Ch. 25 Nuclear Chemistry

Nuclear Reactions:

Nuclear Reactions vs. Ordinary Chemical Reactions: crash course video

Chemical Reactions:

- Rxns that involve the outer electrons
- Elements do not change from one to another.

  Ex. $2H_2 + O_2 \rightarrow 2H_2O$

Nuclear Reactions:

- Rxns that involve the nucleus
- Nucleus changes- products can be different elements than the reactants.

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

Radioactivity:

- Process by which nuclei emit particles and rays (radiation)

Radiation:

- Penetrating rays and particles emitted by a radioactive source
  1. Alpha (α) – stopped by paper, skin, clothing
  2. Beta (β)- stopped by metal foil, wood
  3. Gamma (γ)- stopped by lead, thick concrete

Radioisotope:

- An isotope that has an unstable nucleus
- Undergoes **radioactive decay** –spontaneous decay of the nucleus into a more stable nucleus, emits particles +/or radiation

Types of Radioactive Decay (Transmutation):

- Sum Reactant's Atomic # and mass # = Sum Product's atomic # and mass #

Ex. $^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$

- IF Atomic # changes = identity of element changes

- **Emission/Decay**= release particle/radiation. Product side of rxn
- **Capture**= takes in particle/radiation. Reactant side of rxn

  - **Alpha (α)** $^{4}_{2}\mathbf{He}$
    Ex. $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$

  - **Beta/Electron (β)** $^{0}_{-1}\mathbf{e}$
    Ex. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$

  - **Gamma (γ)** *No particles are emitted just high energy
    Ex. $^{230}_{90}Th \rightarrow ^{230}_{90}Th + ^{0}_{0}\gamma$

  - **Positron (β)** $^{0}_{+1}\mathbf{e}$
    Ex. $^{38}_{19}K \rightarrow ^{38}_{18}Ar + ^{0}_{+1}e$

  - **Neutron** $^{1}_{0}\mathbf{n}$
    Ex. $^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U$

  - **Proton** $^{1}_{1}\mathbf{H}$
    Ex. $^{18}_{9}F \rightarrow ^{17}_{8}O + ^{1}_{1}H$

Artificial Transmutation:

- Particles bombard the nucleus of an atom
- Particle accelerator (Atom Smasher), Nuclear reactors, Nuclear bombs
- Elements above 92 = man-made

ex.

$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$

$^{238}_{92}U + ^{1}_{0}n \rightarrow ^{239}_{92}U \rightarrow ^{239}_{93}Np + ^{0}_{-1}e$

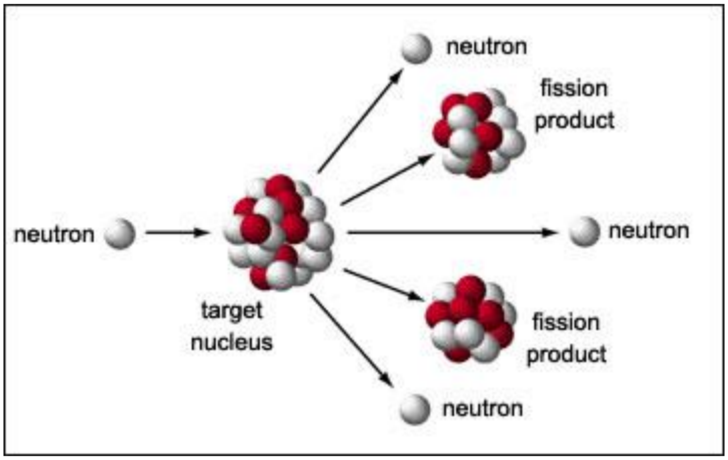
Higgs-boson (crazy girl)
Higgs-boson Explanation cartoon*
More Higgs-boson explanation*
http://ed.ted.com/lessons/brian-cox-on-cern-s-supercollider**

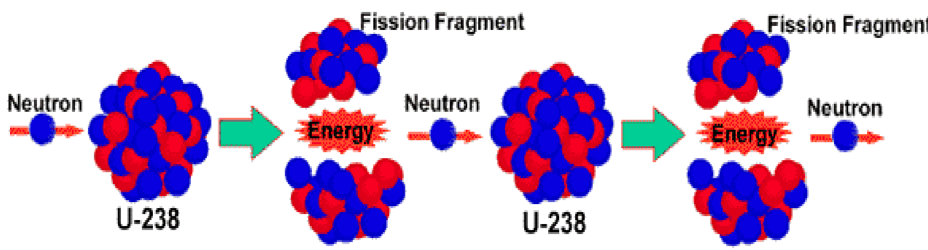
Comparing Fission & Fusion:

Fission:

- Heavy nuclei are split into lighter nuclei.
- Relatively easy to control but produce radioactive wastes.
- Plutonium and uranium

