N6 – Intro to the Nucleus

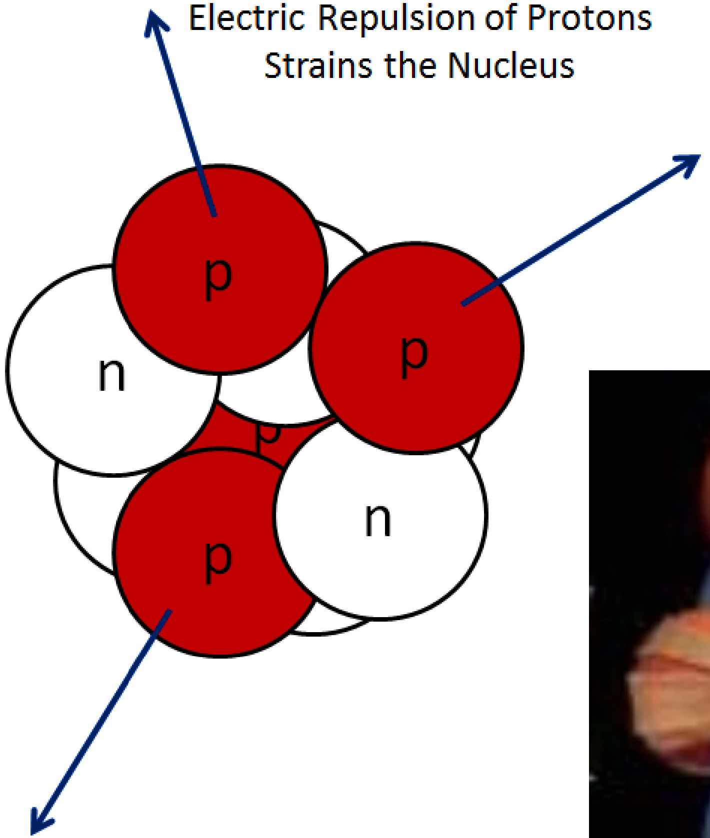
Target: I can describe how the nucleus can change to become more stable if needed.

Not all atoms are stable!

- Sometimes the nucleus of an atom is unstable and cannot stay together.
- This is called being **radioactive.**

What keeps nuclei together normally?

- **STRONG FORCE** – Holds the nucleus together, even though the protons want to repel each other.

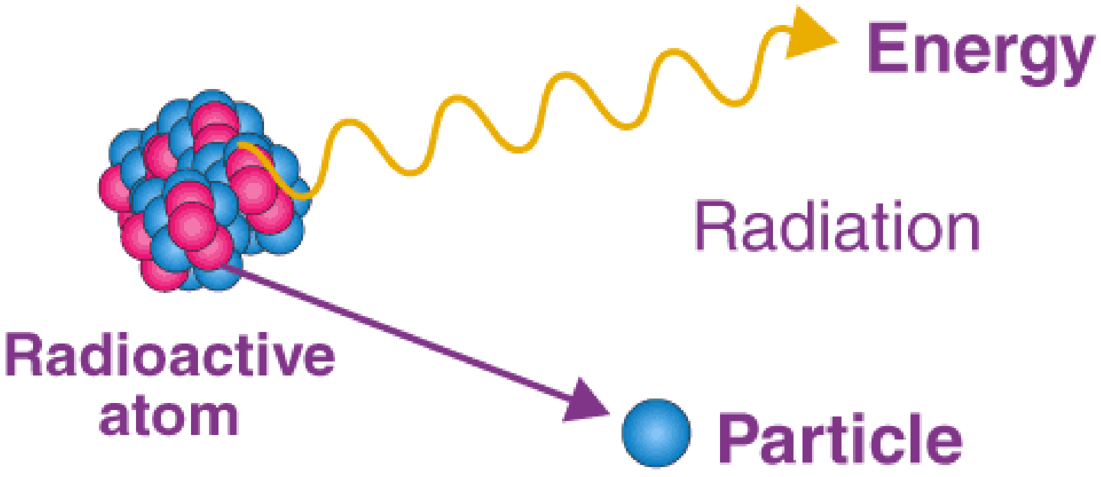


Why do nuclei come apart sometimes?

- **Too many neutrons!**
- Strong force won't be strong enough.
- Like a rubber band that is stretched too far…it will break!

