Warm Up:

Which subatomic particle is MOST responsible for the chemical properties of an element?

Objectives:

TSWBAT:

1. Compare fission and fusion to chemical reactions (include the part of the atom involved and the relative amount of energy released.)
2. Compare a, β, γ radiation in terms of mass, charge, penetrating power, and release of these particles from the nucleus.
3. Explain the concept of half-life, its use in determining the age of materials, and its significance to nuclear waste disposal.

Radiation

How did we ever discover this phenomenon that can't be seen, felt, smelled or heard?

Henri Bequerel and the uranium salts.

Marie Curie

Nobel Laureate in physics, 1903

Nobel Laureate in chemistry, 1911

Dr. Curie died of leukemia in 1934 because radiation is bad for you.

Def: Radiation-

the penetrating rays and particles emitted by a radioactive source.

Def: Radioactivity: the process by which nuclei emit particles and rays.

Def: Radioisotope:

an isotope with an unstable nucleus that undergoes radioactive decay.

Nuclear reactions differ from chemical reactions in several ways:

1. Chemical reactions are driven by electrons. Atoms will lose, gain, or share electrons to become stable. Nuclear reactions occur because an atom has an unstable nucleus and must change the nucleus to become stable.

A second difference between chemical and nuclear reactions is that nuclear reactions are ALWAYS accompanied by the emission of large amounts of energy.

Warm Up

1. What are two main differences between a chemical reaction and a nuclear reaction?

A third difference between nuclear reactions and chemical reactions is that nuclear reactions are NOT affected by changes in temperature or pressure. It doesn't matter what other compounds are present.

Warm UP

$$2H_2 + O_2 \longrightarrow 2H_2O$$

What is the limiting reagent if 99.9 g O_2 is allowed to react with 25.0 g H_2? What is the theoretical yield?

You must hand me your warm up at 10:15.

A fourth difference between nuclear and chemical reactions is: nuclear decay reactions cannot be sped up, slowed down, or turned off.

Radioactivity disproved Dalton's assumption that atoms are indivisible. In nuclear reactions atoms do indeed divide.

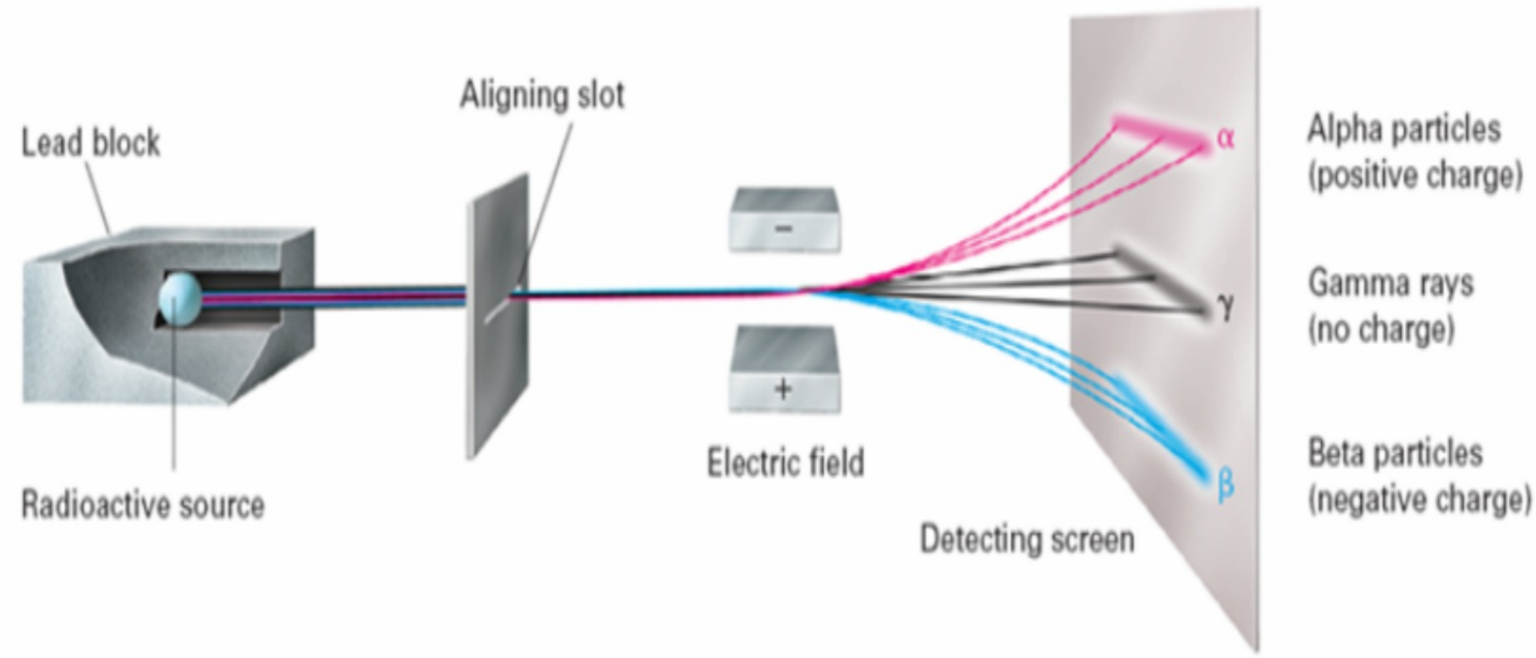
Radioisotopes have UNSTABLE nuclei. The stability of a nucleus depends on the ratio of neutrons to protons in the nucleus and upon the overall size of the nucleus.

