Warm Up

If we start with 1.000 g of strontium-90, 0.953 g will remain after 2.00 years.

What is the half life?

How much strontium-90 will remain after 5 years?

(HINT: Assume first order kinetics)

Today's Agenda

- QOTD: What is a nuclear reaction and why does an isotope decay?

- Half life
- Belt of stability
- Nuclear Transmutations

- HW: Ch 21, pg 909 # 1-9 odds, 29-33 odds, 37, 39 and Gas corrections due Wednesday!

Half Life

- What is it?

Radioactive decay is a FIRST ORDER process where k is the decay constant.

Each isotope has its own characteristic half-life (or time it takes for HALF a sample to radioactively decay).

We will discuss WHY and HOW this happens later

Calculating Half Life

- Use first order kinetics:

$\ln(N_t/N_0) = -kt$ find k, then $t_{1/2} = 0.693/k$

or

$$N_t = N_0 (½)^n$$

N_t – remaining amount of element

N_0 – initial amount of element

n – number of half lives that have passed

Practice

1. The half life of ^{14}C is 5730 years. Approximately how many years will it take for 94% of the sample to decay?
2. A sample used for medical imagining is labeled with ^{18}F, which has a half life of 110 min. What percentage of the original sample remains after 300 mins?

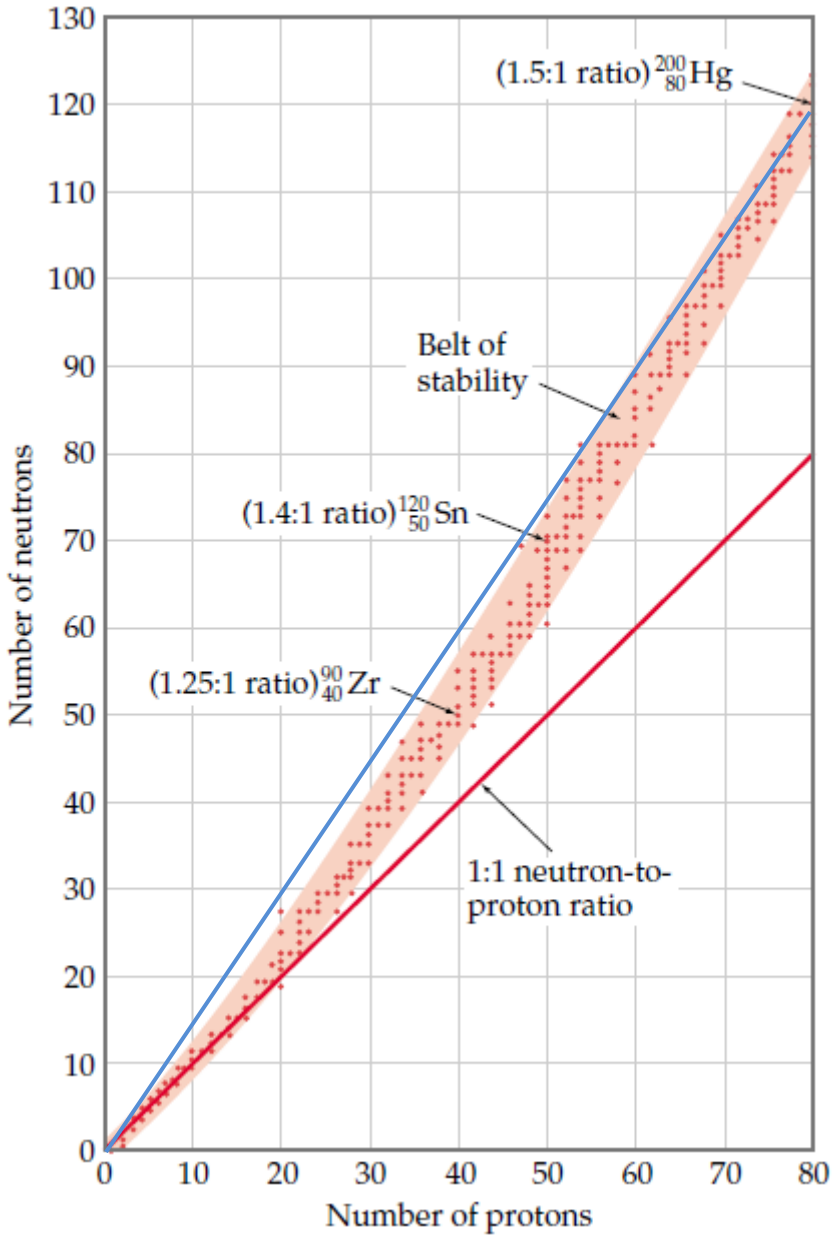
3. Radiometric Dating **Challenge**:

A rock contains 0.257 mg of lead-206 for every mg of uranium-238. The half life for the decay of uranium-238 is 4.5×10^9 years. How old is the rock??

