Chapter 4 Annotated

Warm Up

Shorthand notation	Atomic mass	Atomic #	Protons	Neutrons	Electrons	Atom /cat/a n
	11	5			5	
		11		12	10	
Pd^{2+}	106					
$^{32}P^{3-}$						
		55		79	55	

Today's Agenda

- QOTD: Why are the masses on the periodic table not whole #'s and how do we know about isotopes?

- Average Atomic Mass calcs
- Determining relative abundance
- Mass Spectrometry

- HW:

Atomic Mass = Average of Isotopes

- Weighted average mass – mass of each isotope contributes to total mass according to *how much* of that isotope exists.

K

Potassium

Three isotopes = $^{39}_{19}K$ $^{40}_{19}K$ $^{41}_{19}K$

Percent Composition: 93.26% 0.01% 6.73%

Calculate the Atomic Mass of K

1. Use % composition and convert to relative abundance (divide by 100)

93.26% composition = .9326 relative abundance

2. Amu = ((Mass of $Isotope_1$)x(Relative $Abundance_1$)) + ((Mass of $Isotope_2$)x(Relative $Abundance_2$))…

((0.9326)x(39)) + ((0.0001)x(40)) + ((0.0673)x(41)) =

39.1347 amu

Amu = (R.A.)x(Mass) + ((R.A.)x(Mass))…

- What element is this?

Isotope	Mass of Isotope	Percent abundance
^{6}X	6.015 amu	7.59%
^{7}X	7.016 amu	92.41%

Find the atomic mass

What element is this? (Use the Periodic Table)

- Boron has two isotopes: Boron-10 (% abundance – 19.8%, mass = 10.013 amu) and Boron-11 (% abundance – 80.2%, mass – 11.009 amu). Calculate the atomic mass of Boron.

- Bromine has two isotopes with the first having a mass of 78.918336 amu and occupying 50.69% and the second isotope having a mass of 80.916289 amu and occupying 49.31%. What is the average atomic mass of bromine?

- Verify the atomic mass of Magnesium:

^{24}Mg = 23.985042 amu and percent abundance of 78.99% , ^{25}Mg = 24.985837 amu and percent abundance of 10.00%, ^{26}Mg = 25.982593 amu and percent abundance of 11.01%.

One more…

- Copper has two naturally occurring isotopes, Cu-63 and Cu-65. The atomic mass of Cu is 63.55 amu. Calculate the percent abundances of the two isotopes.

You try

- Braintrium has two isotopes Bt-143 and Bt-145. The average isotopic mass is 144.231 amu. What is the percent abundance of each?

How do we know about isotopes?

- Mass Spectrometry:

Separates atoms based on mass!

Since masses of isotopes are different, when a sample of a pure compound is analyzed, we detect multiple masses and can determine the mass and the percent abundance!

What can we DO with isotopes?

- Radioactive Dating
- All sorts of COOL spectrometry for chemists to study molecules that are important for us
- Medicine: MRI’s, medical imaging, biochemical studies on DNA,
- Also, agricultural studies, studies on alternative fuel sources.

Warm Up!

- Boron has two isotopes:

Boron-10 (% abundance – 19.8%) and Boron-11 (% abundance – 80.2%). Calculate the atomic mass of Boron.

- Identify the element!

Isotope	Mass of Isotope	% abundance
X	6.015 amu	7.59%
X	7.016 amu	92.41%

Find the atomic mass What element is this?

Today's Agenda

- Review for Quiz TOMORROW

- In class Review
- Review sheet
- Finish up Beanium lab from Tues.

- HW finish review sheet for Friday! Lab books due today!

Warm Up

1. Create your own table: Fill in only a few values and then switch with a neighbor to complete each other's tables!

Shorthand notation	Atomic mass	Atomic #	Protons	Neutrons	Electrons	Atom/ cat/an

2. Why do the # of neutrons increase as the mass gets larger?

Grab your notebook! (up front) Lab Today!!

- <u>Statement of Problem:</u> Given a model of an element, “Beanium”, with several isotopes, determine the average atomic mass using beans, cups, and the analytical balance.

