Radioactivity

- Emission of high energy photons and particles

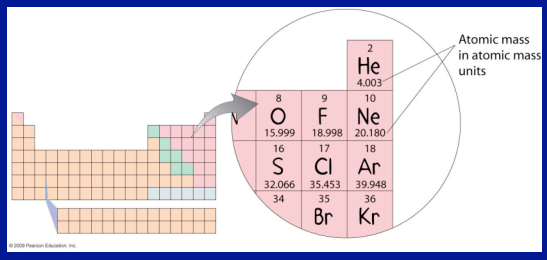
Alpha, Beta and Gamma Rays

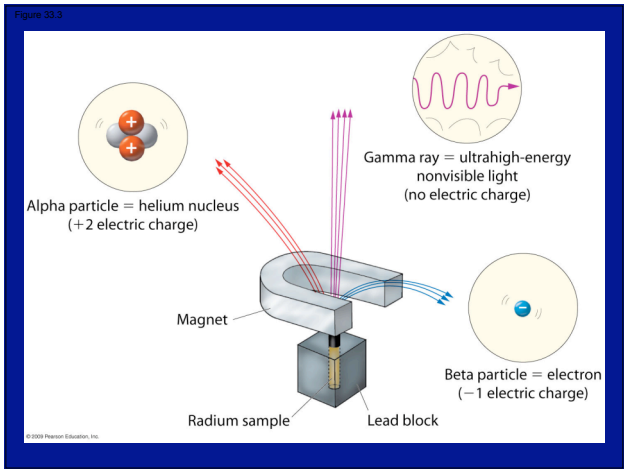
- Elements heavier than lead (Z=82), are radioactive
- Radioactive materials emit:
  - alpha particles (helium nucleus)
  - beta particles (electrons)
  - gamma rays (electromagnetic radiation)

DEMO

How can we tell the difference between these?

Remember the Periodic Table?



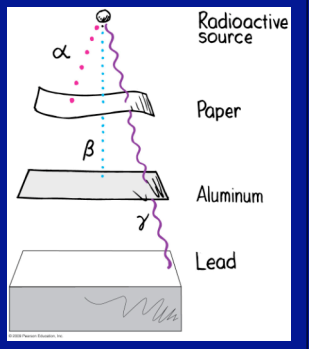


Watch Out!

Penetrating power is different for the different radioactive "particles" emitted

Lead is the best shield as it is the densest. This is also why your dentist makes you wear a lead vest when you get your teeth X-ray'd.

DEMO



Practical Uses

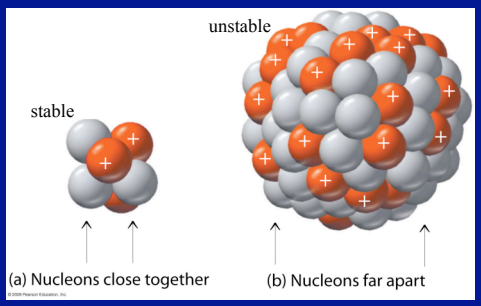
Gamma-rays can kill micro-organisms helping to keep food fresh longer

Strawberries themselves are unharmed

Practical Uses

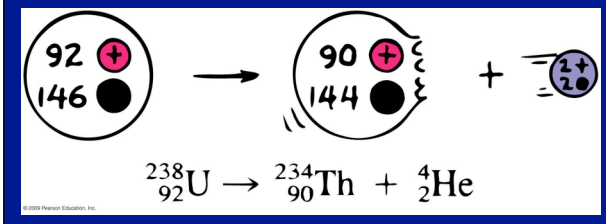
Gamma-rays can kill cancerous tumors
Radiation therapy has saved millions of lives

Why are some materials Radioactive?



Big nucleii are unstable due to the limited range of the strong force that holds them together

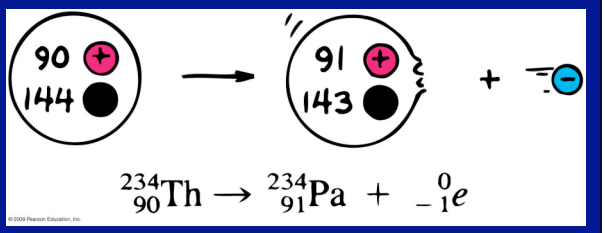
What Happens?