Radioactivity – The WHY and HOW

- Nuclear reactions – change an element into a new element!! Lots of energy involved!
  - Unlike a chemical reaction because we are doing more than rearranging – **we CHANGE the identity**.

- UNSTABLE nuclei are unhappy and lose energy/mass by emitting radiation –through radioactive decay.
- They form STABLE atoms of a different element.



Low atomic #'s have a 1:1 neutron to proton ratio

$^{4}_{2}He$

High atomic #'s are stabilized by a 1.5:1 ratio

$^{200}_{80}Hg$

If atom is not in band (belt) of stability it undergoes radioactive decay to get there!

Warm Up

Phosphorus-15 has a half-life of 14 days. What percent of the original phosphorus-15 remains after 8 weeks?

Today's Agenda

- QOTD: How do you balance a nuclear reaction?

- Types of decay
- Balancing nuclear equations

- Turn in Gas Q corrections!

Radioisotopes

- Isotopes of atoms with unstable nuclei.

- Undergo radioactive decay to attain stability.

Emit 4 types of radiation

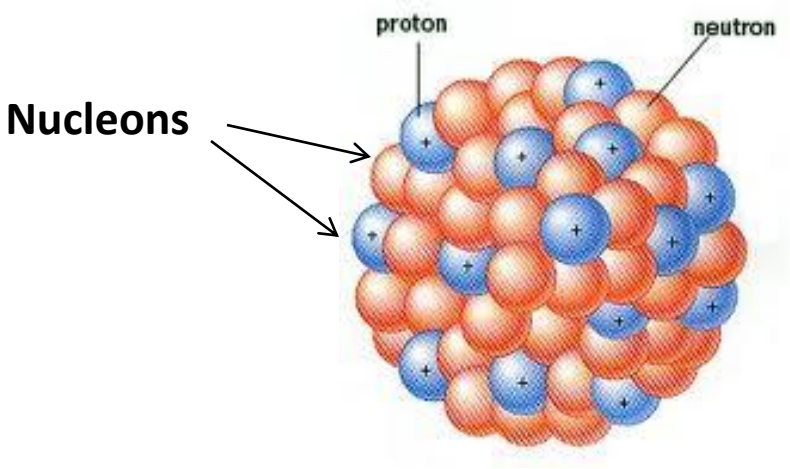
- alpha, α, ($^{4}_{2}He$)
- beta, β, ($^{0}_{-1}e$)
- gamma, γ

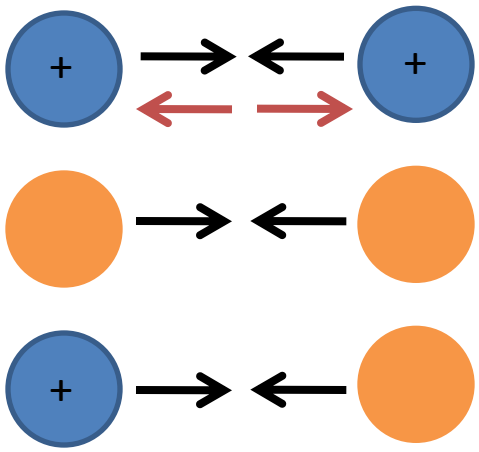
positron $^{0}_{+1}e$

and electron capture, ($^{0}_{-1}e$)