<u>Background info:</u> Summarize paragraphs (include equation) in handout.

How do you find a percent??

Today’s Agenda

- QOTD: What is a nuclear reaction?

- Radioactive Decay
- Balancing nuclear equations

- HW due tomorrow, quiz Friday!

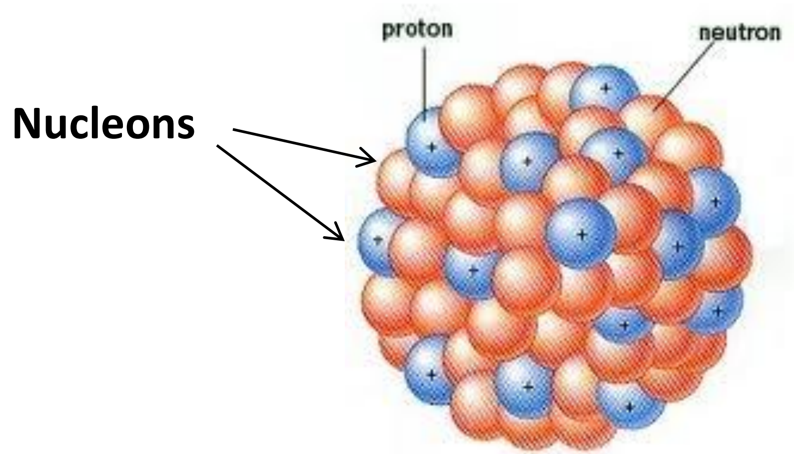
Radioactivity – emit radiation

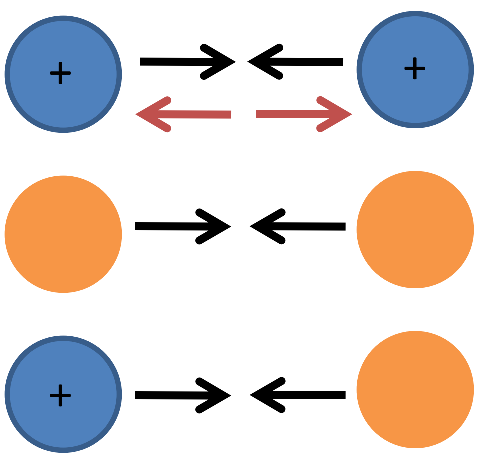
- Nuclear reactions – change an element into a new element!! Lots of energy involved!
  - Unlike a chemical reaction because we are doing more than rearranging – we **CHANGE the identity**.

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

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!!!

Radioisotopes

- Isotopes of atoms with unstable nuclei.

- Undergo radioactive decay to attain stability.

Emit 3 types of radiation

  - alpha, α
  - beta, β
  - gamma, γ

Warm Up

- What are the two opposing forces in the nucleus?
- Why do you need to add more neutrons to the nucleus as the mass gets larger and larger?
- When the nucleus becomes unstable, how does the atom solve the problem?