Remember the extra credit project about Tc?

Key points:

- An unstable nucleus emits radiation during the process of radioactive decay.
- One element (an unstable radioisotope) actually transforms into another element
- Radioactive decay is spontaneous. No added energy is needed.

The three main types of nuclear radiation are alpha radiation, beta radiation, and gamma radiation.

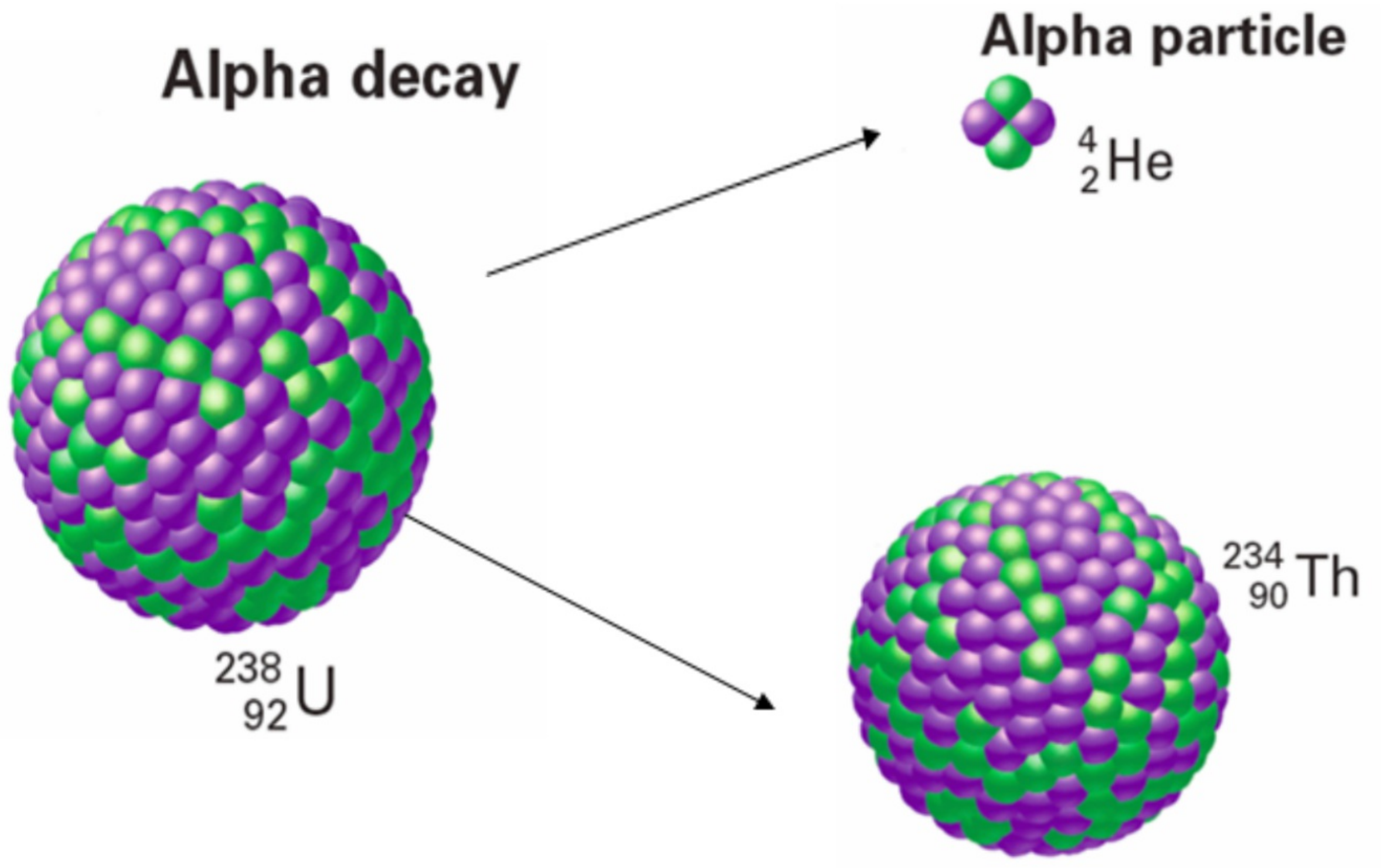


Alpha Radiation

Alpha radiation consists of helium nuclei that have been emitted from a radioactive source. These emitted particles, called alpha particles, contain two protons and two neutrons and have a double positive charge.