In the Nucleus

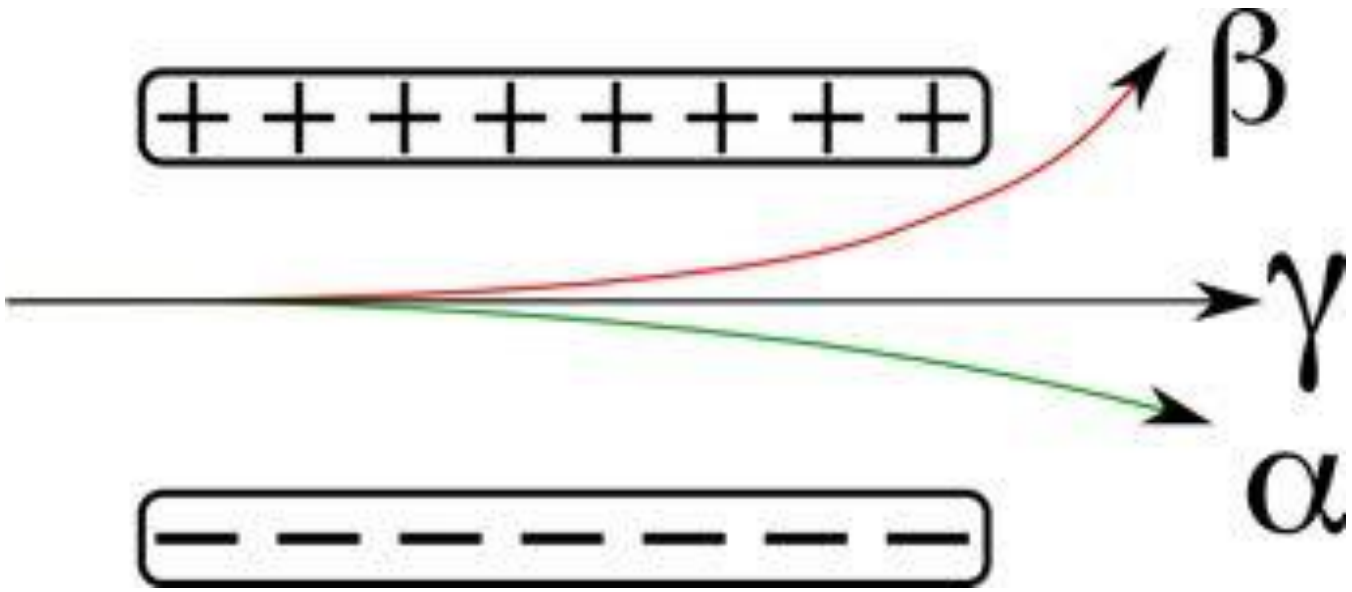
- Radioactive decay – **transmutation**
  - Atomic # is altered = identity of element changed





Strong nuclear force between all nucleons.
Repulsive force between 2 protons (electrostatic).
Neutron attraction have to overcome the repulsive forces – as atomic # increases we need more neutrons to stabilize the nucleus!!!

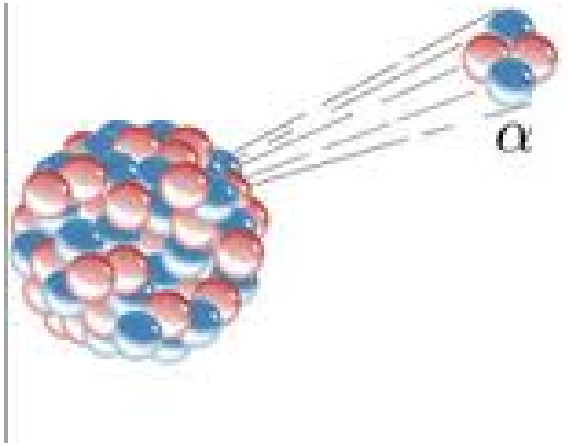
What are the charges on radioactive particles?