Uranium 238 spontaneously decays to Thorium 234 and an alpha particle

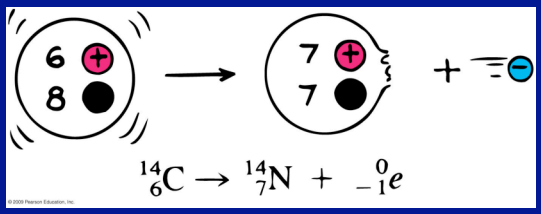
What is this transmutation of heavy to light elements called?

What Happens?



Thorium 234 decays to Protactinium and a beta particle

What Happens?



Carbon-14 (with two "extra" neutrons") is also unstable and will decay into Nitrogen and an electron

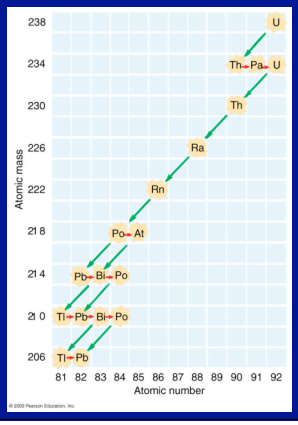
What Happens?

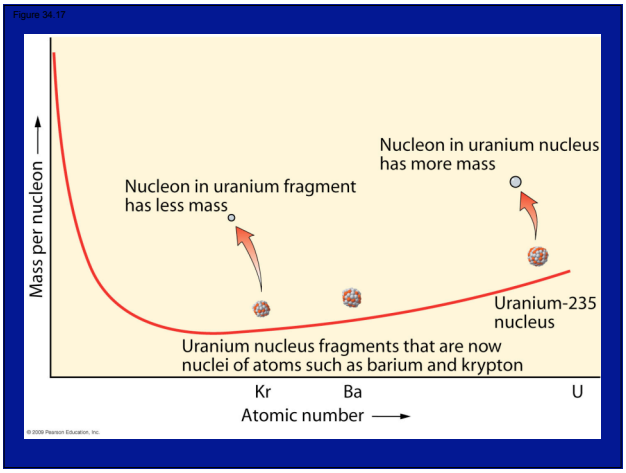
Uranium 238 spontaneously decays to Thorium 234 and an alpha particle

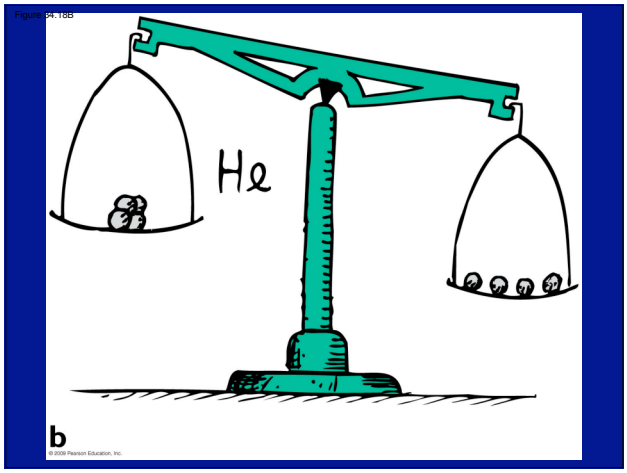
Thorium decays to Protactinium and so on, all the way down to lead

Various byproducts are alpha, beta and gamma radiation

Particles (and gamma rays) leave the nucleus with a lot of energy (high speed)







Some Materials can become radioactive

Radioactive waste products

HIGH: spent fuel rods

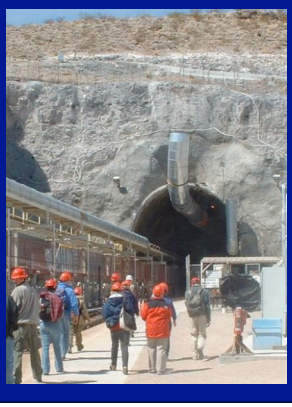
low: containment materials, pipes, suits

Current total US waste: 100 million gallons + 2500 tons solid waste

Bombardment of nuclei with high energy particles can increase the number of unstable isotopes

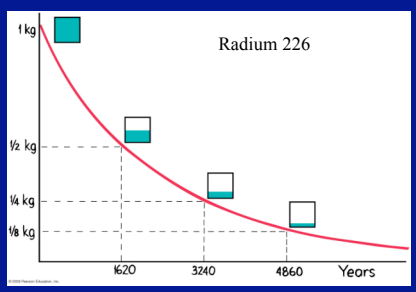
Yucca Mountain

80 miles North of Las Vegas
Studies began in 1978
Under construction since 2002
$9 Billion spent so far
Considerable opposition
Planned to open in 2020



How Fast?