$$^{238}_{92}\mathrm{U} \xrightarrow[\text{decay}]{\text{Radioactive}} {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}\,(\alpha\ \text{emission})$$

Uranium-238 Thorium-234 Alpha particle


Alpha decay
Alpha particle
$^{4}_{2}He$
$^{238}_{92}U$
$^{234}_{90}Th$

Beta Radiation

An electron resulting from the breaking apart of a neutron in an atom is called a beta particle.

stays in nucleus

ejected

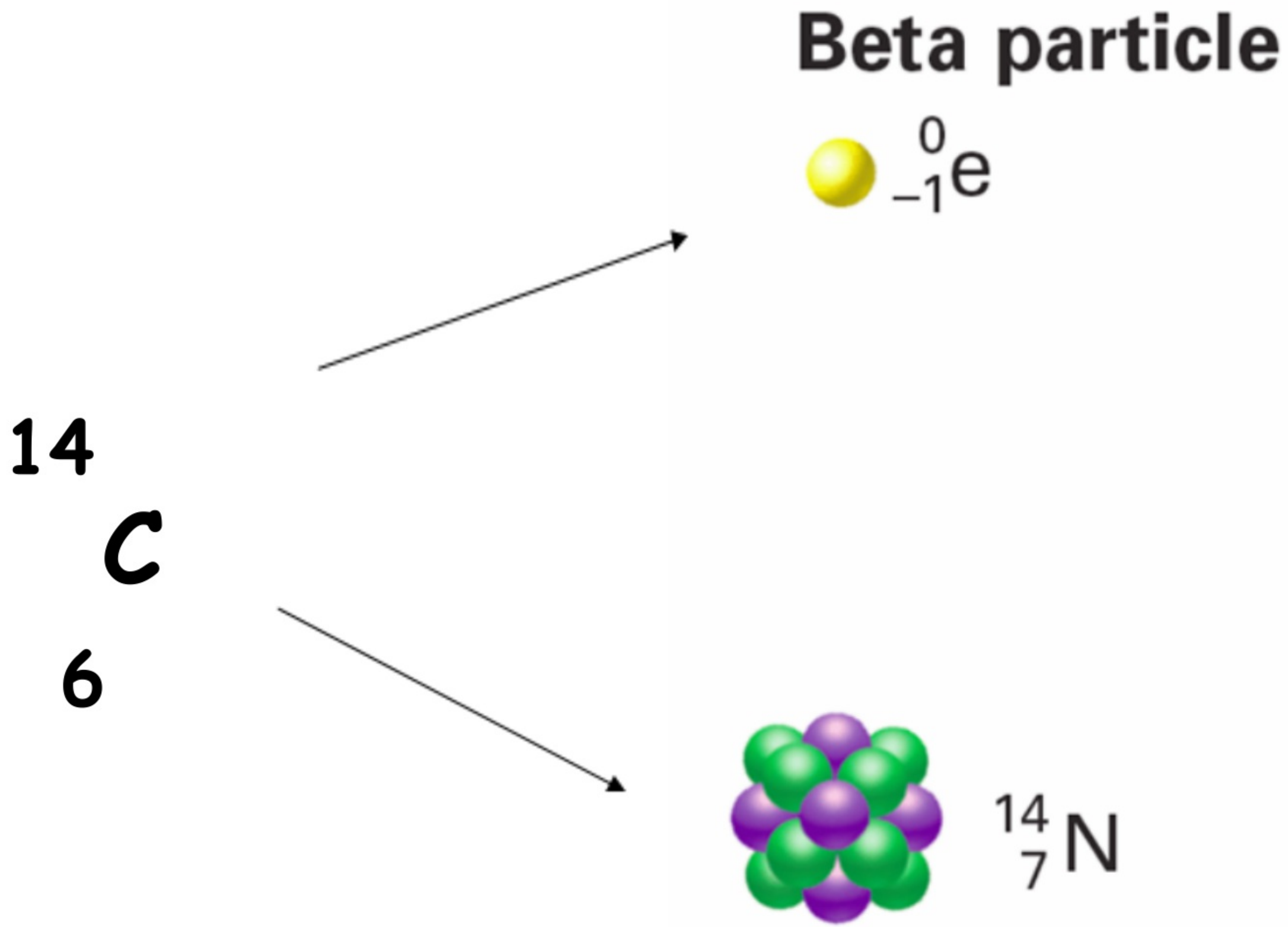
$$ {}^{1}_{0}\mathrm{n} \longrightarrow {}^{1}_{1}\mathrm{H} + {}^{0}_{-1}\mathrm{e} $$