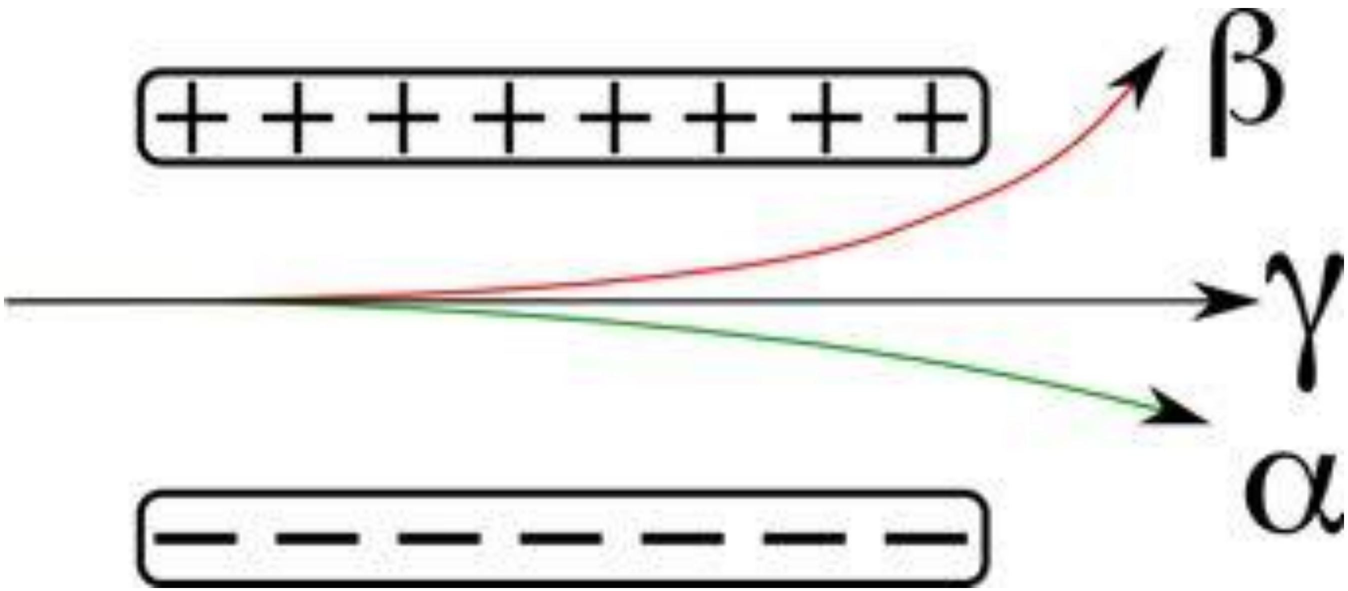
Today's Agenda

- Question of the Day: How do you balance a nuclear equation and how fast do atoms decay?

- Balancing nuclear equations (α and β decay)
- Calculating half life

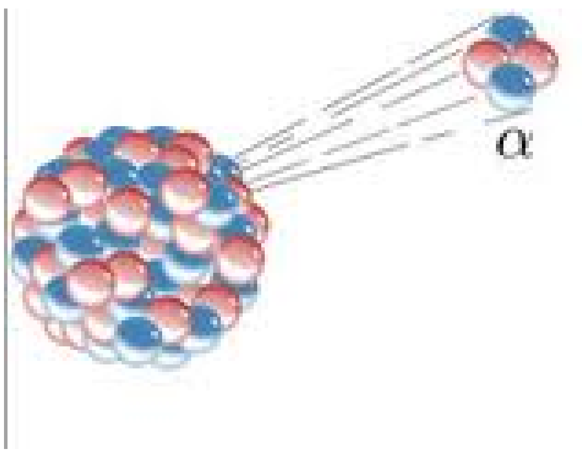
- HW: due Wednesday pg 894 # 34-54 evens

What are the charges on radioactive particles?



