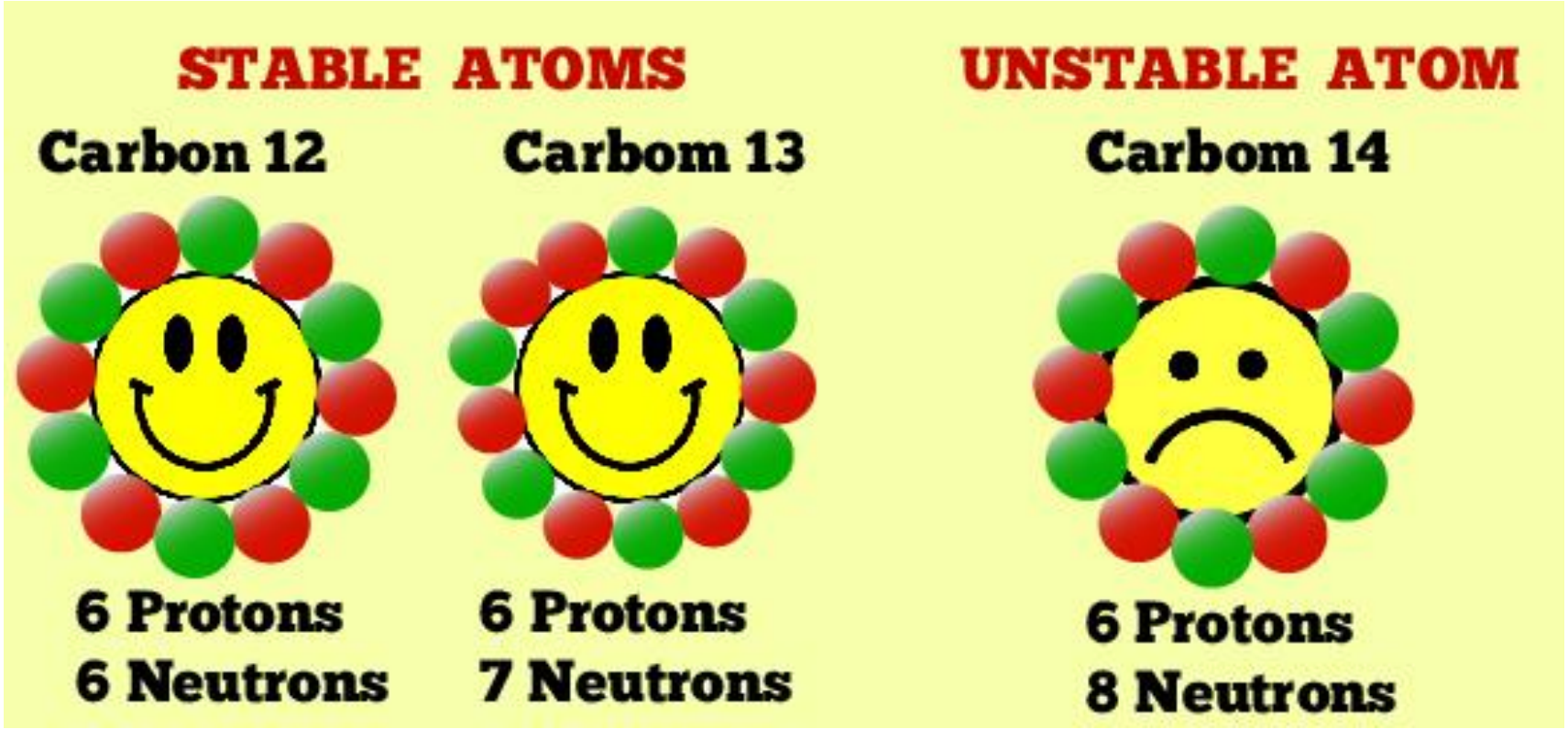
Radioactive Decay

Scientists have discovered that when atoms of one kind of element emit radiation, they can change into atoms of a NEW element.

Why would an atom emit radiation in the first place?

Radioactive Decay

- Atoms emit radiation because their nuclei are **unstable**.
- Unstable atoms gain stability by losing energy (emitting radiation).