Neutron — Proton — Electron (beta particle)

Carbon-14 emits a beta particle as it undergoes radioactive decay to form nitrogen-14.

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e \ (\beta \text{ emission})$$

Carbon-14 (radioactive)	Nitrogen-14 (stable)	Beta particle



Beta particle
$^{0}_{-1}e$
$^{14}_{6}C$
$^{14}_{7}N$

Gamma Radiation

A high-energy photon emitted by a radioisotope is called a gamma ray. The high-energy photons are electromagnetic radiation.

$$
\underset{\text{Thorium-230}}{{}^{230}_{90}\mathrm{Th}} \longrightarrow \underset{\text{Radon-226}}{{}^{226}_{88}\mathrm{Ra}} + \underset{\text{Alpha particle}}{{}^{4}_{2}\mathrm{He}} + \underset{\text{Gamma ray}}{\gamma}
$$

Alpha particles are the least penetrating. Gamma rays are the most penetrating.

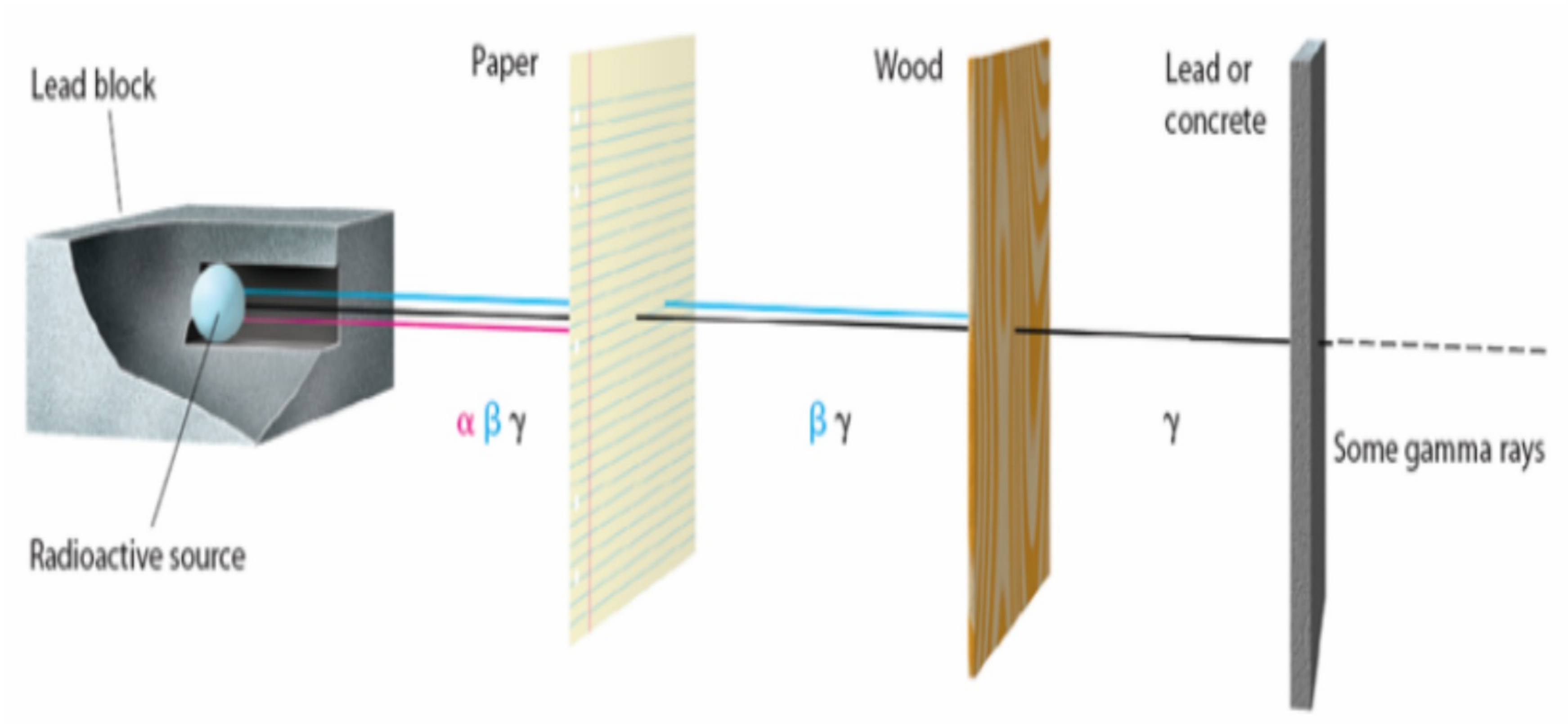


Table 25.1

Characteristics of Some Types of Radiation			
Property	**Alpha radiation**	**Beta radiation**	**Gamma radiation**
Composition	Alpha particle (helium nucleus)	Beta particle (electron)	High-energy electromagnetic radiation
Symbol	α, ${}^{4}_{2}He$	β, ${}^{0}_{-1}e$	γ
Charge	2+	1–	0
Mass (amu)	4	1/1837	0
Common source	Radium-226	Carbon-14	Cobalt-60
Penetrating power	Low (0.05 mm body tissue)	Moderate (4 mm body tissue)	Very high (penetrates body easily)
Shielding	Paper, clothing	Metal foil	Lead, concrete (incompletely shields)

Warm Up

Learning Check:

Certain elements are radioactive because their atoms have

a. more neutrons than electrons.
b. an unstable nucleus.
c. a large nucleus.
d. more neutrons than protons.

An unstable nucleus releases energy by

a. emitting radiation.
b. thermal vibrations.
c. a chemical reaction.
d. giving off heat.

Which property does NOT describe an alpha particle?

a. 2+ charge
b. a relatively large mass
c. a negative charge
d. low penetrating power

When a radioactive nucleus releases a high-speed electron, the process can be described as

a.oxidation.
b.alpha emission.
c.beta emission.
d.gamma radiation.

Half-Life

A half-life ($t_{1/2}$) is the time required for one-half of the nuclei of a radioisotope sample to decay to products.

After each half-life, half of the existing radioactive atoms have decayed into atoms of a new element.