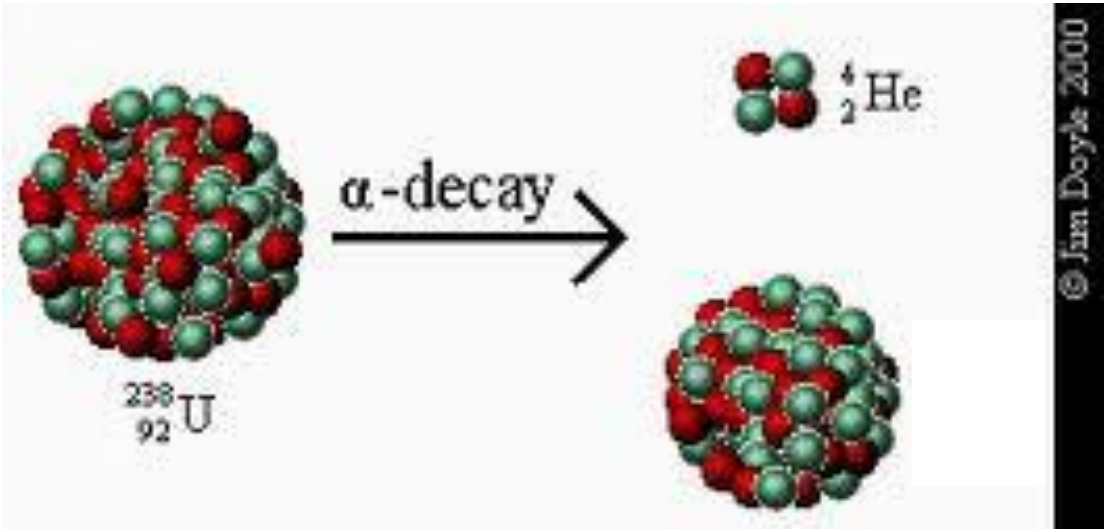
Types of Radiation

- Alpha radiation – (remember the gold foil experiment?!?!) made up of POSITIVE "alpha particles".
- 2 protons and two neutrons (no electrons!)



$^{4}_{2}He^{2+}$ or α

Alpha decay



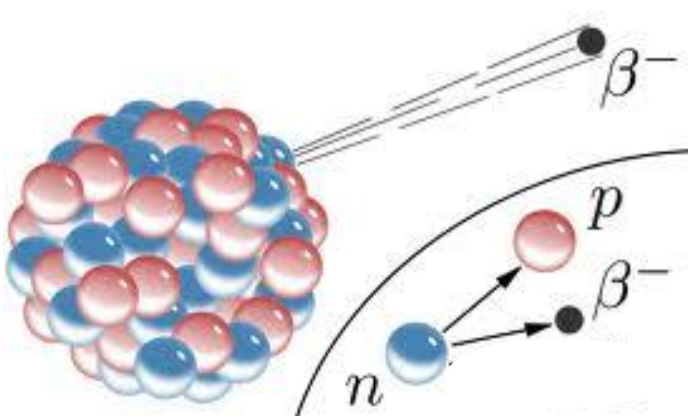
$$^{238}_{92}U \longrightarrow \, ^{4}_{2}He + \, ^{234}_{90}Th$$

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

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

Types of Radiation

- Beta radiation – negatively charged beta particles
- Unstable neutron 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.

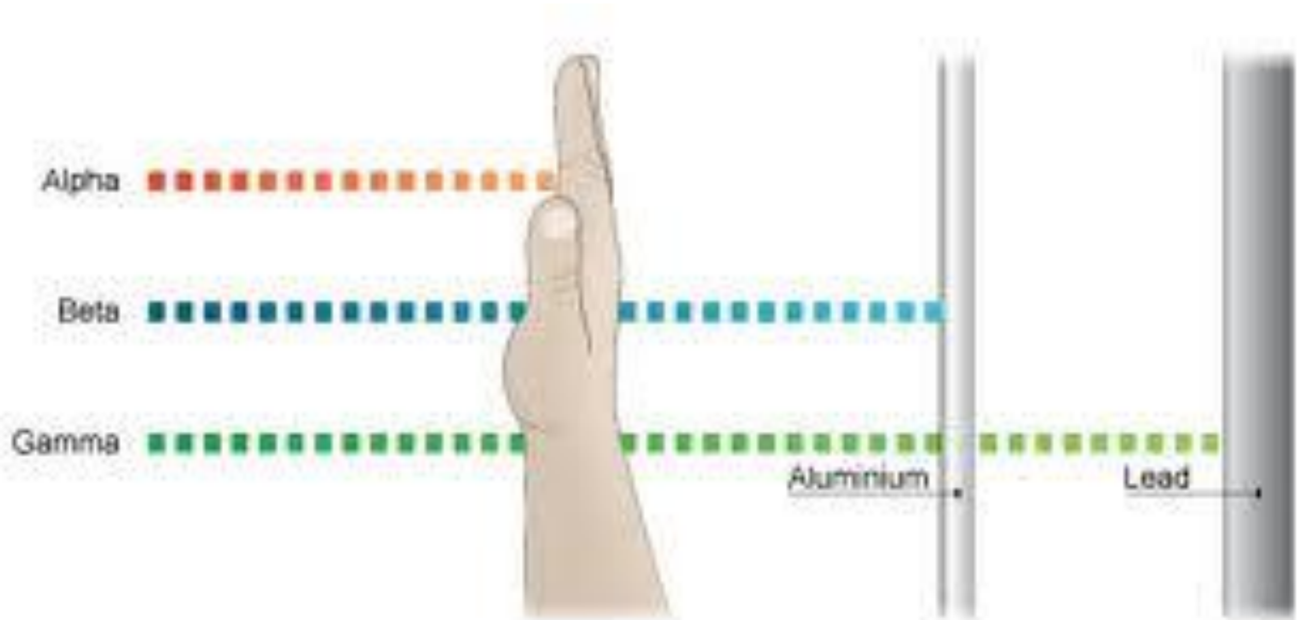
- Gamma rays almost always accompany alpha and beta radiation and account for the energy lost in the nucleus.

