Honors Chemistry -Outline Nuclear Chemistry Test

Atoms - The Building Blocks of Matter

- **Half-life- time required for half of the atoms of a radioactive nuclide to decay.**
- **5 kinds of emissions (radioactivity)**
  1. **Alpha particles – α (Helium Nuclei)**

$^{4}_{2}He$

Ex.

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

- Cannot penetrate paper, skin (not large, so doesn't go very far)
- Very dangerous if ingested

2. **Beta Particles- β or** $^{0}_{-1}e$

Ex. Carbon-14 ($t_{1/2}$ about 5270 years=half life)

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

$$^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e$$

*What happens in beta emission

- Can penetrate paper, skin
- Can be stopped by thin piece of foil or wood

3. **Gamma Radiation- γ – High energy photons w/ no mass**

Ex.

$$^{239}_{90}C \rightarrow {}^{226}_{88}Ra + {}^{4}_{2}He + {}^{0}_{0}\gamma$$

- **Very dangerous**
- **Passes through wood, paper, skin, human body**
- **Stopped by lead or several meters of concrete**

4. **Positron – mass of electron, oppositely charge, considered anti-matter**

Ex. Carbon-11

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

$$^{1}_{1}p \rightarrow {}^{1}_{0}n + {}^{0}_{1}e$$

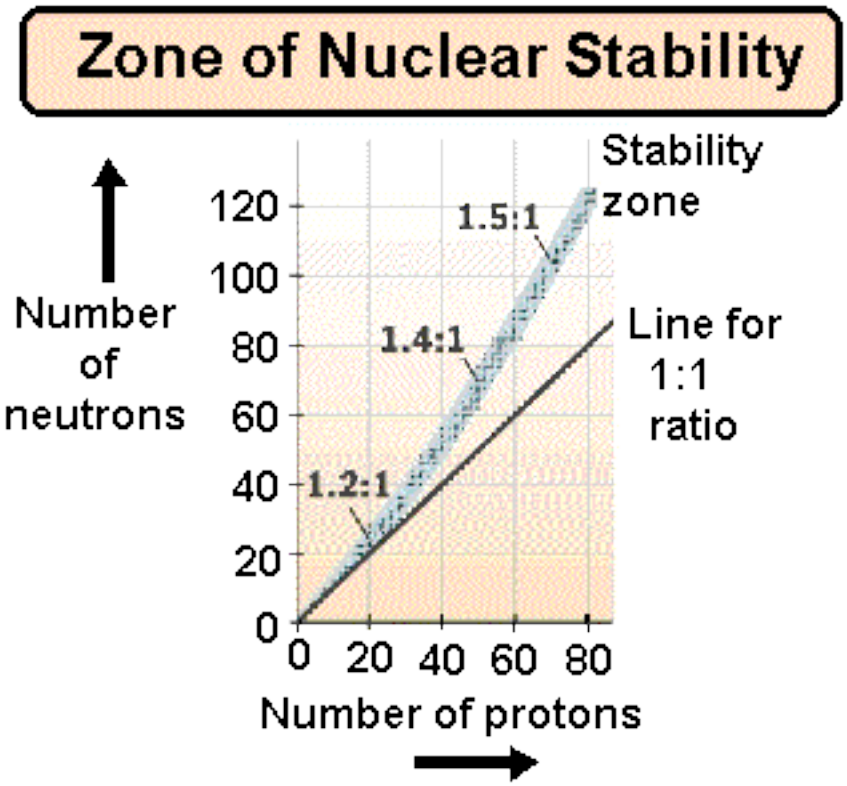
Proton became neutron plus positron

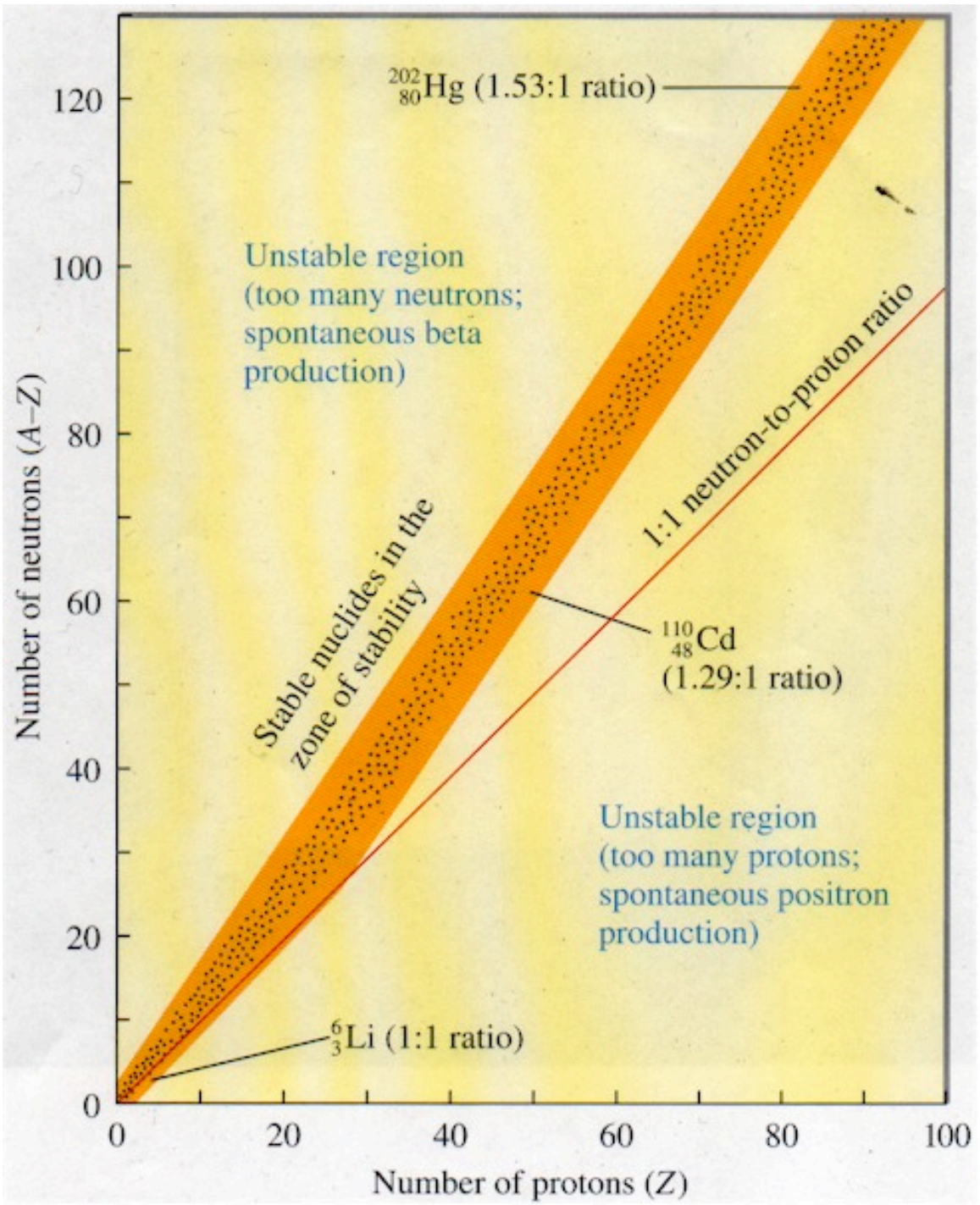
5. **Electron capture**

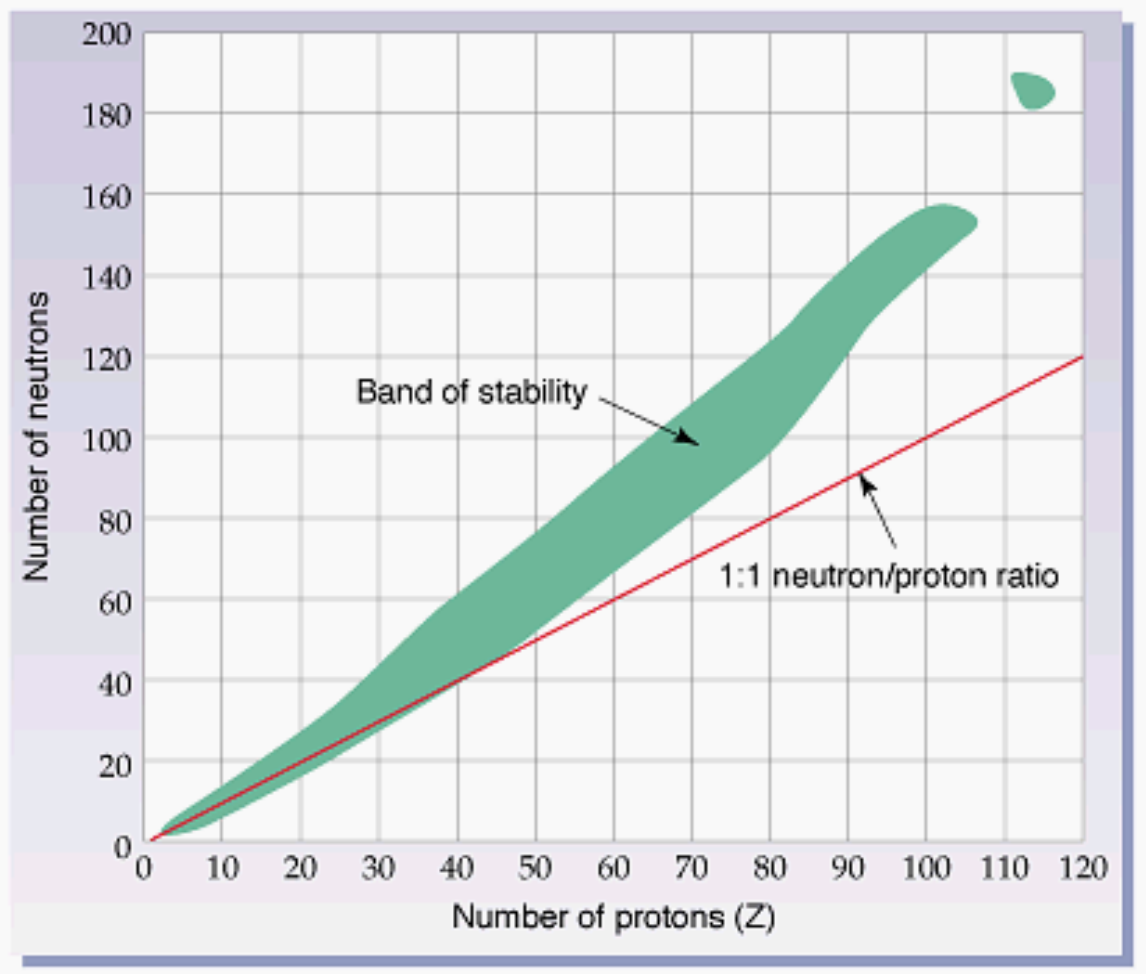
$$^{1}_{1}p \rightarrow {}^{0}_{-1}e + {}^{1}_{0}n$$

6.