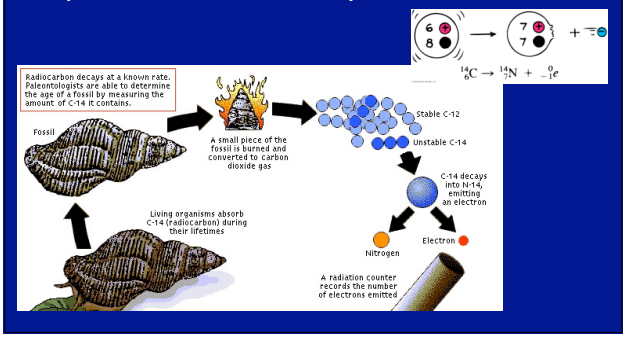
Its an "exponential" decay
Half of the radioactive material will transmutate in a set amount of time
This amount of time is called the "half-life"



Half-life for radium 226 is 1620 y

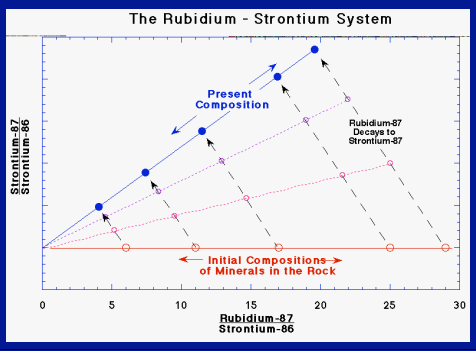
Radioactive Dating

All living things contain trace elements of radioactive C-14
After they die the C-14 levels gradually diminish due to radioactive decay of the C-14 with a half-life of 5730 years



Rock Clocks

At creation rubidium and strontium are equal
rubidium-87 decays to strontium-86 with a half-life of 49 billion years



Rock Clocks

Nuvvuagittuq greenstone belt, exposed on the eastern shore of Hudson Bay in northern Quebec. 4.28 billion y old

Clicker Question:

The half-life of Carbon-14 is roughly 6000 years. How old is a skeleton that contains only 12.5% of its original C-14?

A: 3000 years

B: 6000 years

C: 12000 years

D: 18000 years

Clicker Question:

When a heavy element like Uranium decays to a lighter element like Thorium, what do we call it?

A: Fusion

B: Fission

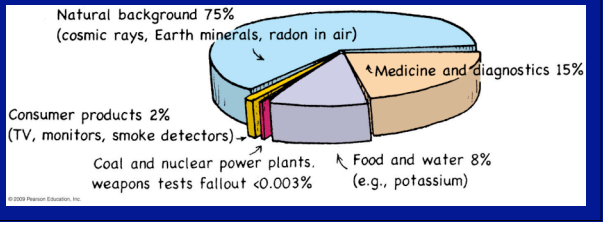
C: Transmogrification

D: Uranicide

Environmental Radiation

Common rocks and minerals contain small amounts of radioactive isotopes
- Radon gas is radioactive and may accumulate in basements
- Burning coal releases 13,000 tons of Th and Ur annually
- Nuclear power plants generate 10,000 tons of radioactive waste annually
- Flying on airplanes results in higher exposures to gamma-rays
- Medicine and diagnostics (e.g., X-rays)

300 mrems total



Environmental Radiation - Dosage

Common measure is *rads* (radiation absorbed dose)
1 rad = 0.01 joules/kg

unit of measure for damage is *rems* (roentgen equivalent man)