$$\gamma$$

Usually omitted from nuclear equations.

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

Penetrating Power of Radiation



Penetrating Power

Least

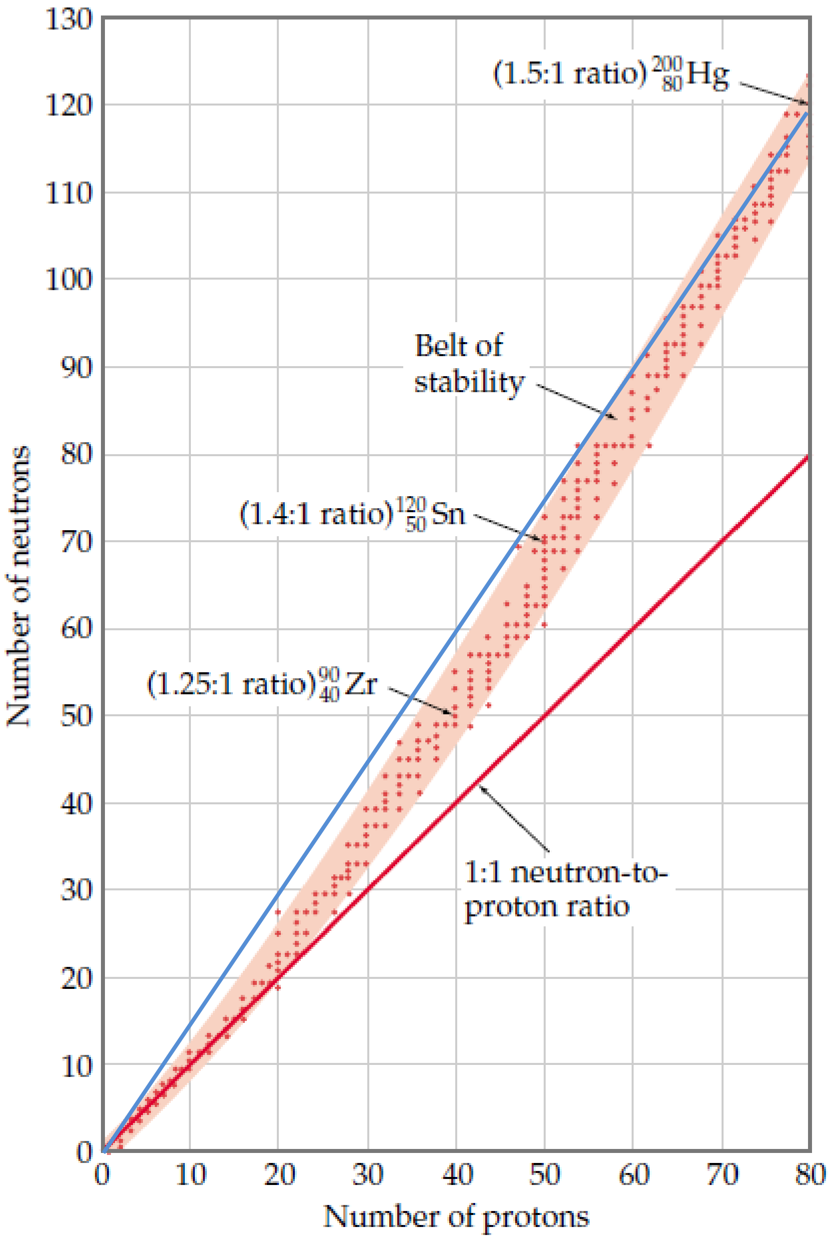
Alpha particles most mass and charge.