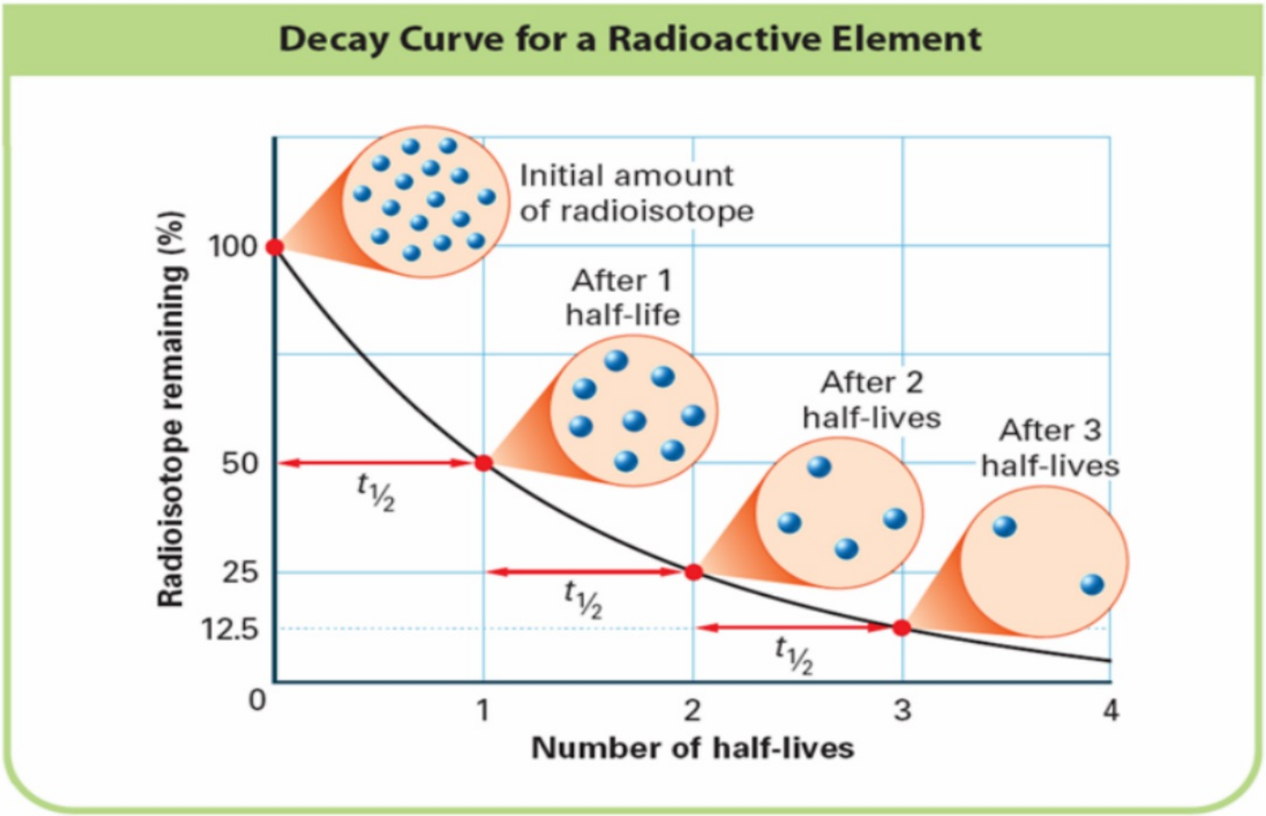