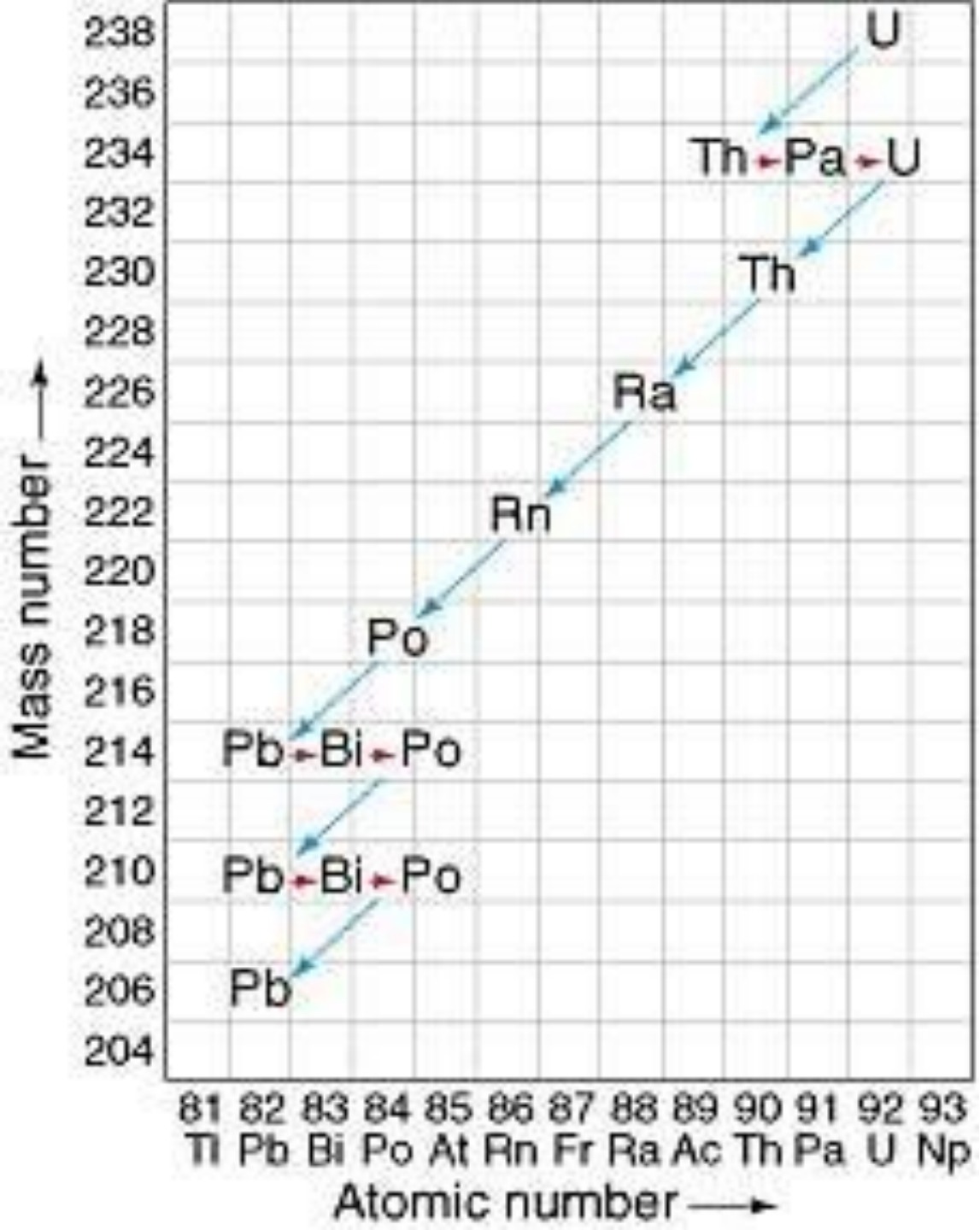


Radioactive Decay

- **Radioactive decay** is the process by which unstable nuclei lose energy by emitting radiation until they are stable.
- Unstable (radioactive) atoms release energy (undergo radioactive decay) until they become stable, often becoming atoms of different elements.
- An element may have only **certain isotopes** that are radioactive. These are called **radioisotopes.**

Radioactive Decay

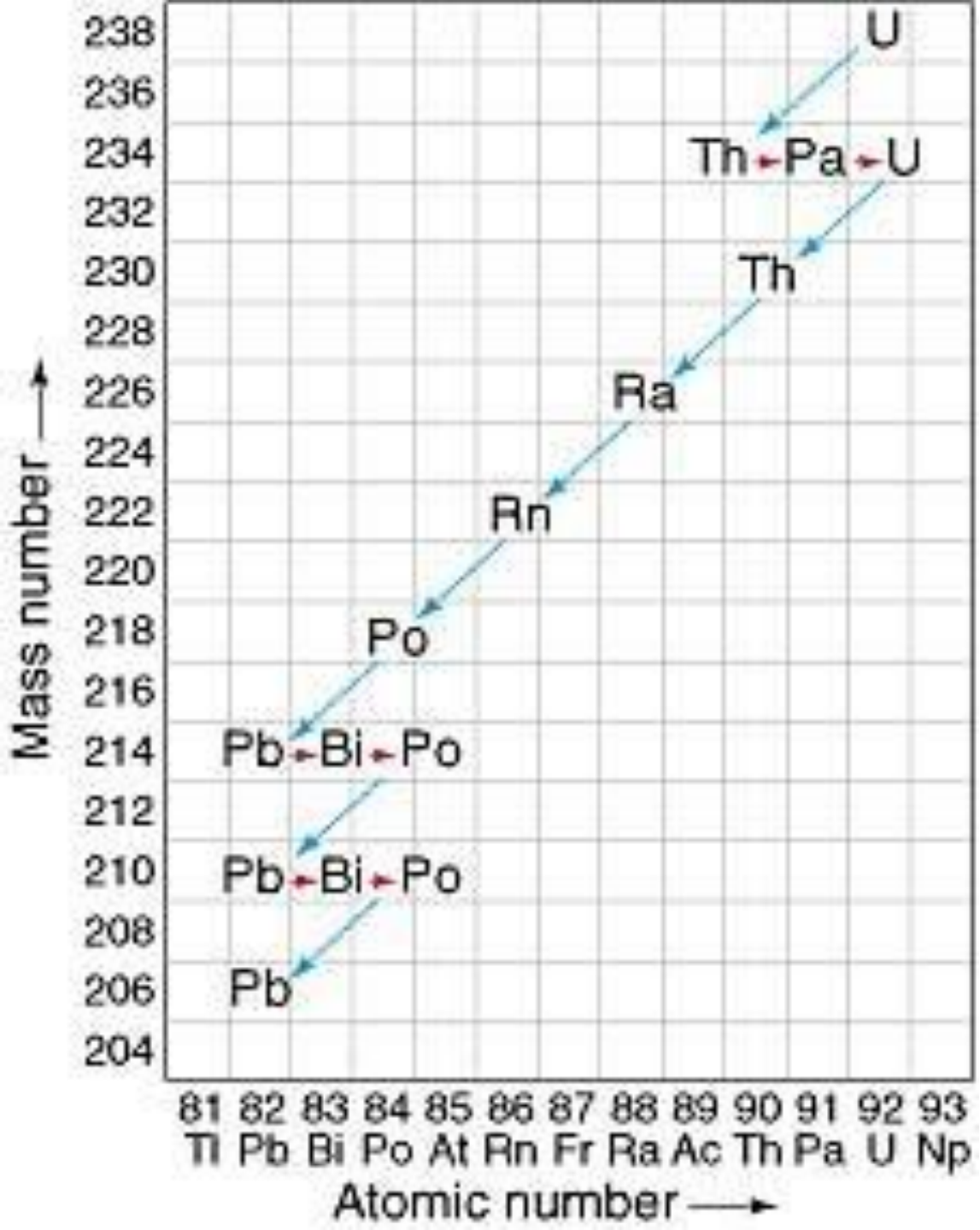
How does the radioisotope Uranium-238 decay?



Radioactive Decay

How does the radioisotope Uranium-238 decay?

Change Mass #, And Atomic #



Three Types of Radiation

P294-298

Three Types of Radiation

- Ernest Rutherford (1871-1937) identified three types of radiation using an electric field.