Isotopic mass → $^{4}_{2}He^{2+}$ ←

Beta particles less mass (only the mass of an electron) and a neg charge.

Gamma rays have no mass and no charge.

Most



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!

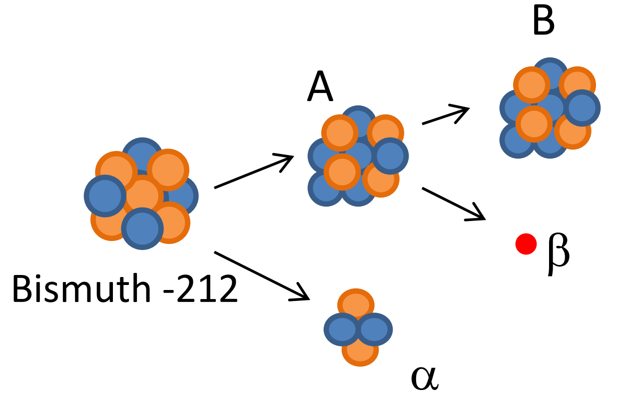
Decay Practice

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**

Warm – Up!!

- What is the band of stability and how does it relate to the proton to neutron ratio?
- How does the neutron to proton ratio change when polonium-210 decays into lead-206? What type of decay does polonium-210 undergo?

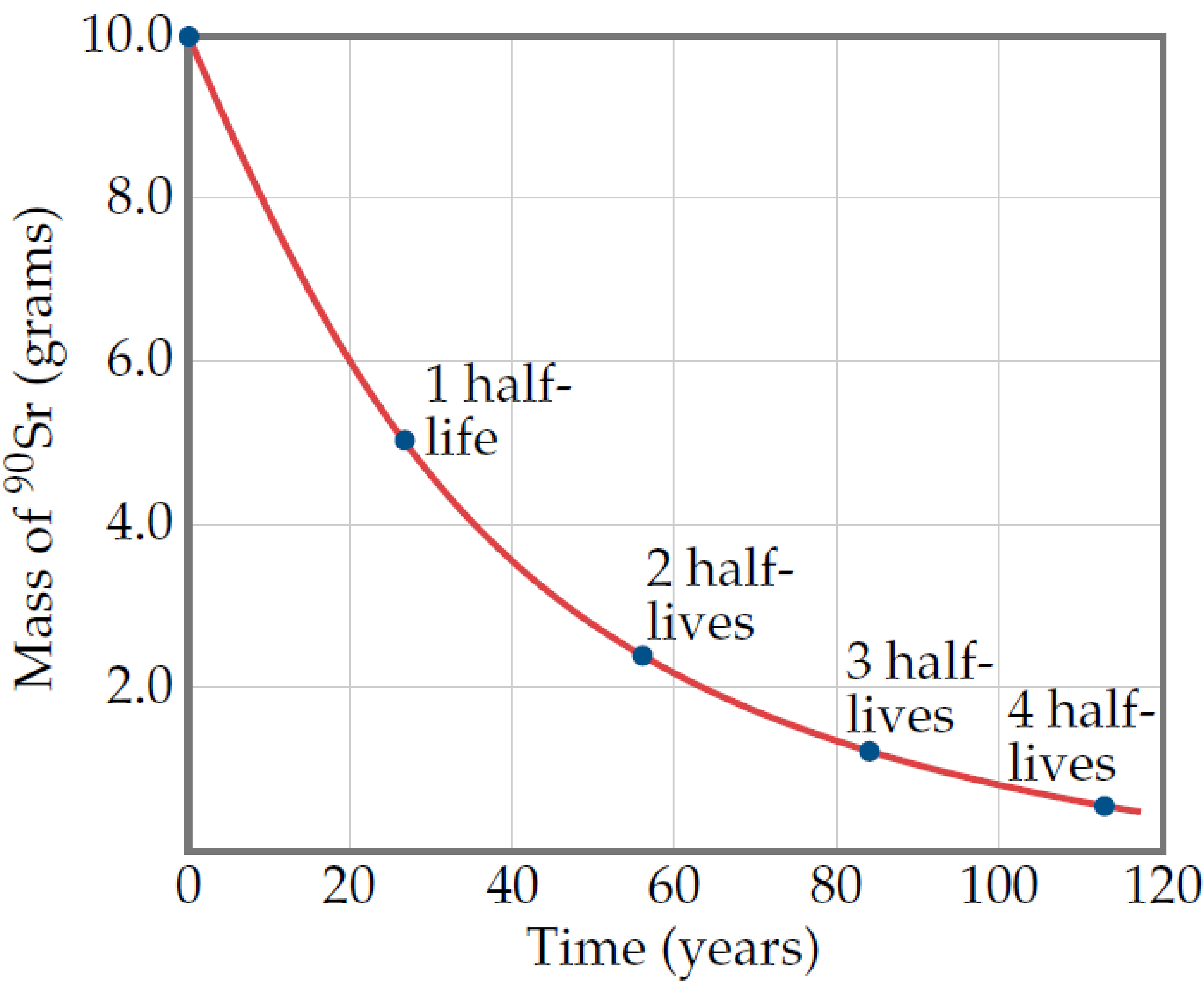
(Low atomic # elements are happy with a 1:1 ratio of neutrons to protons. Heavier elements need a 1.5:1 ratio and all elements above 82 are radioactive.)