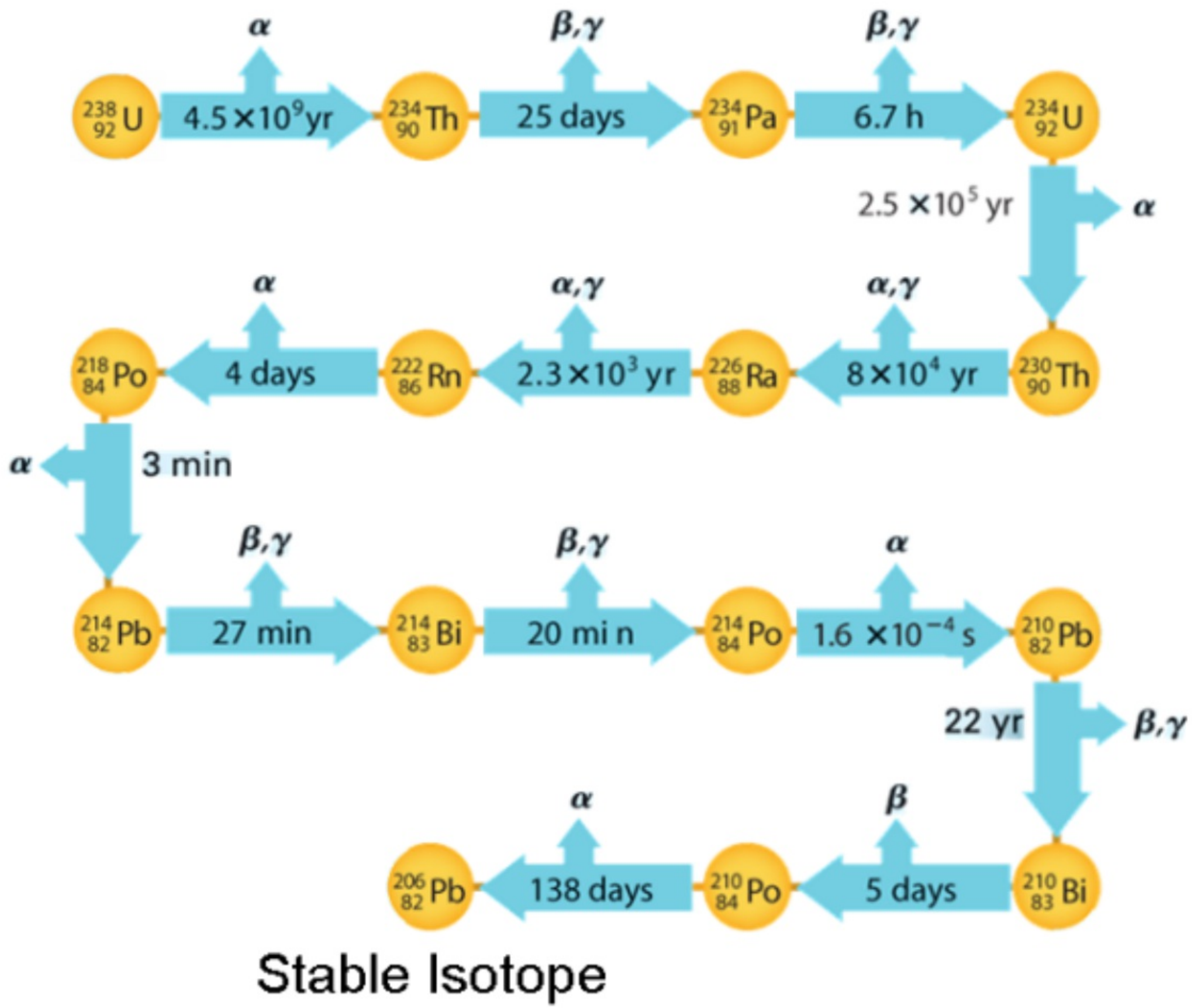