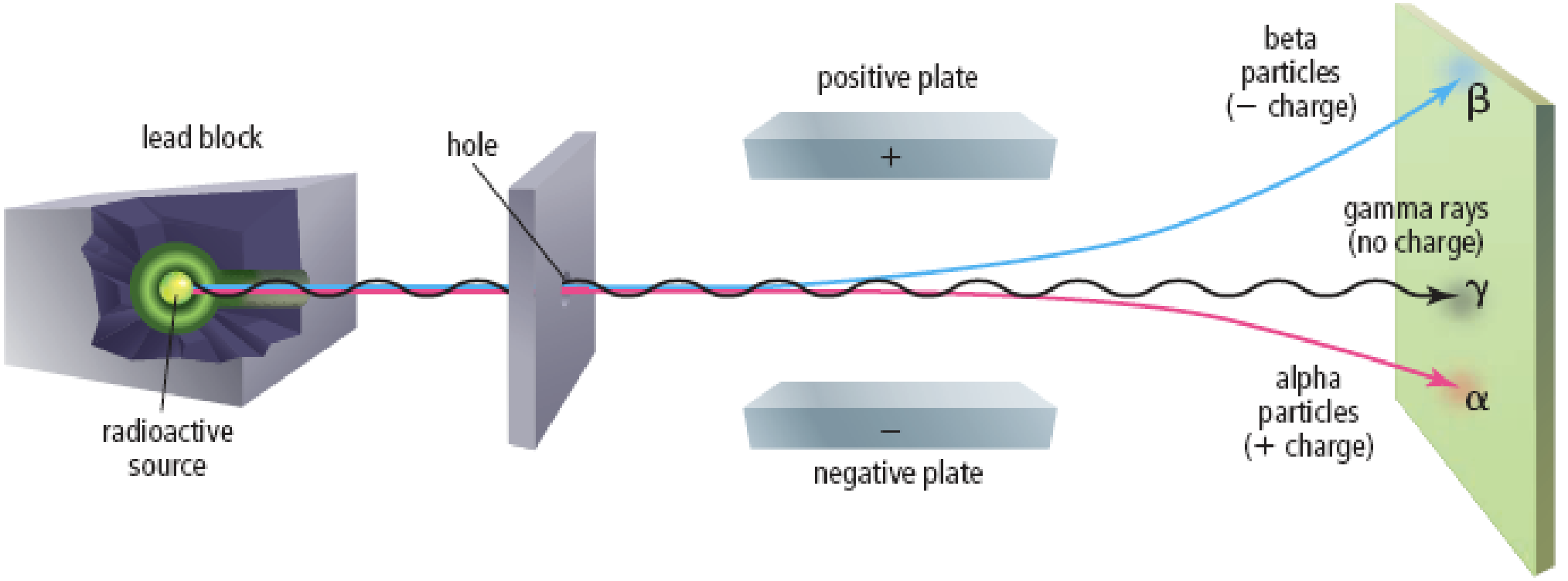


Figure 7.9 Alpha particles are deflected toward the negative plate. Beta particles are deflected toward the positive plate. Gamma radiation is not deflected by the electric field.

Three Types of Radiation

- He placed a radioactive source inside a lead block that allowed the radiation to pass out only through a tiny hole.

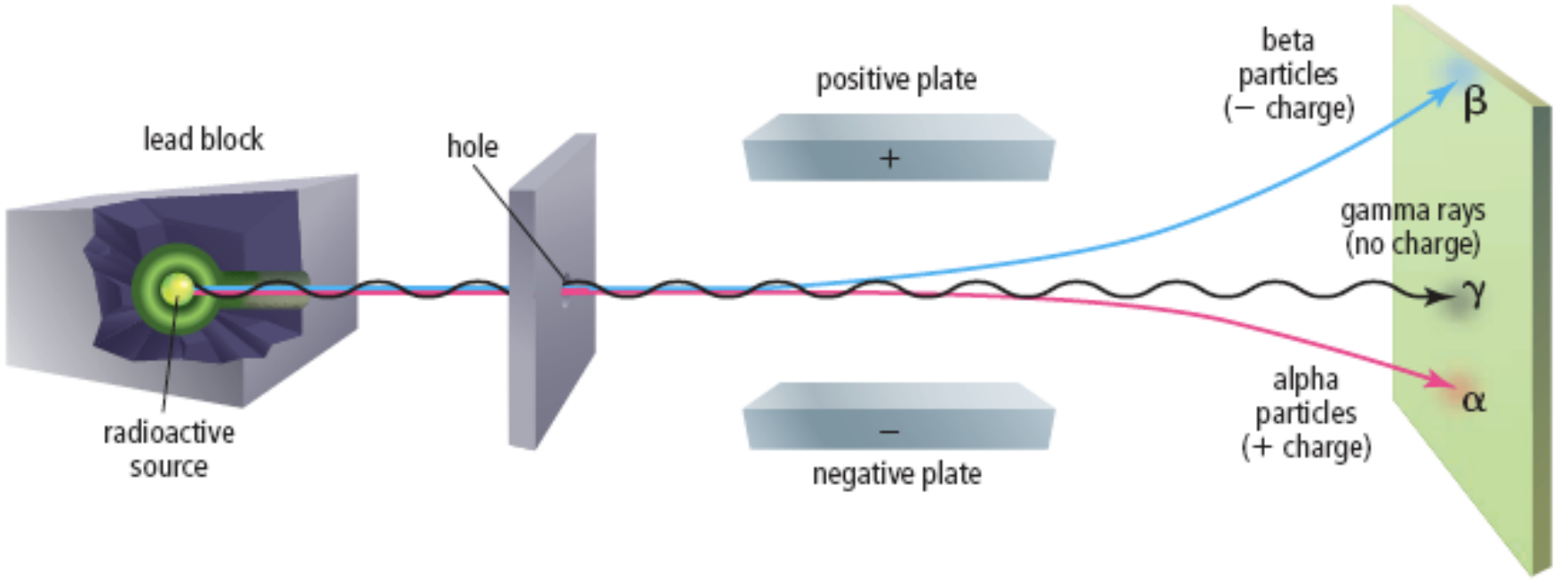


Figure 7.9 Alpha particles are deflected toward the negative plate. Beta particles are deflected toward the positive plate. Gamma radiation is not deflected by the electric field.

Three Types of Radiation

- From the hole, the radiation travelled through a slot between electrically charge plates that defected any electrically charged particles.