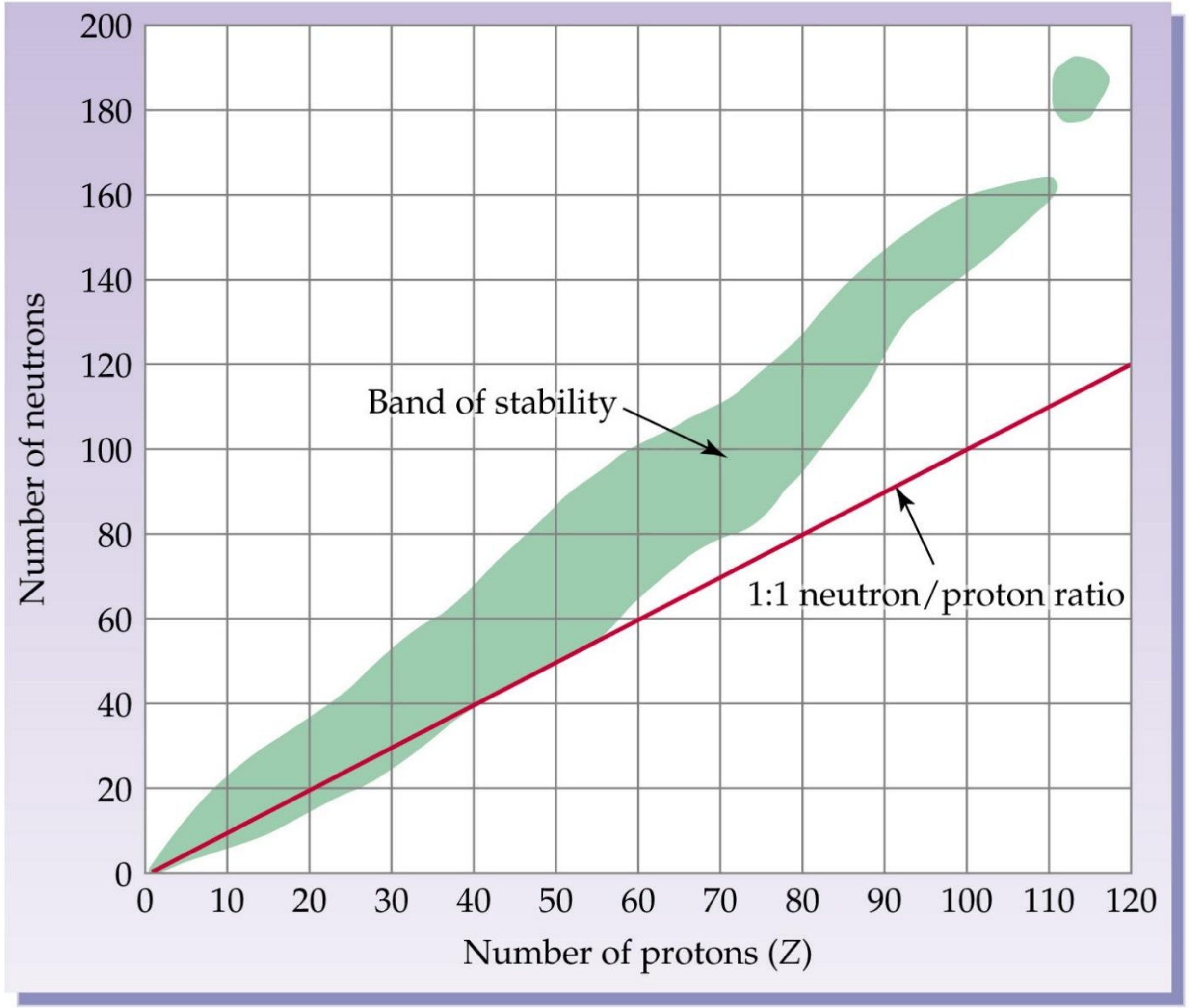
What happens when it comes apart?