Table 25.3

Half-Lives and Radiation of Some Naturally Occurring Radioisotopes		
Isotope	Half-life	Radiation emitted
Carbon-14	5.73×10^3 years	β
Potassium-40	1.25×10^9 years	β, γ
Radon-222	3.8 days	α
Radium-226	1.6×10^3 years	α, γ
Thorium-234	24.1 days	β, γ
Uranium-235	7.0×10^8 years	α, γ
Uranium-238	4.46×10^9 years	α

Half-Life



α
β,γ
β,γ
238 92 U
4.5×10⁹yr
234 90 Th
25 days
234 91 Pa
6.7 h
234 92 U
2.5 ×10⁵ yr
α
α
α,γ
α,γ
218 84 Po
4 days
222 86 Rn
2.3×10³ yr
226 88 Ra
8×10⁴ yr
230 90 Th
α
3 min
β,γ
β,γ
α
214 82 Pb
27 min
214 83 Bi
20 mi n
214 84 Po
1.6 ×10⁻⁴ s
210 82 Pb
22 yr
β,γ
α
β
206 82 Pb
138 days
210 84 Po
5 days
210 83 Bi
Stable Isotope

The ratio of Carbon-14 to stable carbon in the remains of an organism changes in a predictable way that enables the archaeologist to obtain an estimate of its age.

Half-Life Simulation

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