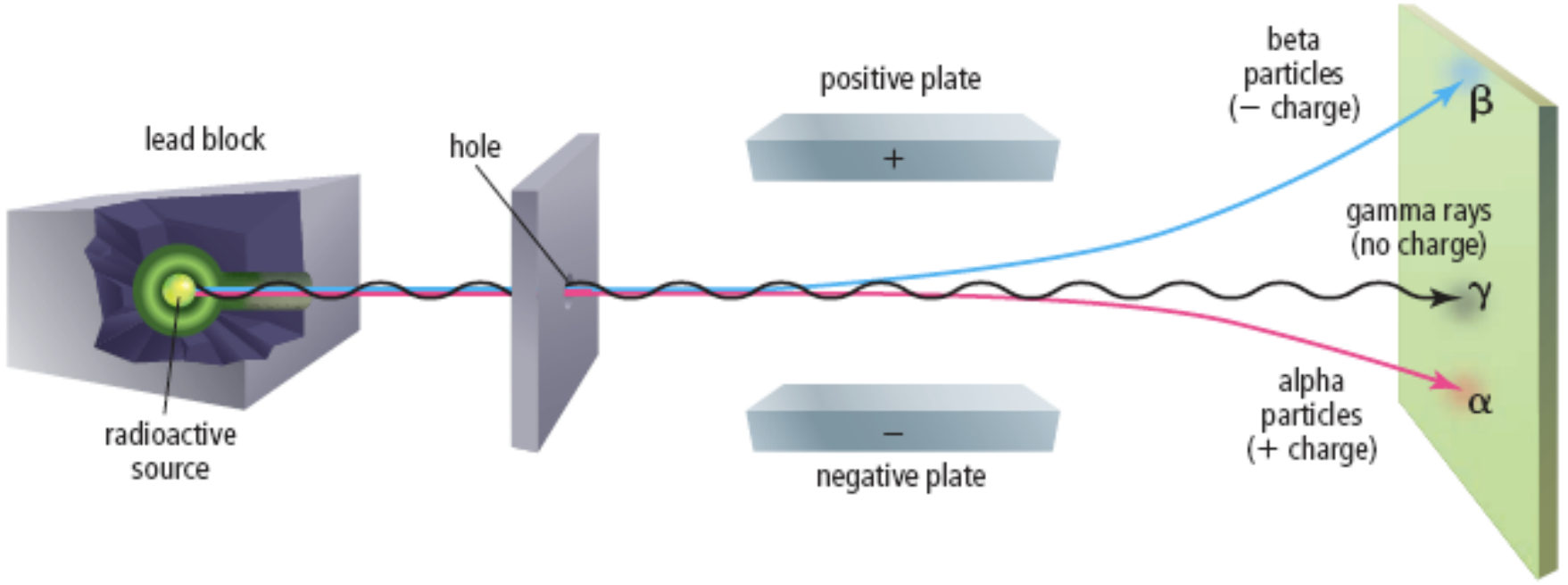


Figure 7.9 Alpha particles are deflected toward the negative plate. Beta particles are deflected toward the positive plate. Gamma radiation is not deflected by the electric field.

- **Positive <u>alpha particles</u>** were attracted to the negative plate.
- **Negative <u>beta particles</u>** were attracted to the positive plate.
- **Neutral <u>gamma rays</u>** had no charge, and therefore did not move towards any plate.

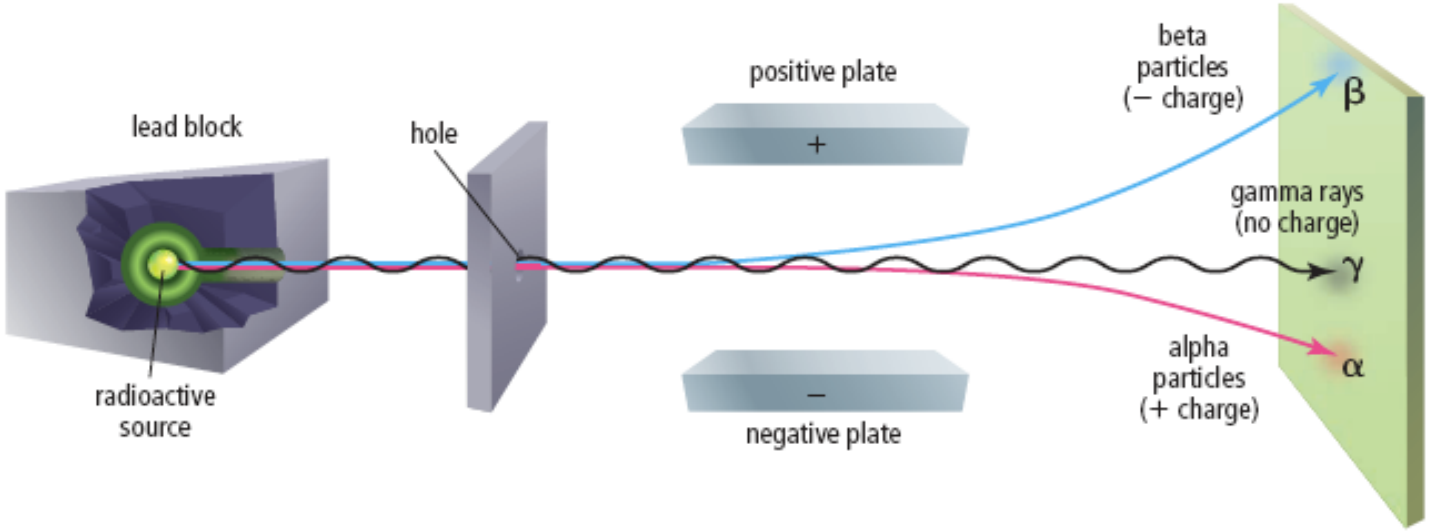


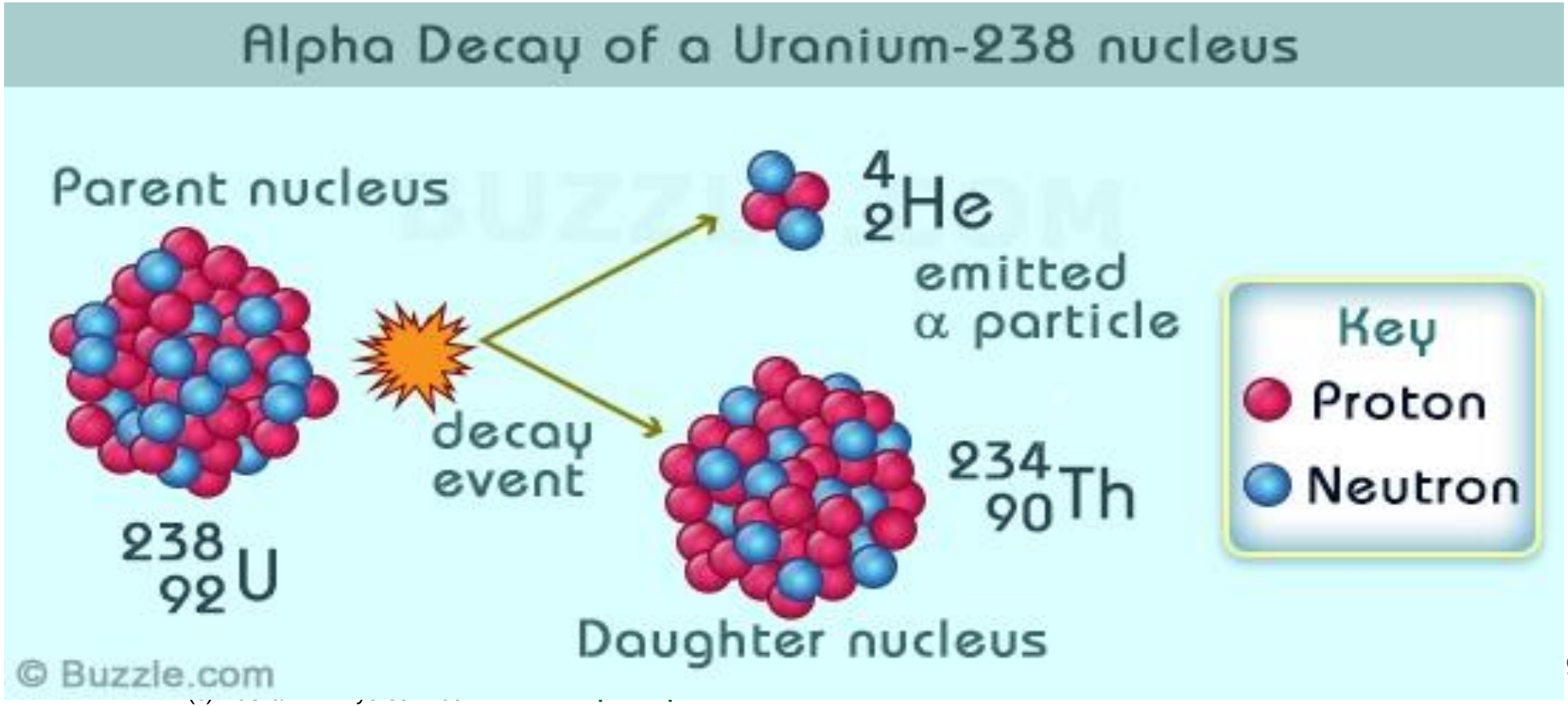
Figure 7.9 Alpha particles are deflected toward the negative plate. Beta particles are deflected toward the positive plate. Gamma radiation is not deflected by the electric field.