- **Radiation!**
- Particles and energy come flying out of the nucleus at high speeds/energies
- Radioactivity is these particles being released



Band of Stability and Island of Stability

- Neutron : Proton ratio larger than 1:1 makes it more likely to be unstable, radioactive



Nuclear Atomic Symbols

- We will be writing our symbols like this:

mass # → 14

$^{14}_{6}C$

atomic # → 6

Remember…to find # of neutrons, subtract mass # - atomic #

Chemical vs. Nuclear Reactions

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken	Occur when nuclei emit particles and/or rays

Chemical vs. Nuclear Reactions

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken	Occur when nuclei emit particles and/or rays
Atoms remain unchanged, although they may be rearranged	Atoms often converted into atoms of another element

Chemical vs. Nuclear Reactions

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken	Occur when nuclei emit particles and/or rays
Atoms remain unchanged, although they may be rearranged	Atoms often converted into atoms of another element
Involve only valence electrons	May involve protons, neutrons, and electrons

Chemical vs. Nuclear Reactions

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken	Occur when nuclei emit particles and/or rays
Atoms remain unchanged, although they may be rearranged	Atoms often converted into atoms of another element
Involve only valence electrons	May involve protons, neutrons, and electrons
Associated with small energy changes	Associated with large energy changes

Chemical vs. Nuclear Reactions

Chemical Reactions	Nuclear Reactions
Occur when bonds are broken	Occur when nuclei emit particles and/or rays
Atoms remain unchanged, although they may be rearranged	Atoms often converted into atoms of another element
Involve only valence electrons	May involve protons, neutrons, and electrons
Associated with small energy changes	Associated with large energy changes
Reaction rate influenced by temperature, particle size, concentration, etc.	Reaction rate is not influenced by temperature, particle size, concentration, etc.

Nuclear Reactions

Isotopes of one element are changed into isotopes of another element

- Contents of the **nucleus** change
- **Large** amounts of energy released

Uses of Nuclear Reactions

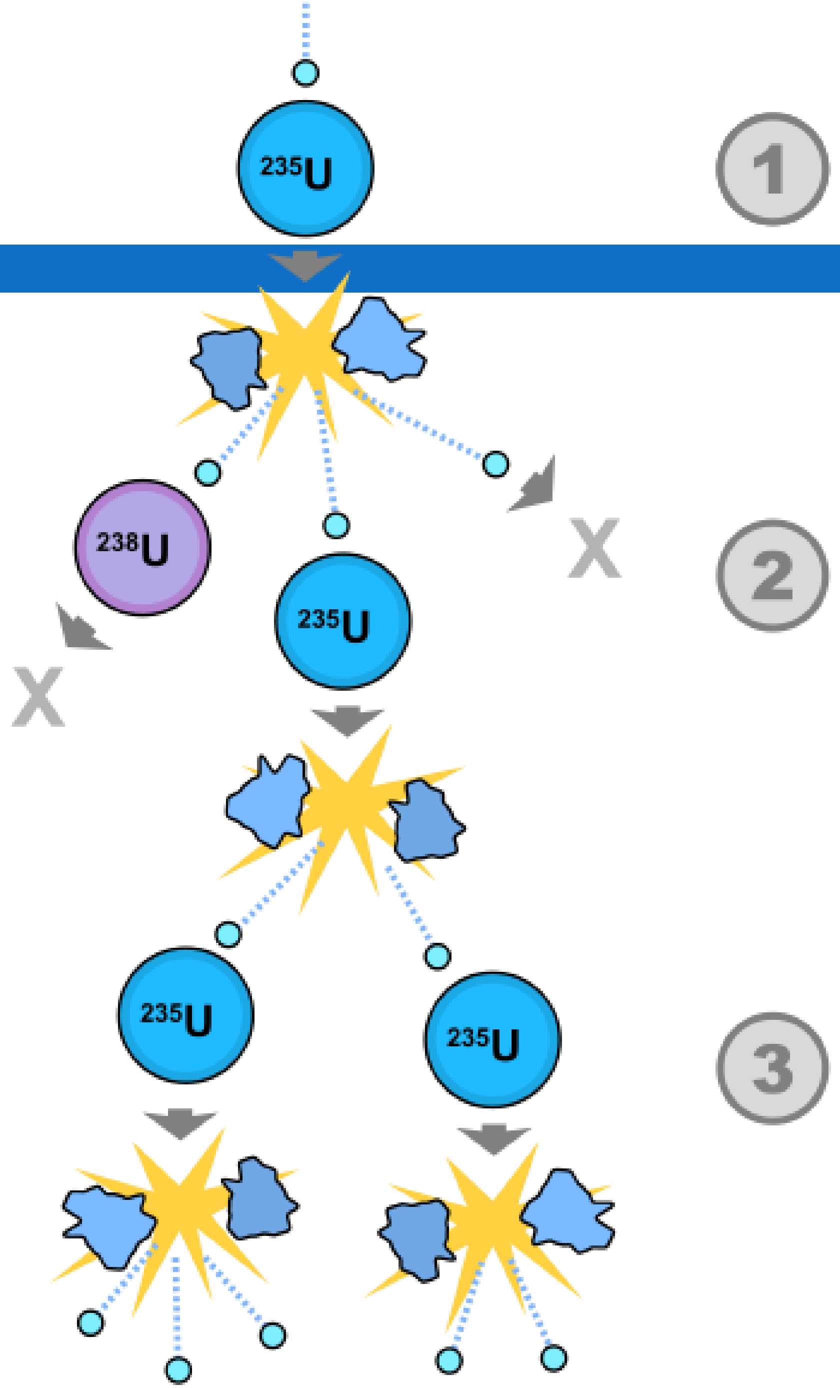
Uncontrolled reactions are dangerous, but when used properly they can be useful!