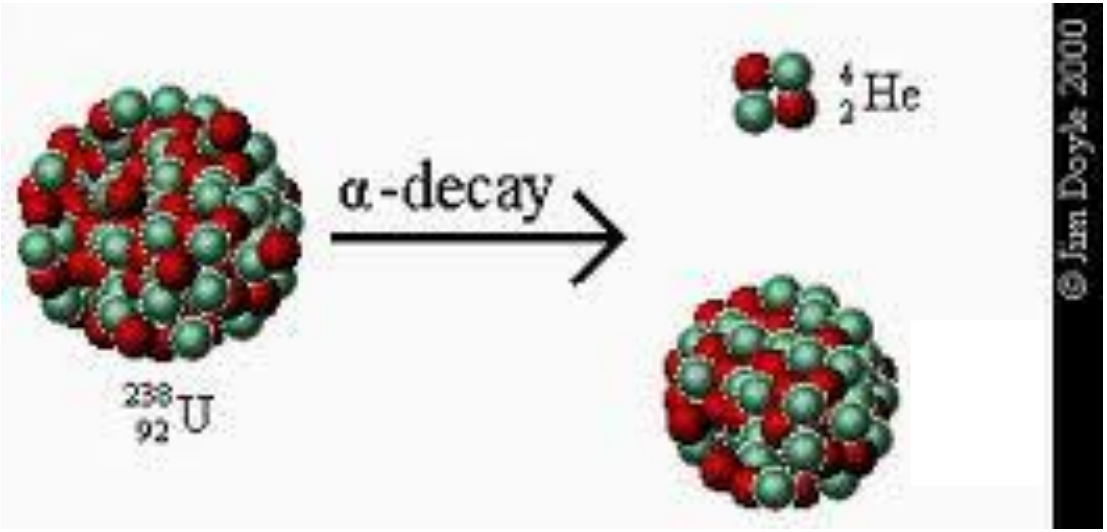
Types of Radiation

- Alpha radiation – ejects 2 protons and two neutrons (no electrons!)

$^{4}_{2}He^{2+}$ or α



Alpha decay



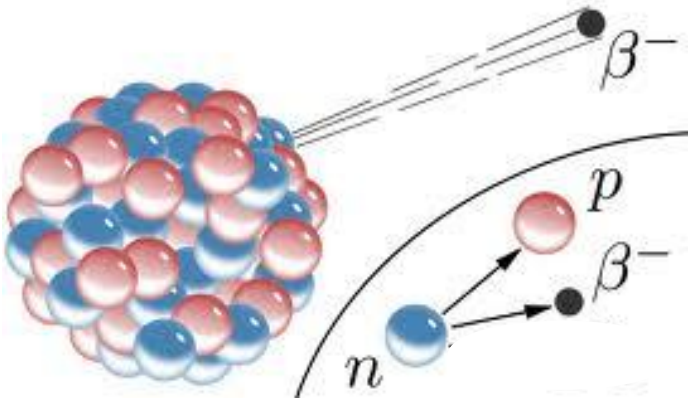
$$^{238}_{92}U \longrightarrow {}^{4}_{2}He + {}^{234}_{90}Th$$

$$^{226}_{88}Ra \longrightarrow {}^{4}_{2}He + {}^{222}_{86}Rn$$

$$^{247}_{96}Cm \longrightarrow {}^{4}_{2}He + {}^{243}_{94}Pu$$

Types of Radiation

- Beta radiation – negatively charged beta particles
- Unstable neutron essentially turns into a proton and ejects 1 electron



e^- or β

β Decay practice

$$^{14}_{6}C \rightarrow {}^{0}_{-1}\beta \; +$$

$$^{60}_{27}Co \rightarrow {}^{0}_{-1}\beta \; +$$

Types of Radiation

- Gamma radiation – emits gamma rays, high energy photon that has no mass nor charge.