Three types of radiation: Video

- https://www.youtube.com/watch?v=5oUagoF_viQ

Alpha Radiation

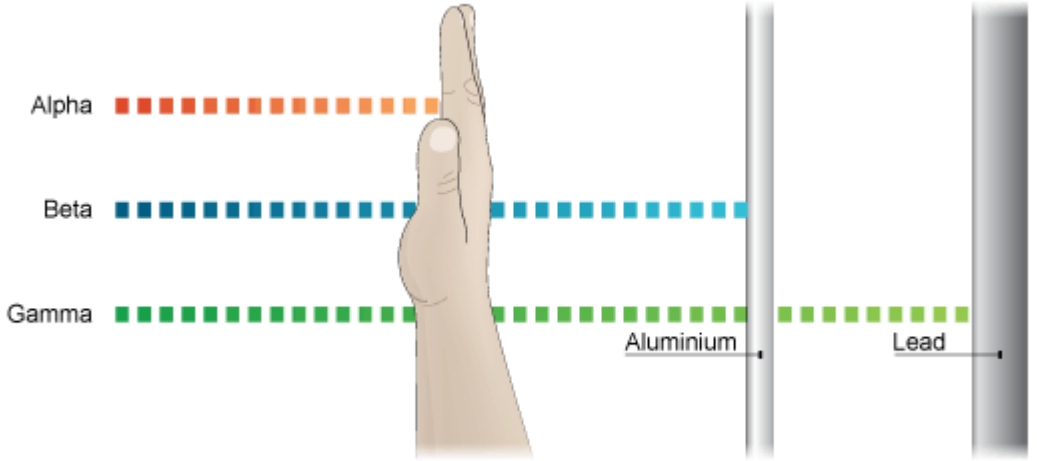
- Alpha radiation is a stream of alpha particles.
- What are some characteristics of Alpha particles?



Radon-222. Radon has two less protons than radium.

Characteristics of Alpha Particles

- Are **positively** charged,
- Are the **most massive** of the 3 radiation types
- Have same combination of particles as a **helium nucleus.**
- Are **slow** and **penetrate materials much less** than the other forms of radiation. A sheet of paper will stop an alpha particle.



Radium-226 releases an alpha particle and becc
Radon-222. Radon has two less protons than rac

Representing Alpha Particles

- represented by the symbols

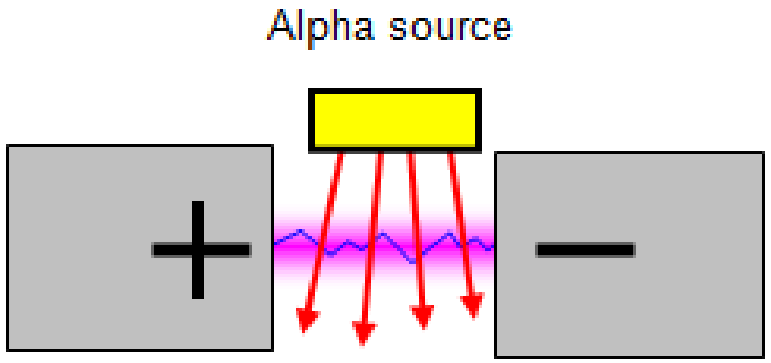
$$^{4}_{2}\mathrm{He}^{2+} \; or \; ^{4}_{2}\alpha \; or \; \alpha$$

- Because it has two protons, it has a charge of 2+.
- The release of alpha particles is called **alpha decay**.

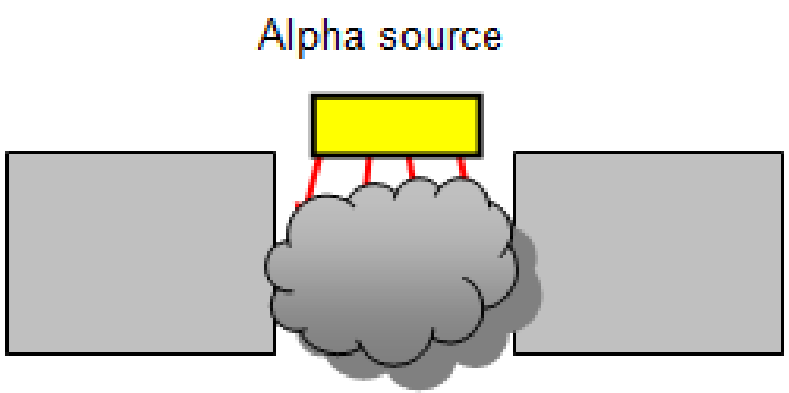
See page 294 - 295

Uses of Alpha Radiation

- Used in smoke detectors:
  - Radioactive americium releases alpha radiation, which ionises the air inside the detector.
  - Smoke from a fire absorbs alpha radiation, altering the ionisation and triggering the alarm.



Current flows from positive to negative



Current flow stopped by smoke

Alpha Radiation

$$^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{88}\mathrm{Rn} + {}^{4}_{2}\alpha$$

or

$$^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{88}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$$

Radium-226 releases an alpha particle and becomes Radon-222. Radon has two less protons than radium.

Practice

- Practice Problems p295

What is Beta Radiation?