- Power plants
- Tracking chemical reactions and biological processes
- Radiation therapy for cancer
- Determining the age of dead plants/animals, or even rocks.

Nuclear Fission

- **Splitting of a nucleus**
- **Chain Rxn** – one released particle sets off another atom, keeps happening
- **Nuclear Reactor** – controlled situation, energy released slowly

Nuclear Fission



Nuclear Fission (don't need to write this)

- *1st controlled* nuclear reaction in December 1942.
- *1st uncontrolled* nuclear explosion occurred July 1945.
- **Examples** – atomic bomb, current nuclear power plants

Nuclear Fusion

- **Combining nuclei**
- **Doesn't normally happen** (+ and + repel)
- **Pros** – Inexpensive, no radioactive waste
- **Cons** – Hard to control, large startup energy
- **Examples** – stars, hydrogen bomb, future nuclear power plants

Nuclear Stability

Very Stable	Marginally Stable	Unstable/Radioactive

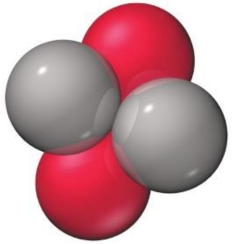
Nuclear Stability

Very Stable	Marginally Stable	Unstable/Radioactive
Atomic #s 1-20	**Atomic #s 21-82**	**Atomic #s > 82**
1:1 ratio Protons : Neutrons	**1:1.5 ratio** Protons : Neutrons	**> 1:1.5 ratio** Protons : Neutrons
Example: Carbon-12 6p : 6n	**Example:** Mercury-200 80p : 120n	**Example:** Uranium Plutonium

Type of Decay: Alpha Decay

- Nucleus emits a particle made of two protons and two neutrons – like a helium nucleus (not a helium atom, because it doesn't have any e^-)

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



Alpha radiation

Composition	Symbol	Charge	Mass
helium nuclei	$^{4}_{2}He$, α	+2	4amu
Shielding	**Approx. Energy**	**Penetrating power**	
Paper, clothing	5 MeV	Low 0.05mm body tissue	

Type of Decay - Beta Decay

- Neutron is split into a proton an a "beta particle" which is like an electron

$$^{228}_{88}\text{Ra} \longrightarrow {}^{228}_{89}\text{Ac} + {}^{0}_{-1}\text{e}$$

Beta radiation

Composition	Symbol	Charge	Mass
Same as an electron	e^-, β	-1	$1/1837^{th}$ (basically 0)
Shielding	**Approx. Energy**	**Penetrating power**	
Aluminum foil	0.05-1MeV	Moderate 4mm body tissue	

Type of Decay - Positron

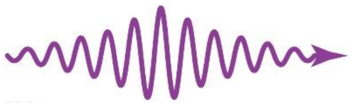
- Proton splits into a neutron and a positron.
- Like a beta particle, but has a charge of +1

$$ {}^{30}_{15}\mathrm{P} \longrightarrow {}^{30}_{14}\mathrm{Si} + {}^{0}_{+1}\mathrm{e} $$

Type of Decay - Gamma Emission

- High energy photons.
- No loss of particles from the nucleus
- Usually after the nucleus undergoes some other type of decay and the remaining particles rearrange

$$ {}^{238}_{92}U^{*} \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He + {}^{0}_{0}\gamma $$



Gamma radiation

Composition	Symbol	Charge	Mass
High energy electromagnetic radiation	γ	0	0
Shielding	**Approx. Energy**	**Penetrating power**	
Lead, Concrete	1MeV	High Penetrates easily	

YouTube Link to Presentation

- https://youtu.be/LrCO_eciSLQ