- **Zone of Stability**

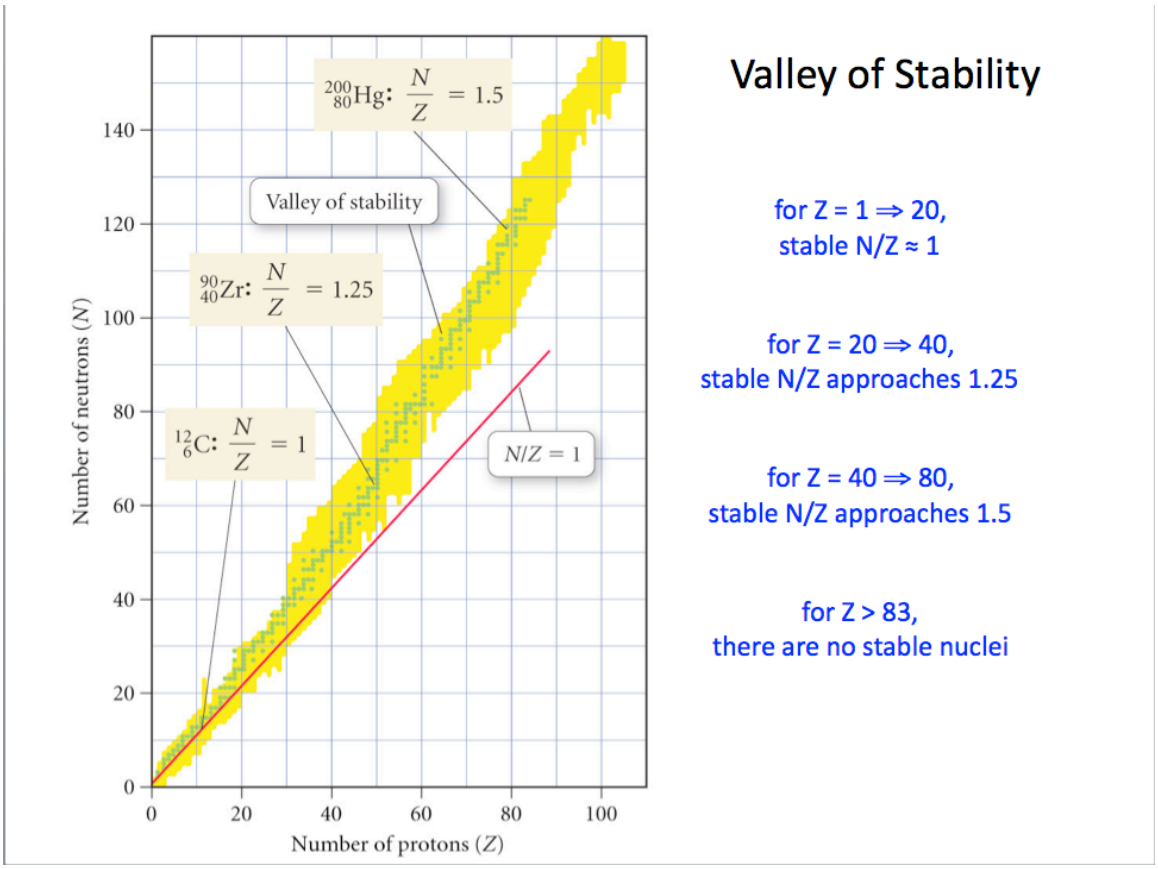

Zone of Nuclear Stability
Number of neutrons
120
100
80
60
40
20
0
0 20 40 60 80
Number of protons
1.5:1
1.4:1
1.2:1
Stability zone
Line for 1:1 ratio
Adapted from an image by S. Goode (2001)


$^{202}_{80}$Hg (1.53:1 ratio)
Unstable region
(too many neutrons;
spontaneous beta
production)
1:1 neutron-to-proton ratio
Stable nuclides in the
zone of stability
$^{110}_{48}$Cd
(1.29:1 ratio)
Unstable region
(too many protons;
spontaneous positron
production)
$^{6}_{3}$Li (1:1 ratio)
Number of neutrons (A–Z)
Number of protons (Z)
0
20
40
60
80
100
120



Stability means measurable half-life

- **Nonradioactive = indefinitely stable**
- **When 3000 known are plotted, fall within "band"**
- **Within "band" all but 264 disintegrate spontaneously**
- **Every element has at least 1 radioactive isotope**
- **H is only element whose most abundant isotope contains more protons than neutrons**
- **Ratio of neutrons to protons gradually increases for elements heavier than Ca (curved band)**
- **All isotopes heavier than Bi-209 are radioactive**
- **Of 264 nonradioactive 207 have even number of neutrons. Most have even protons & neutrons (156), 51 have an even number of neutrons but odd number of protons, and only 4 have odd both protons & neutrons**



- **Nuclear Power (Plant)**
- **Einstein's Equation ($E=mc^2$)**

IV. Basic Nuclear Chemistry

A. Nuclear Stability **[4.2b]** p.582-600
1. Stable zone
2. Half-life **[4.3a;4.3b]**

B. Nuclear Reactions **[4.2b]**
1. Common nuclear particles
2. Natural decay
3. artificial transmutation **[4.4a]**
   - Particle accelerator – accelerates charged particle "bullets" to hit target nuclei. The target nuclei are changed to nuclei of a different element.

