Nuclear Chemistry

Lecture 10

Atomic Nuclei

- The periodic table tells you about the **average atom** of an element.
- Atoms of an element can have different amounts of neutrons, this gives them different mass, these variations within an element are called **isotopes.**
- When referring to a specific atom, of known neutron number and mass, one uses the term **nuclide** and the following notation.

Nuclide:

a specific atom of known atomic #,
neutron number and mass

- The **symbol** which represents the name of the element (A single capitalized letter, or one followed by a lowercase letter)
- Numbers Indicate
  - **atomic number** on the lower left side
  - **particular atomic mass** in the upper left corner.

Nuclide Notation

Using your periodic table you see the symbol for **carbon** as **C**, it always has an atomic number **6**, and the average mass is **12.011**amu.

This is an average, carbon comes in different forms called isotopes, with the same atomic number but different amounts of neutrons which give them differing mass. Such as Carbon 14 and Carbon 12, Carbon 12 is the stable isotope.

- When referring to atoms of the isotope of carbon 14, you would write the **nuclide** so:

atomic mass $\rightarrow$ 14

atomic number $\rightarrow$ $^{14}_{6}\mathbf{C}$ $\leftarrow$ symbol that represents carbon

Often only the atomic mass is written since it is understood that the atomic number remains the same.

The more abundant stable carbon nuclide, with a lower atomic mass of 12 is written so:

atomic mass

$$^{12}_{6}\mathbf{C}$$

atomic number

symbol that represents carbon

If you are given a nuclide notation you can figure out the neutron # of an atom.

How do you do that?

If you know the neutron # you can figure out the mass.

How do you do that?

Radioactivity

Many elements have both stable isotopes and isotopes capable of having the nucleus undergo “spontaneous” change or disintegration, this is called **natural radioactive decay**.

In fact, elements with an atomic number larger than 83 have no known stable isotopes.

- Radioactive decay is accompanied by the release of subatomic particles, and/or **photons**, such as X rays. When it results in a different element it is called **transmutation**.

- The time it takes for a sample to be reduced to half of its initial amount is called the **Half-life**.

Radioactivity can involve

- Alpha decay : transmutation and release of an alpha particle (helium)

- Beta decay: transmutation and release of a beta particle (electron)

- Gamma Ray Emission : changes energy state only, release of a gamma ray

Alpha decay

- During transmutation caused by the release of helium (alpha decay) the product is a helium atom ${}^{4}_{2}He$ and a new element with an atomic number 2 lower than the initial atom and 4 mass units lower.

For example:

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

Radium Radon Helium

Chemical equations generally use arrows to show direction instead of using equal signs.

These equations follow thermodynamics. Energy is conserved and things should add up on each side of the arrow.

Beta Decay (the switch)

- No change in mass,
- But a change in atomic number and a transmutation to a new element, plus the release of an electron. How can this be?

For example:

$$^{234}_{90}\mathbf{Th} \rightarrow \; ^{234}_{91}\mathbf{Pa} + \; ^{0}_{-1}\mathbf{e}$$

What has gone on?

- The neutron disintegrated, switching to a proton and releasing energy in the form of electrons.
- How else could you essentially not change mass, but change atomic number?

Gamma Ray Emission

Atomic number and atomic mass remain the same.

There is a notation (m) after the atomic mass indicating an elevated energy state of the radioactive isotope.

After emitting a gamma ray, the m is left out, but a ray is noted.

For example:

Higher energy state normal energy state + gamma ray

$$^{99m}_{43}\mathbf{Tc} \rightarrow \, ^{99}_{43}\mathbf{Tc} + \, ^{0}_{0}\gamma$$

