Chemistry 6A F2007

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Wednesday

12/5/07

Exam 3: Friday 12/7/07 (here in lecture)

What will be covered on the exam?

- •Chapter 6: 6.9-6.15
- •Chapter 7: All
- •Chapter 8: All
- •Chapter 9: 9.1 - 9.9
- •Any thing from lab as well

What do I need to bring?

Bring a Pencil, Eraser, Calculator and scamtron form 882

YOU NEED TO KNOW YOUR LAB SECTION NUMBER!

What do I need to bring?

Scantron form 882
100 question jobby-doo

chewing optional…

EXAMPLES OF NUCLEAR REACTIONS

Example 1: Bromine-84 decays by emitting a beta particle. What is the symbol for the daughter produced?

Recall for isotopes: $^{A}_{Z}X$

X = the element
A = mass number
Z = atomic number

35 protons, 49 neutrons

$$^{84}_{35}Br \longrightarrow \,^{0}_{-1}\beta + \,^{84}_{36}Kr$$

When a beta particle is lost $\left(^{0}_{-1}\beta\right)$ the daughter must have a mass number of 84 and an atomic number of 36.

$$^{84}_{35}\text{Br} \longrightarrow {}^{0}_{-1}\beta + {}^{84}_{36}\text{Kr}$$

Notice that overall mass and the number of protons are the same on each side of the arrow…

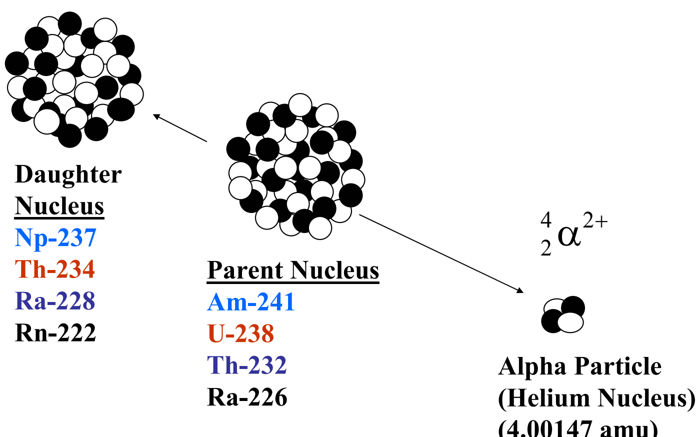
$$84 = 84 + 0$$
$$35 = -1 + 36$$

Just as in a chemical process, mass must be balanced in a nuclear process.

The Decay Processes – General Rules

1. When one element changes into another element, the process is called *spontaneous decay* or *transmutation*
2. The sum of the mass numbers, A, must be the same on both sides of the equation
3. The sum of the atomic numbers, Z, must be the same on both sides of the equation
4. Conservation of mass-energy and conservation of momentum must hold

Alpha Decay:



Example 2: When samarium-148 undergoes radioactive decay, the daughter produced is neodymium-144.

What kind of radiation is emitted during the decay?

$$^{148}_{62}\text{Sm} \longrightarrow {}^{144}_{60}\text{Nd} + {}^{4}_{2}\alpha$$

The daughter has a mass number of 144, so the emitted radiation must have a mass number of 4.

The difference between the atomic numbers is 2.

Therefore, it is an alpha particle.

Example 3: Tungsten-175 decays by drawing in an electron from outside the nucleus in a process called **electron capture.**

Write a balanced nuclear equation for the process.

$$^{175}_{74}W + \,^{0}_{-1}e \longrightarrow \,^{175}_{73}Ta$$

The daughter must have a mass number of 175, because the mass number of an electron is 0.

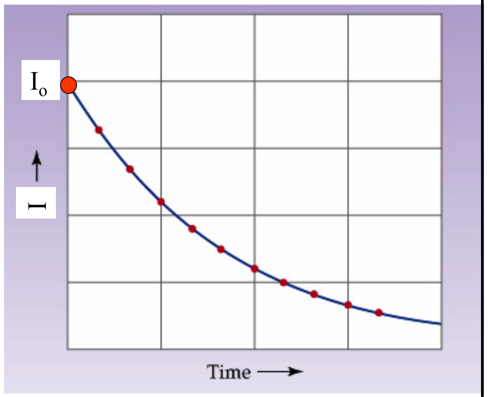
The atomic number of the daughter must be 73 because the charge on the electron is –1.