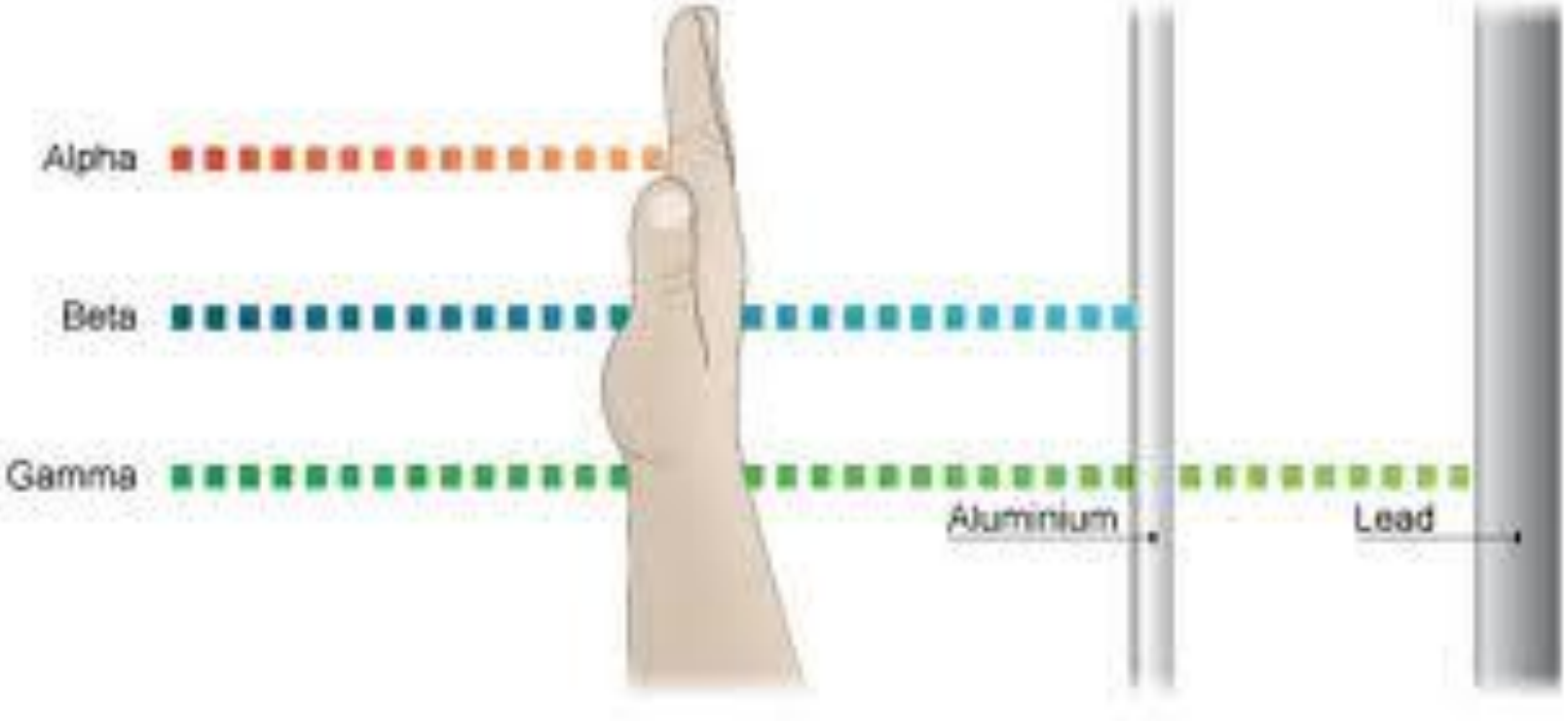
- Gamma rays almost always accompany alpha and beta radiation and account for the energy lost in the nucleus. NEVER HAVE TO BALANCE!

γ

Usually omitted from nuclear equations.

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

Penetrating Power of Radiation



Positron Emission

- Positron has same mass as an electron but an opposite charge.
- Carbon -11 decays by positron emission:

$$^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{+1}e$$

- Emission of a positron converts a proton to a neutron, and decreases the atomic # by 1

Electron Capture

- Nucleus captures an electron from the surrounding cloud.

$$^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{+1}e$$

Atomic number decreases by 1

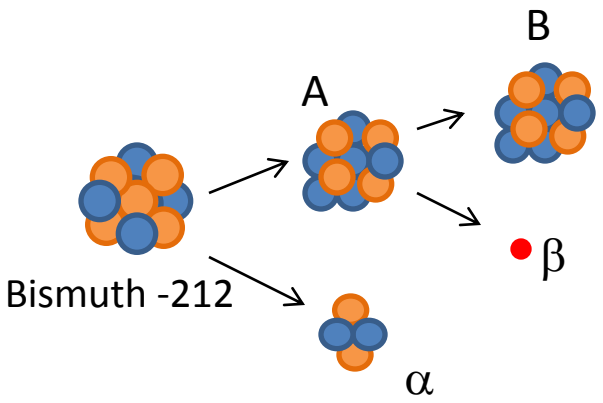
Decay Practice

α decay $\quad {}^{238}_{94}Pu \longrightarrow {}^{4}_{2}He + {}^{234}_{92}U$

Thorium-229 is used to increase the lifetime of fluorescent bulbs.
What type of decay occurs when thorium-229 decays to form radium-225?
Write out the nuclear equation.

${}^{229}_{90}Th \longrightarrow {}^{4}_{2}He + {}^{225}_{88}Ra$

Write a balanced nuclear equation for the decay shown on the right.
Identify **A** and **B**



${}^{212}_{83}Bi \longrightarrow {}^{4}_{2}He + {}^{208}_{81}Tl$ **A**

${}^{208}_{81}Tl \longrightarrow \beta + {}^{208}_{82}Pb$ **B**