Atomic Theory, Isotopes, and Radioactive Decay

PowerPoint 7.1

Isotopes

Isotopes are atoms of a particular element that have the same number of protons but different numbers of neutrons.

Isotopes are often written in standard atomic notation.

Also called the nuclear symbol

Mass number = #p + #n

Nuclear charge = #p

$^{39}_{19}K$

Chemical symbol

The name of this isotope is Potassium-39

Other isotopes of potassium

$^{40}_{19}K$ $^{41}_{19}K$

Isotopes of Potassium

	Potassium-39	Potassium-40	Potassium-41
# of protons	19	19	19
# of neutrons	20	21	22
# of total electrons In a neutral atom	19	19	19

Why Are Atomic Masses on the Periodic Table of Elements Often Decimals?

19 -
K
chlorine
39.09835

The atomic mass cited in the Periodic Table of Elements is actually an ***average*** the element's isotopes' masses based on their relative abundance.

For potassium,
93.3% is $^{39}_{19}K$,
6.73% is $^{41}_{19}K$, and
0.01% is $^{40}_{19}K$.

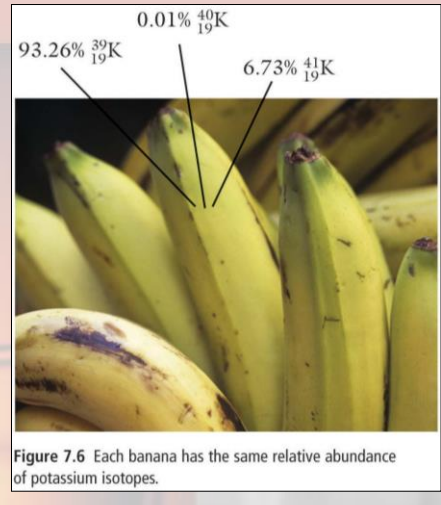


Figure 7.6 Each banana has the same relative abundance of potassium isotopes.

Radioactivity and Radiation

Radioactivity is the release of high-energy particles and rays of energy from a substance as a result of changes in the nuclei of its atoms.

Radiation refers to high-energy rays and particles emitted by radioactive sources.

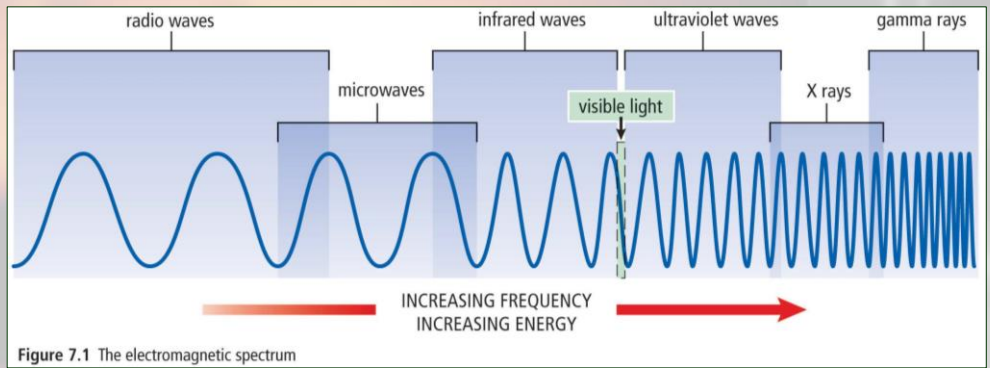


Figure 7.1 The electromagnetic spectrum

Radioactive Decay

Radioactive decay is the process in which unstable nuclei lose energy by emitting radiation.

Radioactive decay typically continues in a particular atom until a stable, non-radioactive isotope form is obtained.

Radioisotopes are isotopes that can undergo radioactive decay.

Three types of radioactive decay are,

1. Alpha decay, α
2. Beta decay, β
3. Gamma radiation, γ

Alpha Decay

Alpha decay is the emission of an ***alpha particle***, $^{4}_{2}\alpha$ or $^{4}_{2}He$, from the nucleus of an atom.

$$^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}\alpha$$

- The total number of protons and neutrons before and after the reaction are equal.
- The element has changed into a different element, $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn$

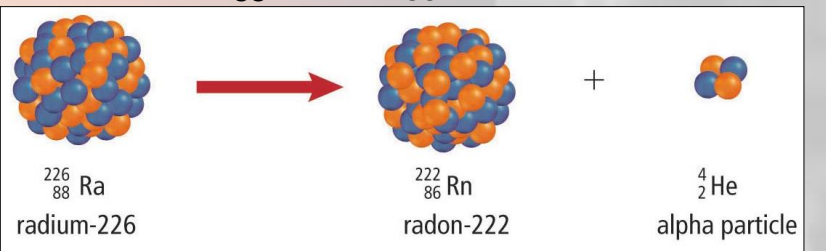


Figure 7.10 The nucleus of an atom of radium-226 contains 88 protons and 138 neutrons. A radium-226 nucleus undergoes alpha decay to form a different element, radon-222, and an alpha particle.

Beta Decay

Mass of an electron is ≈ 0

Charge of an electron = -1

The emission of a beta particle which is an electron which written $^{0}_{-1}\beta$ or $^{0}_{-1}e$.

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

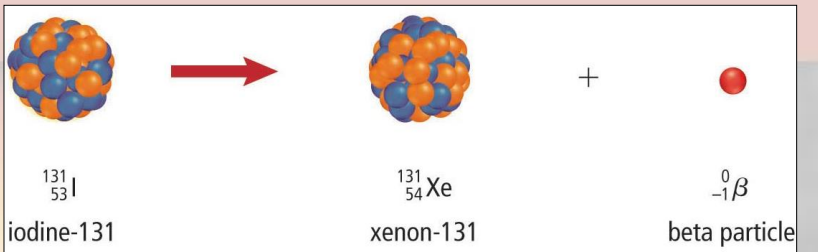


Figure 7.11 The beta particle that is emitted during beta decay has high energy and can penetrate human skin and damage cells.

