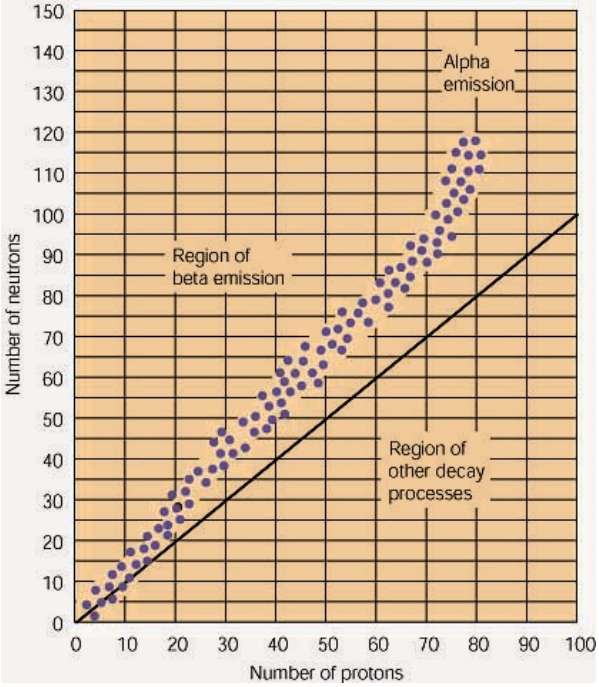
Nuclear Chemistry
CHM 1020 Part 3

What makes a nucleus Stable?

- Must have a "good ratio" of protons and neutrons.
- This ratio is defined in a "band of stability".
- There are other aspects that seem arbitrary.

http://www.cartage.org.lb/en/themes/Sciences/Chemistry/NuclearChemistry/NuclearReactions/NuclearStability/NuclearStability.htm

A plot of the stable nuclei reveals a band of stability.
Nuclei outside the band are unstable.



Types of decay

A stable nucleus must have the right combination of protons and neutrons.

- Too big: Alpha decay
- Too many protons: positron emission
- Too many neutrons: Beta decay
- Nucleus has excess energy: Gamma decay

Beta Decay ($^{0}_{-1}e$)

•Occurs if there are too many neutrons.
•A neutron to proton conversion occurs. This releases an electron or beta particle.
•Carbon-14 undergoes beta decay to the stable nitrogen-14 isotope.

$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

Balancing Nuclear Equations

- Sum of top numbers on the left must equal sum of top numbers on right.
- Same thing for bottom numbers.

$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

Top: 14=14+0
Bottom: 6= 7-1

Positron Emission ($^{0}_{+1}e$)

- Isotopes on the lower side of the band of stability might want to turn a proton into a neutron through positron emission.
- A positron is essentially a positive electron.

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

Top: 11=11+0
Bottom: 6= 5+1

Alpha Decay ($^{4}_{2}He$)

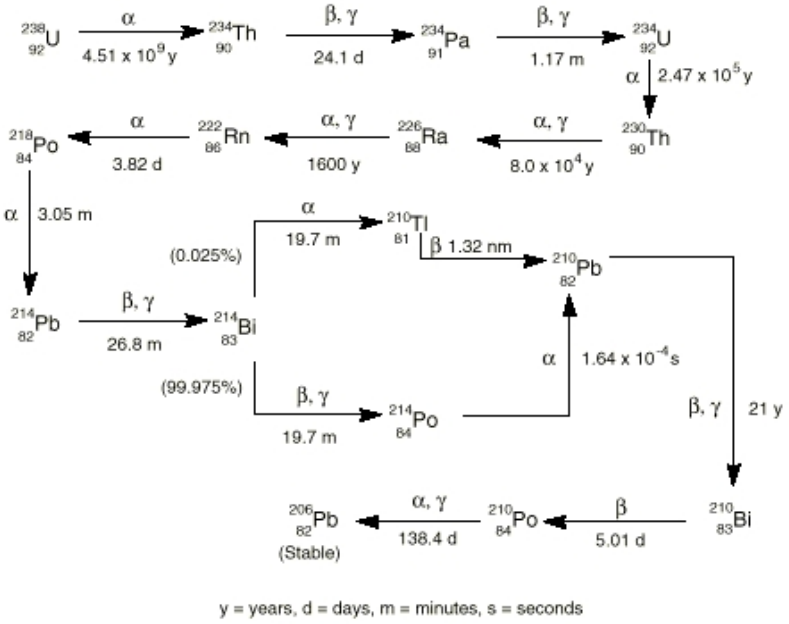
•Large isotopes that need to decrease their size tend to decay by alpha emission.
•An alpha particle can be described as a helium nucleus, , 2 protons and 2 neutrons.