3. Fission & fusion [4.4b]
   - Einstein discovered relationship between mass and energy, that mass is nothing more than super concentrated energy: $E=mc^3$
   - Nuclear changes disobey law of conservation of mass and energy. Instead of mass and energy being conserved, a tiny bit of mass is converted into a large amount of energy.
   - (Fe-56 is excellent absorber of neutrons)

- **<u>Nuclear Fission</u>**
  - **Splitting of a heavy nucleus into two or more lighter nuclei**
  - **Nuclear power plants provide some of our power to our house as well as for air power and submarines.**
  - **Nuclear power safe as long as handled carefully**
- **<u>Nuclear Fusion</u>**
  - Fuse nuclei together
  - Have to overcome repelling force of two positive nuclei.
  - **Process that takes space to power sun for last 4.5 billion years, as well as stars in universe for 15 million years**

4. Writing/balancing nuclear equations **[4.2c]**

C. Uses of Radioactive Materials **[4.3c]**

- When used for medical uses/ingested has a short half life so it gets out of the body quickly
- I-131: Absorbed by thyroid gland to kill tumor
- Co-60: Can kill cancer cells
- Tc-99: Can give 3-D images of brain, vascular/blood system to see if brain tumors
- U-235: Undergo Nuclear fission to produce electricity, by-product is Plutonium-239 can also be used as nuclear fuel in nuclear power plants.3% enriched used by nuclear power around world.
- U-238: Oldest rocks in earth contain it b/c half life millions of years
- Carbon-14: Tracer in organic reactions and can be used to date objects that were created by/out of once living organisms.
- Am-141: Used as ionizing force in smoke dectectors to enable it to oberate.