- During beta decay, a neutron changes into a proton and an electron,
- The proton remains inside the nucleus while the electron is emitted with great energy.
- Note that the mass of an atom undergoing beta decay remains the same.

Gamma Decay

- Gamma radiation, ${}^{0}_{0}\gamma$, consists of high-energy, short-wavelength radiation.

Example, ${}^{60}_{28}Ni \rightarrow {}^{60}_{28}Ni + {}^{0}_{0}\gamma$

- Gamma radiation can accompany other types of radiation, such as alpha radiation.

Example, ${}^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha + 2{}^{0}_{0}\gamma$

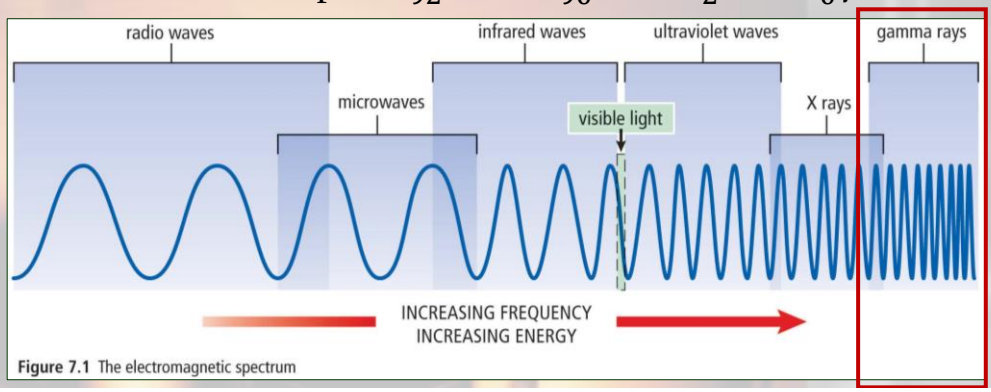


Figure 7.1 The electromagnetic spectrum

Some Isotopes Can Undergo Numerous Decays Until a Stable Form Is Obtained

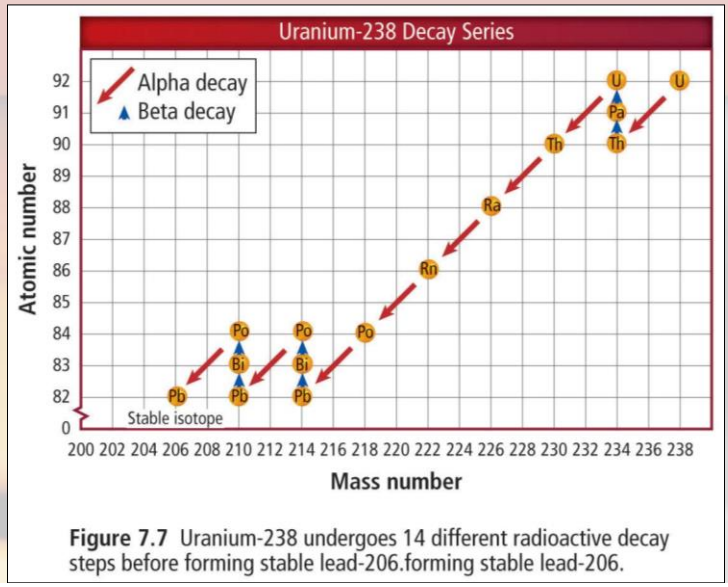
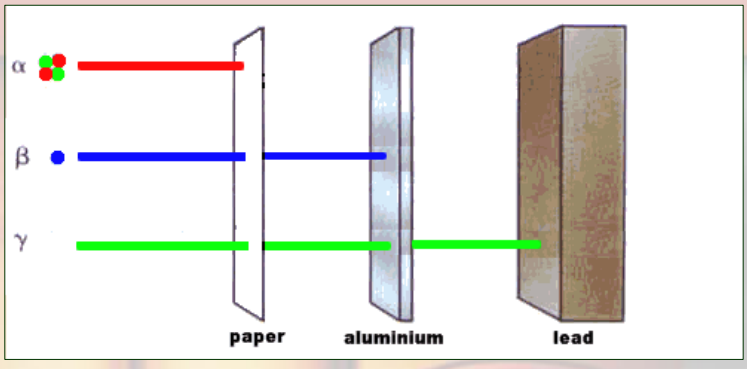


Figure 7.7 Uranium-238 undergoes 14 different radioactive decay steps before forming stable lead-206.forming stable lead-206.

Relative Penetrating Power of Alpha Radiation, Beta Radiation, and Gamma Radiation



Summary

Isotopes of an element have varying quantities of neutrons

Radioisotopes undergo various forms of radioactive decay such as Alpha, Beta, and Gamma.

Property	Alpha Radiation	Beta Radiation	Gamma Radiation
Symbol	${}^{4}_{2}\alpha$ or ${}^{4}_{2}He$	${}^{0}_{-1}\beta$ or ${}^{0}_{-1}e$	${}^{0}_{0}\gamma$
Composition	Alpha particle	Beta-particle	High-energy electromagnetic radiation
Description of the radiation	Helium nucleus	electron	High energy rays
Charge of the emission	2+	1-	0
Relative Penetrating Power	Blocked by paper	Blocked by metal foil or concrete	Partly blocked or completely blocked by lead