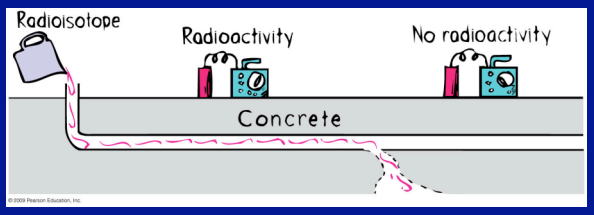
normal annual exposure: 300 millirems (mrem)

bonus exposure on commercial airline in US: 0.25 mrem/hour
bonus exposure flying the polar route: 3 mrem/hour
bonus exposure from an X-ray: 40 mrem

fatal instantaneous dosage: 500 rems
(500,000 mrems)

Geiger counter

Figure 33.15



Marie Curie (1867-1934)

Pioneer in magnetism and radioactivity
Winner of two Nobel Prizes
First Woman Professor at Sorbonne
Discovered and named Radium and Polonium

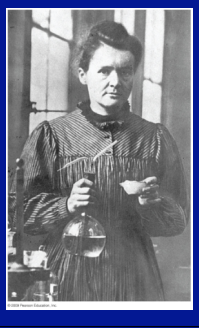


Figure 33.11

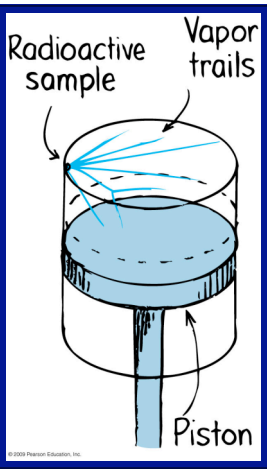


Figure 33.12

Figure 33.13

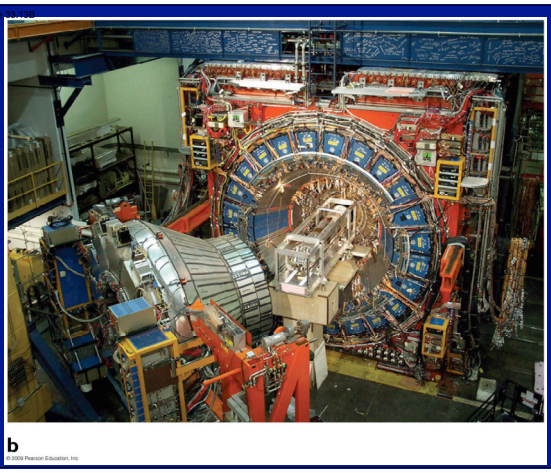


Table 33.1

TABLE 33.1
Transuranic Elements

Atomic Number	*Mass Number*	*Name*	*Symbol*	*Discovery Date*
93	237	Neptunium	Np	1940
94	244	Plutonium	Pu	1940
95	243	Americium	Am	1944
96	247	Curium	Cm	1944
97	247	Berkelium	Bk	1949
98	251	Californium	Cf	1950
99	252	Einsteinium	Es	1952
100	257	Fermium	Fm	1952
101	258	Mendelevium	Md	1955
102	259	Nobelium	No	1958
103	262	Lawrencium	Lr	1961
104	261	Rutherfordium	Rf	1964
105	262	Dubnium	Db	1967
106	266	Seaborgium	Sg	1974
107	264	Bohrium	Bh	1981
108	269	Hassium*	Hs	1984
109	268	Meitnerium	Mt	1982
110	271	Darmstadtium*	Ds	1994
111	272	Roentgenium	Rg	1994
112	285	Unnamed		1996
114	289	Unnamed		1998
116	292	Unnamed		2000

*Hassium is named for Hesse (in its Latin spelling), the German state in which the Darmstadt laboratory is located. Other locations recognized by element names are America, Berkeley, California, and Dubna. People honored by heavy-element names are Marie Curie, Albert Einstein, Enrico Fermi, Dmitri Mendele'ev, Alfred Nobel, Ernest Lawrence, Ernest Rutherford, Glenn Seaborg, Niels Bohr, Lise Meitner, and Wilhelm Roentgen, representing nine countries.

Clicker Question:

You find out that you have just received an accidental dose of 250 rems. Should you be concerned?

A: Yes

B: No

C: Only if you were thinking of starting a family

Clicker Question:

Which of the following emits gamma rays whenever it is on?

A: CRT televisions

B: Liquid Crystal Displays (LCDs)

C: Plasma TVs

D: Guns