RADIO ISOTOPE LIFE TIMES AND HALF-LIFES

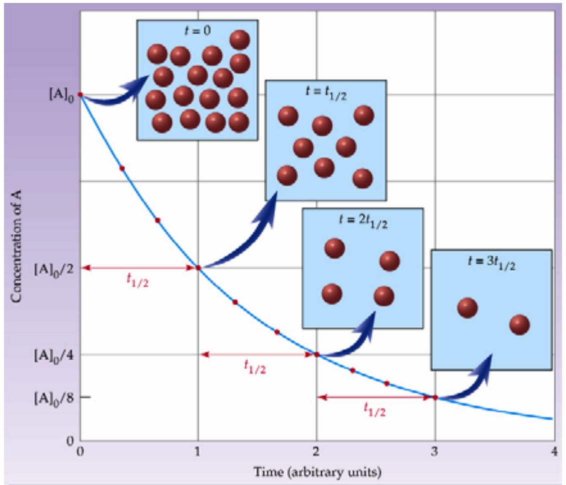
Radioactive decay occurs exponentially with time:

Starting with an initial amount of an isotope, I_o, the amount decreases with time.

$$I = I_o \times e^{-kt}$$



Reaction Half-life



Technetium-99 has a radioactive half life of 6 hours. It is used as a diagnostic tracer isotope in brain cancer scans.

If a patient is given a 9.0 ng dose, how much technetium will remain in the patients system after 1 day?

Recall that there are 24 hrs in one day...
Which means that 4 half-lives will pass!

$$9.0\text{ ng} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 9.0\text{ ng} \times \left(\frac{1}{2^4}\right) = 9.0\text{ ng} \times \left(\frac{1}{16}\right)$$

$$= 0.56\text{ ng or } 560\text{ pg}$$

What happens when a radioactive substance decays through "n" half lives?

$$\text{initial amount}\left(\times\frac{1}{2}\times\ \bullet\ \bullet\ \bullet\ \bullet\ \times\frac{1}{2}\right) = \text{final amount}$$

1 to n

$$\text{Initial}\times\left(\frac{1}{2^n}\right) = \text{final}$$

$$\text{Initial}\times\left(\frac{1}{2}\right)^n = \text{final}$$

$$\left(\frac{1}{2}\right)^n = \frac{\text{final}}{\text{initial}}$$

n = # of half-lives

What happens when a radioactive substance decays through "n" half lives?

Taking the log of the equation:

$$\log\left(\left(\frac{1}{2}\right)^n = \frac{\text{final}}{\text{initial}}\right) \rightarrow \log\left(\frac{1}{2}\right)^n = \log\left(\frac{\text{final}}{\text{initial}}\right)$$

From the rules of logarithms:

$$n\times\log\left(\frac{1}{2}\right) = \log\left(\frac{\text{final}}{\text{initial}}\right) \rightarrow n\times\log(2) = -\log\left(\frac{\text{final}}{\text{initial}}\right)$$

What happens when a radioactive substance decays through "n" half lives?

$$n\times\log(2) = -\log\left(\frac{\text{final}}{\text{initial}}\right) \rightarrow n\times\log(2) = \log\left(\frac{\text{initial}}{\text{final}}\right)$$

$$n = \frac{\log\left(\frac{\text{initial}}{\text{final}}\right)}{\log(2)} \rightarrow n = \frac{1}{0.301}\times\log\left(\frac{\text{initial}}{\text{final}}\right)$$

n = # of half-lives

A 12.5% of a certain isotope remains after 3.5 days. How many half-lives have passed?

$$n = \frac{1}{0.301}\times\log\left(\frac{\text{initial}}{\text{final}}\right)$$

Substituting:

initially all of the material was present.

$$n = \frac{1}{0.301}\times\log\left(\frac{100.0\%}{12.5\%}\right)$$

$$n = 3$$

three half-lives have passed!

Units of Radiation exposure:

•Rad is most often used in US
•International unit called gray (Gy)
•Quality Factor (QF) is used to adjust for differences in tissue absorption

1 Dose in (rads) × QF = rem
rad = cGy

Radiation: Acute Exposure

•10 rad or greater within a short period of time (< 2-3 days)
•Acute Radiation Syndrome is apparent at doses > 100 rad
•Dose >450 rad
•50% of exposed population will die within 60 days without medical care

Radiation: Acute Exposure

•Blood-forming organs affected at >100 rad
•Bone marrow, spleen, and lymphatic tissue
•Symptoms: internal bleeding, fatigue, bacterial infection, fever
•Gastrointestinal tract affected at >1000 rad
Stomach, intestines
Symptoms: nausea, vomiting, diarrhea, dehydration, electrolyte imbalance, bleeding ulcers
Central Nervous System affected at >5000 rad
Damage to brain and nerve cells
Symptoms: loss of coordination, confusion, coma, convulsion

Other symptoms
Thyroid damage: 50 rad
Ovarian damage: 125-200 rad
Gonadal damage with permanent sterility: 600 rad
Skin erythema and hair follicle damage: 200-300 rad

Radiation: Chronic Exposure: Small amounts over a long period:

•Type of exposure typically seen in occupational exposures

•Body usually able to repair itself

• Increased risk of some cancers