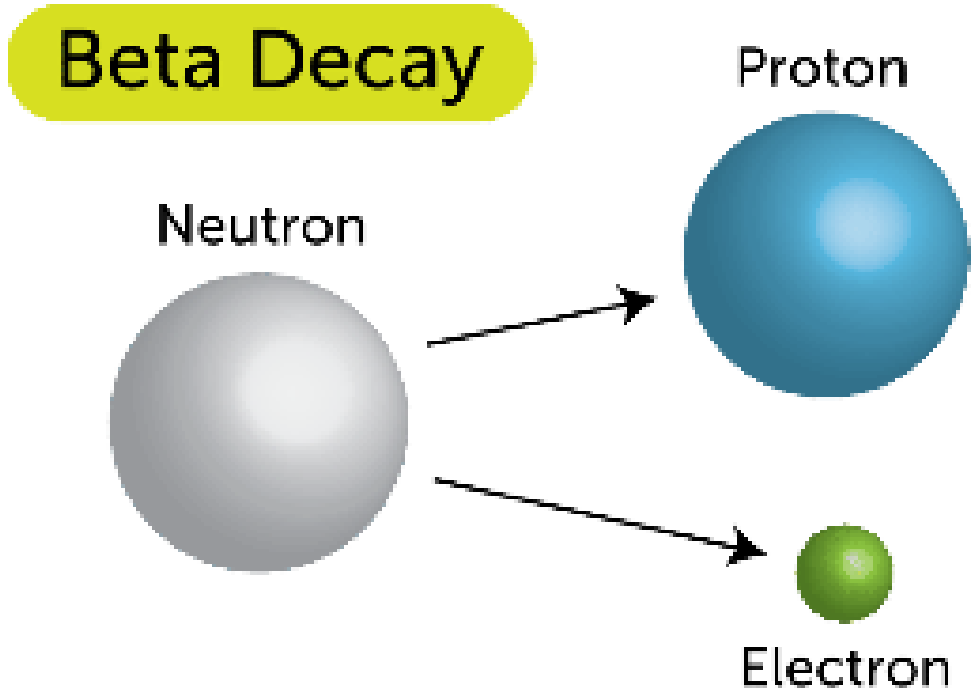
- A beta particle is an **electron**
- Represented by:

$$ {}^{0}_{-1}\beta \textbf{ or } {}^{0}_{-1}e $$

- Electrons are very tiny, so beta particles **have NO mass**.
- Since it is only an electron, a beta particle has a **charge of 1–**
- It takes a **thin sheet of aluminum foil** to stop a beta particle.

How does Beta Radiation occur?

- Beta decay occurs when a neutron changes into a proton and an electron.

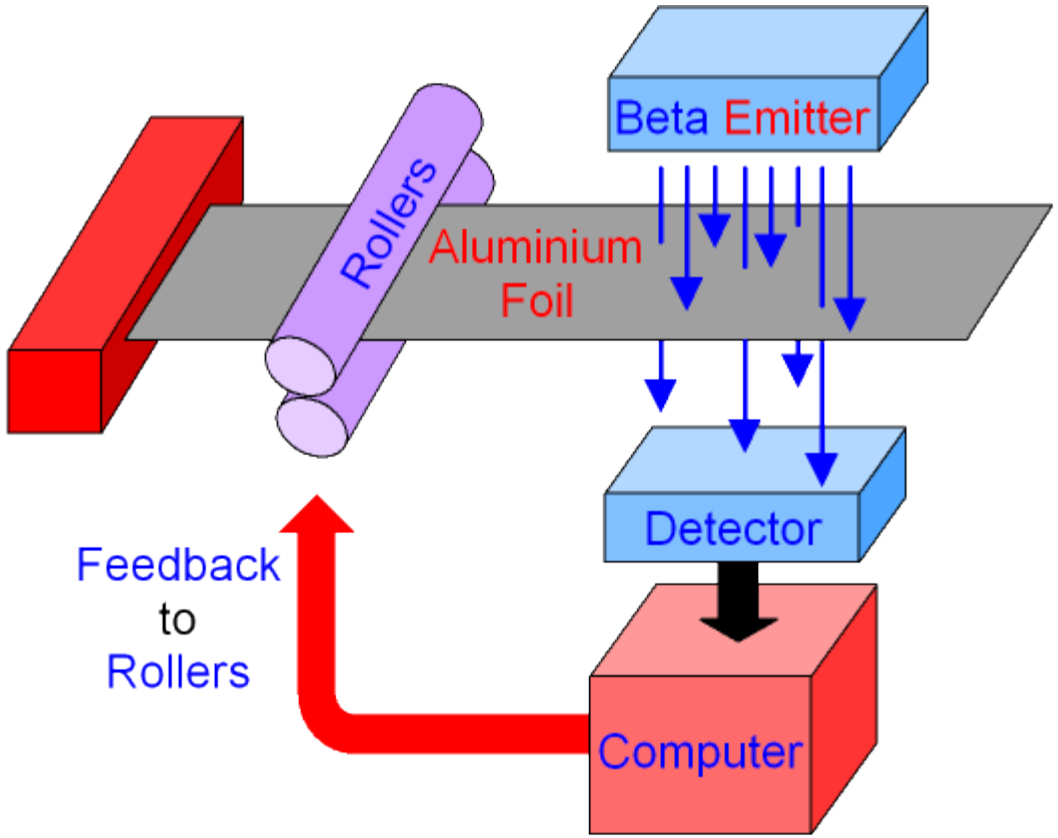


- The proton stays in the nucleus, and the electron is released.