Half Life

- Time required for one half of the nuclei to decay into its products.

- Strontium-90 half life is 29 years.

If you had 10 g now, in 29 years you would have 5g.


10.0
8.0
6.0
4.0
2.0
Mass of ^{90}Sr (grams)
1 half-life
2 half-lives
3 half-lives
4 half-lives
0
20
40
60
80
100
120
Time (years)

Half Life Calculations

$$N = N_0 \left(\tfrac{1}{2}\right)^n$$

N – remaining amount of element

N_0 – initial amount of element

n – number of half lives that have passed

Kr-85 has a half life of 11 years. Kr is used in indicator lights of appliances. If a refrigerator light contains 2.0 mg of Kr-85, after 33 years, how much is left?

N = ?

N_0 = 2 mg

n = 33 years/11 years (years that have passed/half life)

Kr-85 has a half life of 11 years. Kr is used in indicator lights of appliances. If a refrigerator light contains 2.0 mg of Kr-85, after 33 years, how much is left?

$$N = 2.0\ \text{mg}\ (1/2)^{(33/11)}$$

$$N = 2.0\ \text{mg}\ (1/2)^{3}$$

$$N = 2.0\ \text{mg}\ (1/8)$$

$$N = 0.25\ \text{mg left after 33 years}$$

Warm Up!

- Write the following nuclear reactions:
  - Alpha emission of Cm-244
  - Beta decay to produce Sb-116

- Cobalt-60 has a half life of approx. 5 years. It is commonly used in cancer treatments. If a hospital purchases 30.0 g, how much would be left after 15 years?

Today's Agenda

- QOTD: Do we understand half life problems?

- Go over worksheet from yesterday
- Half life problems
- Nuclear reactors

- HW due Fri: pg 895 #'s 55-56, 59-65 odds, 80, 82, 86, 88

Half Life Practice

- The half life of Ra-222 is 3.8 days. How much is left of a 10 mg sample after 15.2 days?

$$N = N_0 \, (½)^n$$

$$N = 10mg \, (½)^{(15.2/3.8)}$$

$$N = 10mg \, (½)^4$$

$$N = 10mg \, (1/16)$$

$$N = 0.625mg$$

Half Life Practice

Bandages can be sterilized by exposure to gamma radiation from cobalt-60, which has a half life of 5.27 years. How much of a 10 mg sample of cobalt-60 is left over after 10.54 years? After four half lives?

$$N = N_0\,(½)^n$$

$$N = 10\text{ mg}\,(½)^{10.54/5.27}$$

$$N = 10\text{ mg}\,(½)^4$$

Half – Life Calculations

- Do the problem intuitively…

Think about how many half lives have passed and just do the division

Two half lives (10 mg/2)/2 = 2.5 mg

Four half lives 10 mg/2/2/2/2 = 0.625 mg