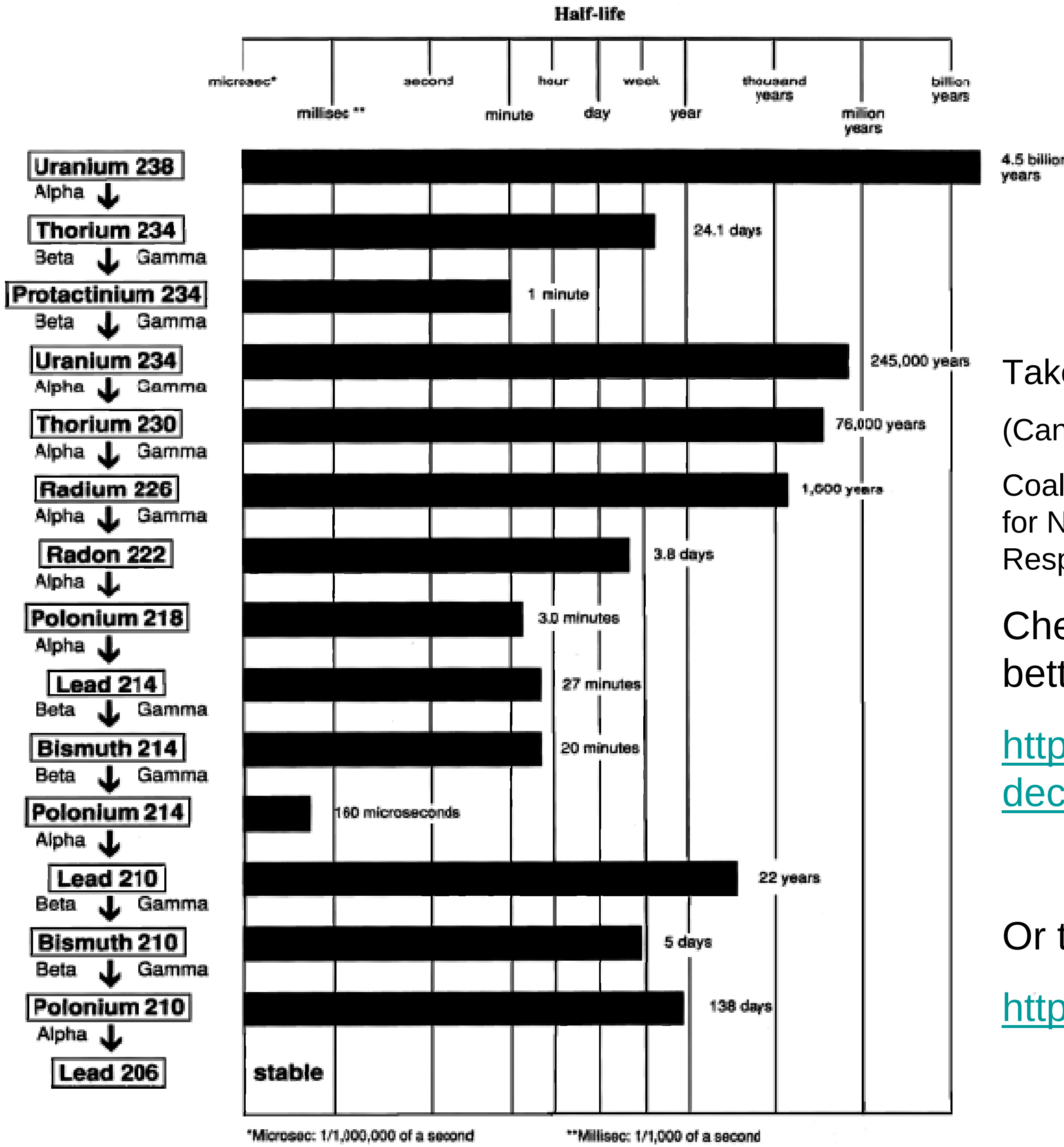
What do we mean by an energized state?

Quantum leap of an electron to a different space, to visualize this you need to have a picture of the distribution of electrons about the atom.

Now we are getting back into electron configuration.

- The modern quantum-mechanical model of the atom uses **quantum numbers, sublevels** and **orbitals** to <u>describe the most probable place to find electrons in a stable atom.</u>

0.00001 of an atom’s space is taken up by the nucleus, the rest are electrons.



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Check out link for a better image.

http://www.ccnr.org/decay_U238.html

Or this for more info:

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