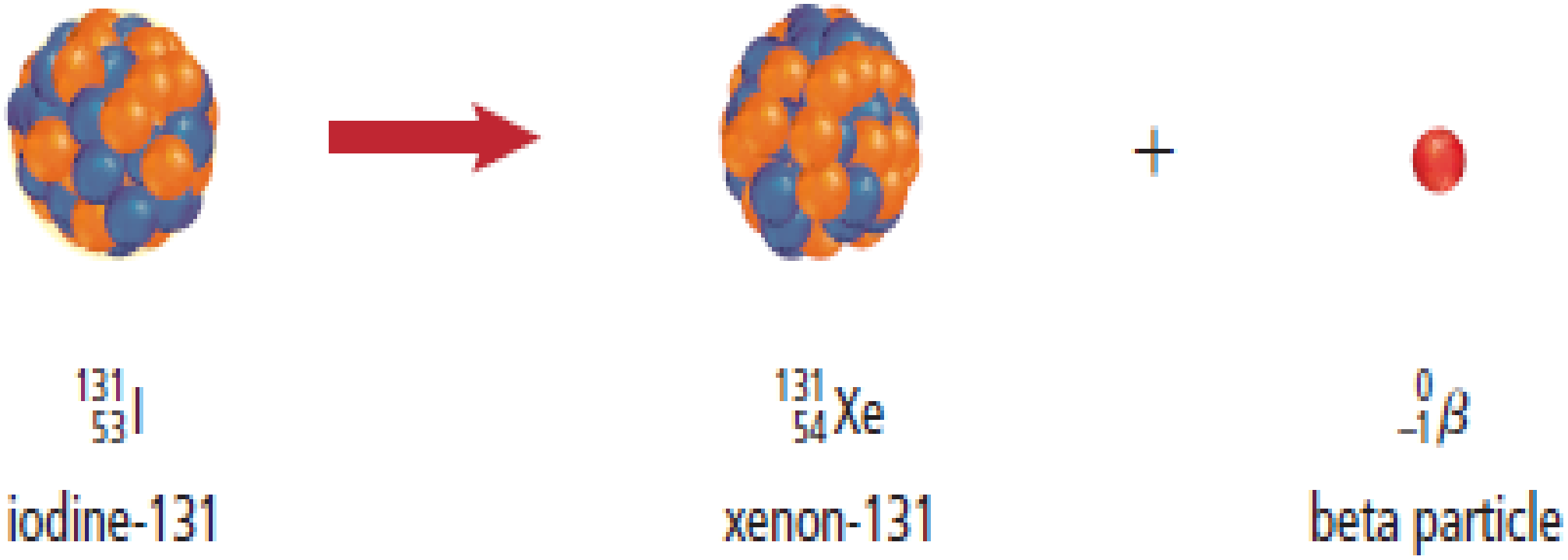
See page 296

Uses of Beta Radiation

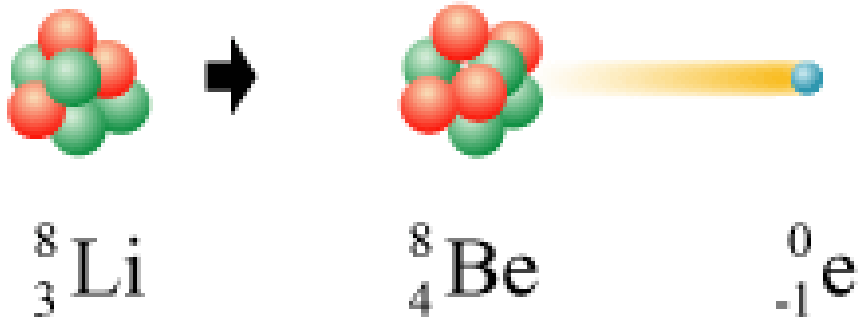
- Used to **treat health conditions** such as eye and bone cancer.
- Used as **tracers**. Strontium-90 is the material most commonly used to produce beta particles.
- Also used to **test the thickness** of an item, such as paper, plastic and aluminium coming through a system of rollers:
  - The thicker the material, the more radiation is absorbed and the less radiation reaches the detector.
  - It then sends signals to the equipment that adjusts the thickness of the material.



Beta Radiation Example



Beta Radiation Example



A Lithium neutron changes into a proton and electron:

1. Mass stays the same because an existing neutron changed to a proton.
2. Atomic number goes up because it has gained a proton

Beta Radiation Example

- Iodine-131 releases a beta particle and becomes xenon-131.
  A neutron has turned into a proton and the released electron.

$$^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\beta$$

or

$$^{131}_{53}\mathrm{I} \rightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}e$$

Practice

- Do practice problems p296

Gamma Radiation

- Gamma radiation is a ray of **high-energy, short-wavelength radiation.**
- Gamma radiation has **no charge and no mass**, and is represented by:

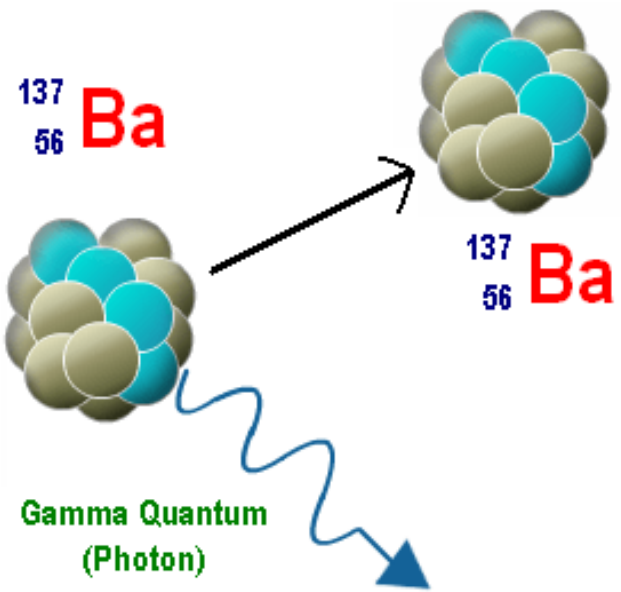
$$^{0}_{0}\gamma$$

- **Highest-energy** form of electromagnetic radiation.
- **Highest penetrating** power. It takes thick blocks of lead or concrete to stop gamma rays. Therefore can cause the **most damage** to a person

See page 297

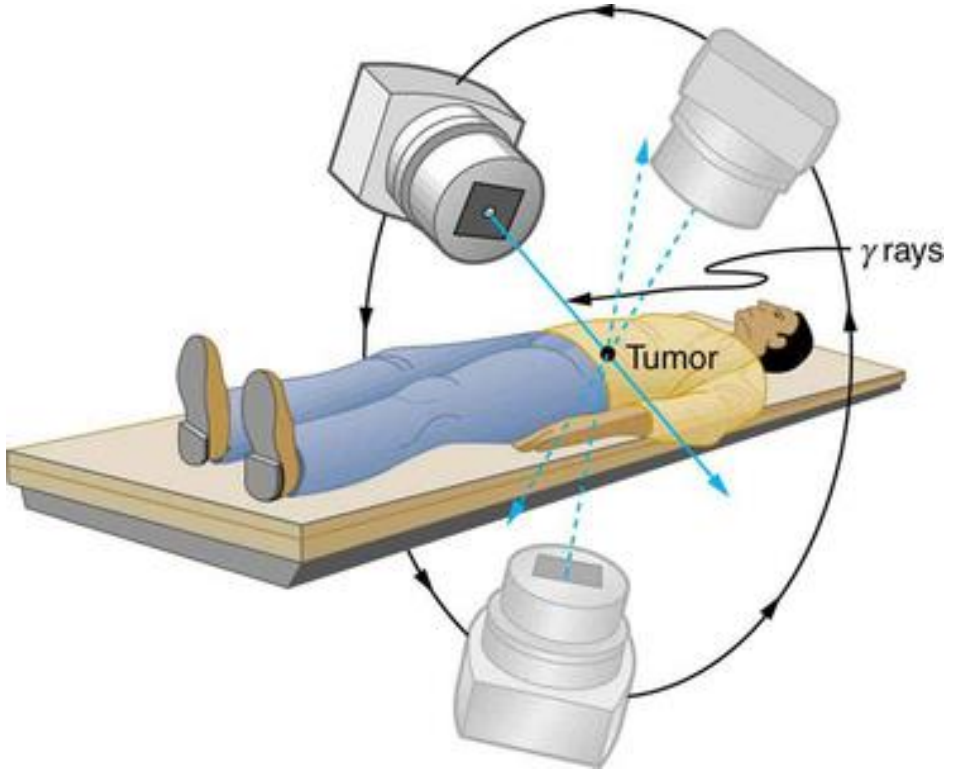
Gamma Radiation does not change atomic mass or number

- Because gamma radiation has almost no mass and no charge, the release of gamma radiation **does not** change the atomic number or the mass number of a nucleus.