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

Uranium Decay

•A nuclear decay may not always produce a stable isotope directly.

•Uranium-238 undergoes 14 decays.



Gamma Decay (γ)

- The gamma ray is not a particle it is part of the electromagnetic spectrum.
- Gamma radiation occurs when a nucleus has excess energy.
- Some nuclei can exist for a little while with excess energy. These are called meta-stable isotopes. Technetium 99 has a meta-stable isotope.
- A gamma ray can be represented by γ.

Technetium-99 has a meta-stable isotope.

$$^{99m}_{43}\mathrm{Tc} \rightarrow {}^{99}_{43}\mathrm{Tc} + \gamma$$

Top: 99=99
Bottom: 43= 43

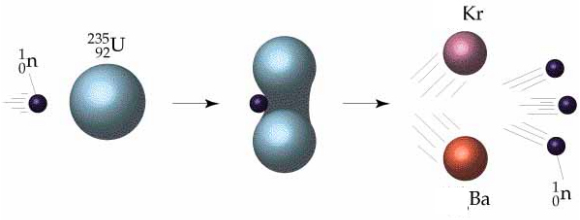
Technetium-99 is used in medical applications.
Another link

Fission and Fusion

•Nuclear Fission involves the breaking up of large nuclei to smaller nuclei. link
•Nuclear Fusion is the energy-producing process, which takes place continuously in the sun and stars. In the core of the sun at temperatures of 10-15 million degrees Celsius, Hydrogen is converted to Helium providing enough energy to sustain life on earth. link

Nuclear fission of U-235

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{139}_{56}Ba + {}^{94}_{36}Kr + 3\,{}^{1}_{0}n $$



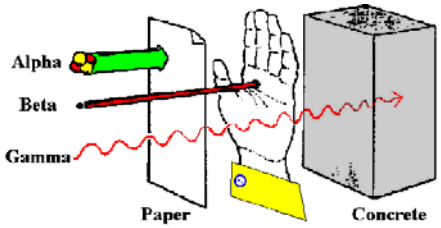
Types of Radiation

	Stopped by	Damage to Cells
Alpha	almost anything. example: paper	Most Damage
Beta	wood, heavy clothing, plastic	
Gamma	lead, concrete	Least Damage

Protect yourself by…

- Minimizing time of exposure
- Distance
- Shielding

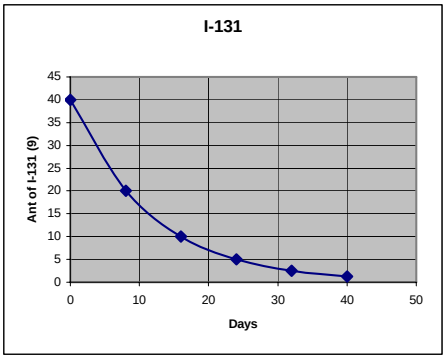
•Radial damage of radioactive substance in lung.



Half Life

•The half-life of a radioisotope is the time it takes for one half of a sample to decay.
•Iodine-131 has a half-life of 8 days.

days	amount of I-131
0	40
8	20
16	10
24	5
32	2.5
40	1.25



•The decay of an isotope is not linear.

Carbon Dating

An archeologist extracts a sample of carbon from an ancient ax handle and finds that it emits an average of 10 beta emissions per minute. She finds that the same mass of carbon from a living tree emits 40 beta particles per minute. Knowing that the half life of carbon-14 is 5730 years, she concludes that the age of the ax handle is?

Measuring radiation

•**Curie** :the amount of any radionuclide that undergoes 37 billion atomic transformations a second.
•A nanocurie is one one-billionth of a curie.
•A Becquerel is one disintegration per second.
•37 Becquerel**,** = 1 nanocurie
•The **curie** is proportional to the number of disintegrations per second

RAD

•**Rad** (radiation absorbed dose) measures the amount of energy actually absorbed by a material, such as human tissue
•Takes into account the absorbing material. (Bone may absorb better then skin or muscle).

REM

•**Rem** (roentgen equivalent man) measures the biological damage of radiation.
•REM=RAD*RBE
  –RBE (relative biological effect) takes into account that alpha particles are 10 X more damaging than beta particles.
•LD_{50} = 500 rems