Fission

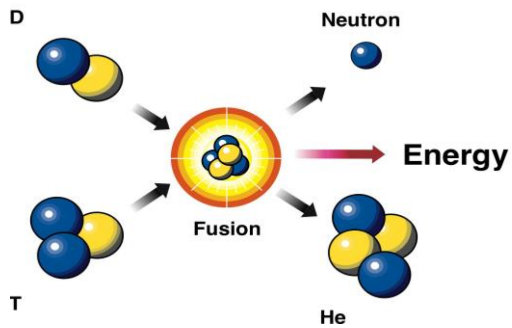


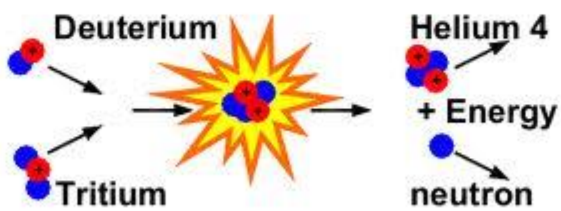


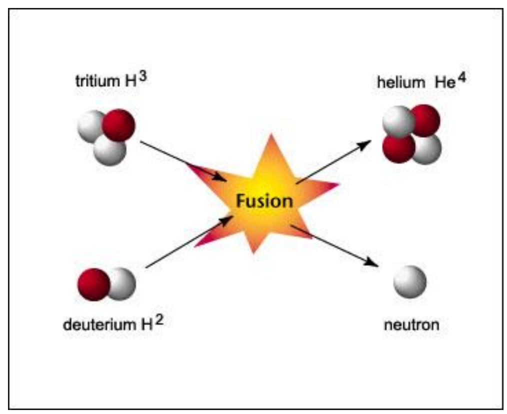
Three mile Island
Chernobyl II
Fukushima I
Fukushima TIME explanation
Chernobyl postcard pics
Nuclear bomb b

Fusion:

- Light nuclei are combined to form heavier nuclei.
- Difficult to initiate and control but produce little radioactive wastes.



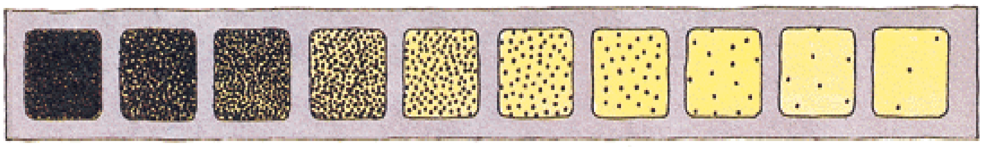




Half-Life:

- Time it takes for ½ of the atoms of a radioactive isotope to decay
- More stable isotopes – decay slowly → longer ½ life
- Less stable isotopes- decay quickly → shorter ½ life

Decay rate of radioactivity: After ten half lives, the level of radiation is reduced to one thousandth



Time: One half life two three four five six seven eight nine

TABLE 22.2 Half-lives of Some Useful Radioisotopes

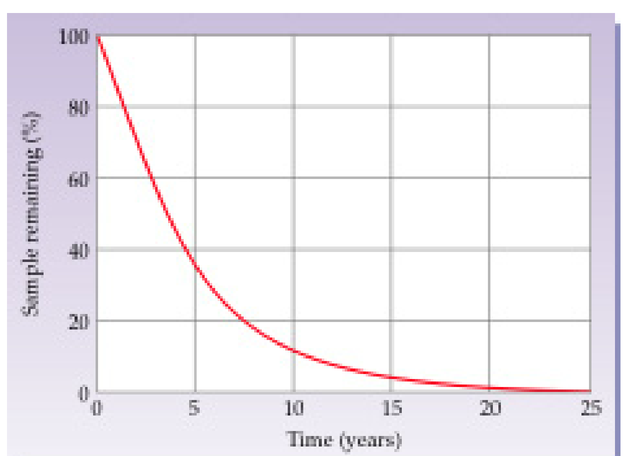
Radioisotope	Symbol	Radiation	Half-life	Use
Tritium	$^{3}_{1}H$	β^-	12.33 years	Biochemical tracer
Carbon-14	$^{14}_{6}C$	β^-	5730 years	Archaeological dating
Phosphorus-32	$^{32}_{15}P$	β^-	14.26 days	Leukemia therapy
Potassium-40	$^{40}_{19}K$	β^-	1.28×10^9 years	Geological dating
Cobalt-60	$^{60}_{27}Co$	β^-, γ	5.27 years	Cancer therapy
Technetium-99*m**	$^{99m}_{43}Tc$	γ	6.01 hours	Brain scans
Iodine-123	$^{123}_{53}I$	γ	13.27 hours	Thyroid therapy
Uranium-235	$^{235}_{92}U$	α, γ	7.04×10^8 years	Nuclear reactors

*The m in technetium-99m stands for metastable, meaning that it undergoes gamma emission but does not change its mass number or atomic number.

QUESTION 1

What is the half-life of the radionuclide with the following decay curve?

- 3.5 years
- 5.0 years
- 7.0 years
- 15 years



Calculating Half-Life:

Ex. 1 Radioactive element has a ½ life of 30 days of an 8 gram sample, how much will be unchanged after 90 days?

½life	**Time**	**Unchanged (Parent)**	**Changed (daughter)**
0	0	8 grams	(0grams)
1st	30 days	4 grams	(4 grams)
2nd	60 days	2 grams	(6 grams)
3rd	90 days	1 gram	(7 grams)

Ex. 2 The following is known about a fossil bone:

a.) Amount of carbon-14 originally in bone = 800g
b.) Amount of carbon-14 presently in bone = 100g
c.) Amount of nitrogen-14 presently in bone = 700g
d.) half-life = 5,730 yrs

How old is the fossil bone?
17,190 yrs

½ life	**Time**	**P (C-14)**	**D (N-14)**
0	0 yrs	800g	0g
1st	5,730 yrs	400g	400g
2nd	11,460 yrs	200g	600g
3rd	17,190 yrs	100 g	700g

Ex.3 The ½ life of radium-224 is 3.66 days. What was the original mass of radium-224 if 0.0500 grams remain after 7.32 days?

Amount remaining= (initial amount)(.5)^n

n= t/T

t=time elapsed

T=length of ½ life

n= # of ½ lives

soo….

n=7.32/3.66

n= 2

$0.0500g = X(.5)^2 = \frac{0.0500}{.25} = \frac{x(.25)}{.25}$

X= .2 grams