Uses of Gamma Radiation

- Used in medicine to treat internal organs, kill cancer cells, sterilise medical equipment and in radioactive tracers.



How does Gamma Radiation occur?

- Gamma Radiation results from a **redistribution of energy within the nucleus.**
- A high-energy gamma ray is given off as the isotope falls from a high-energy state to a lower energy state.
- Eg. **high-energy nickel-60** can decay to **nickel-60** by gamma decay:

Is the gamma Decay reaction balanced?

$$^{60}_{28}\mathrm{Ni}^{*} \rightarrow {}^{60}_{28}\mathrm{Ni} + {}^{0}_{0}\gamma$$

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

Radiation Summary

Nuclear equations are written like chemical equations, but represent **changes in the nucleus** of atoms.

Chemical equations represent changes in the **position of atoms, not changes to the atoms themselves.**

1. The **SUM OF THE MASS** numbers does not change.
2. The **SUM OF THE CHARGES** in the nucleus does not change.

See pages 298 - 299

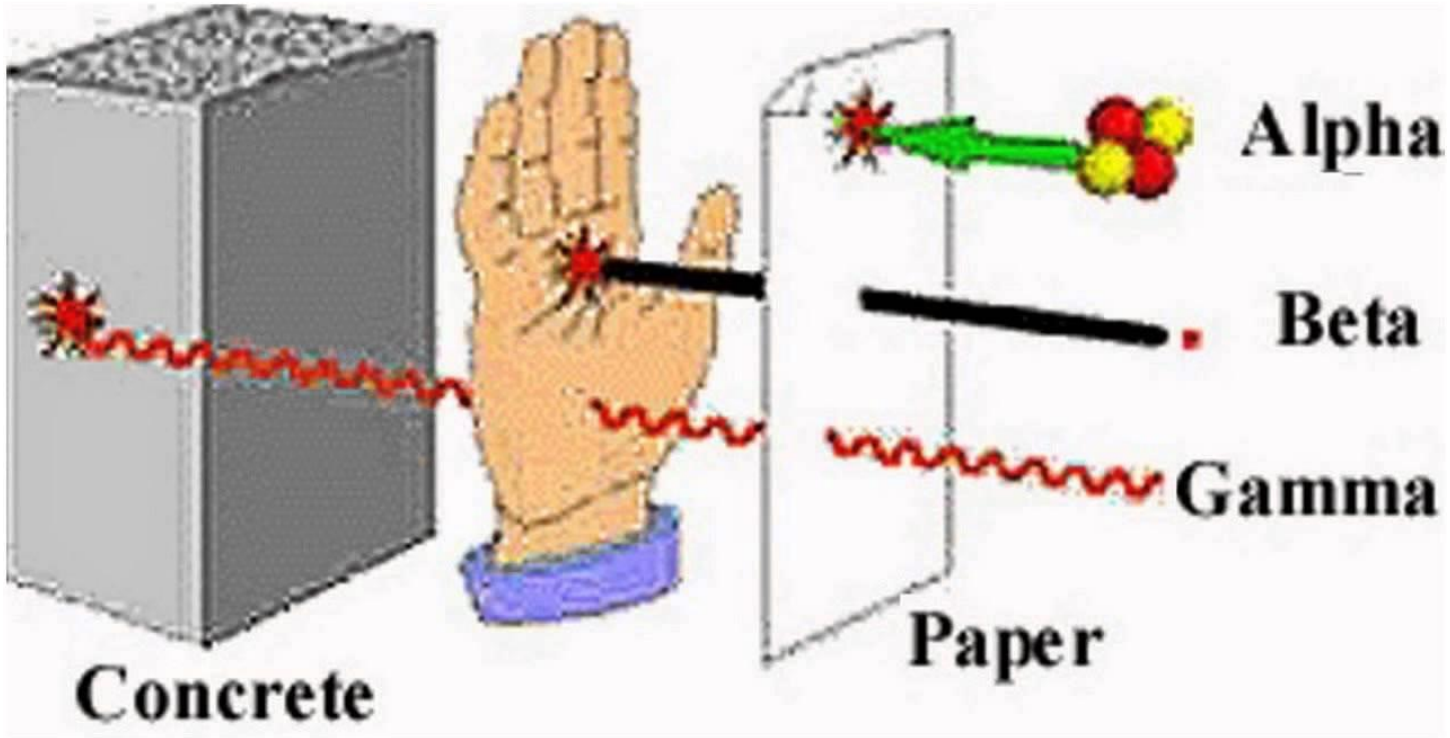
Take the Section 7.1 Quiz

Radiation Summary

Table 7.3 Properties of Alpha, Beta, and Gamma Radiation

Property	Alpha Radiation	Beta Radiation	Gamma Radiation
Symbol	${}^{4}_{2}\alpha$ or ${}^{4}_{2}\mathrm{He}$	${}^{0}_{-1}\beta$ or ${}^{0}_{-1}e$	${}^{0}_{0}\gamma$
Composition	Alpha particles	Beta particles	High-energy electromagnetic radiation
Description of radiation	Helium nuclei, ${}^{4}_{2}\mathrm{He}$	Electrons	High energy rays
Charge	2+	1−	0
Relative penetrating power	Blocked by paper	Blocked by metal foil or concrete	Partly or completely blocked by lead

Three types of Radiation

- 

Radioactivity Decay Summary

Table 7.4 Summary of Radioactive Decay Processes

	Alpha Decay	Beta Decay	Gamma Decay
Particle emitted	${}_{2}^{4}\alpha$ or ${}_{2}^{4}\mathrm{He}$	${}_{-1}^{0}\beta$ or ${}_{-1}^{0}e$	${}_{0}^{0}\gamma$
Change in mass number of starting nucleus	Decreases by 4	No change	No change
Change in atomic number of starting nucleus	Decreases by 2	Increases by 1	No change

Check your progress

1. How is mass number of an element determined?
2. How do you represent a larger nucleus such as radium-226?
3. Why does an alpha particle have a positive charge?
4. How does beta decay result in the production of an element with one more protons than the nucleus started out with?
5. Since gamma rays are not made of matter, how can they be detected?

Homework

- WB p
- Find out activity p 299
- Reading Check, Page 297