Aim: ~~Atomic Mass Unit~~ Nuclear Mass & Energy

1 amu = $\frac{1}{12}$ the mass of an atom of Carbon 12

1 proton = 1.0073 u

1 u = 1.66×10^{-27} kg   1 neutron = 1.0087 u

1 electron = .0005 u

Review Book pg 178: Given Helium   2 protons 2 neutrons

mass of helium nucleus = 4.0016 u

2 protons = 2(1.0073 u) = 2.0146 u

2(1.0087 u) = 2.0174 u

4.0320 u   Mass of 4 individual nucleons

individual nucleons	−	(overall) Mass of the nucleus	=	Difference Mass Defect
4.0320 u	−	4.0016 u	=	.0304 u.

★ Due to energy needed to separate the nucleons

★ Sum of these | Mass of the individual nucleons (protons & neutrons indiv. parts) must be greater than the overall mass of the nucleus.

MeV | Convert ~~Difference to Energy~~   1 MeV (Million) = 1,000,000 eV

1 u = 931 MeV

Convert the mass from the above problem to MeV

$$.0304\,u \times \frac{931\,MeV}{1\,u} = 28.3\,MeV$$

1 Proton Energy (MeV)

Find the energy in Joules to convert ~~[illegible]~~ into ~~[illegible]~~ of energy

$1u = 1.66 \times 10^{-27} kg$

Isotope - Elements that have the same number of protons & electrons, but a different number of neutrons

$^{44}_{22}$ ~~Sc~~ Ti $^{46}_{22}$ ~~Sc~~ Ti

Equipment

Particle Accelerator accelerates charged particles (proton)

- cyclotron - Particle Accelerator

Cloud Chamber - Uses water vapor to detect charged particles

Van de Graff Generator - Used to provide k. energy for a positively charged particles to penetrate the nucleus

Geiger Counter - Detect sub-atomic particles that exit the nucleus (Measures Radiation)

4/30/06 <u>Radioactive Decay</u>

- Process whereby unstable atomic nuclei decay

☆ - Every decay involves the emission of the follow radiations

Alpha α Beta β Gamma γ

All radiations are <u>ionising</u> - Collisions occur & electrons are removed from the atom.

<u>Detection</u> - Geiger-Muller Tube (Geiger Counter) can count the number of ionising radiations that enter the device

Cloud/Bubble Chamber - Gas is cooled, Gas molecules condense on any ionized molecules present

Photographic Emulsion - Particles ionize atoms along their path. Film dev. paths revealed

α <u>Alpha</u> - Alpha Particles are helium nuclei ^4_2He. In alpha decay, a chunk of nucleus is emitted. Part that remains will be a different nuclide

Ex $^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^4_2\alpha$

β <u>Beta</u> - Beta particles are electrons (Ex. $^0_{-1}\beta$ or $^0_{-1}e^-$) emitted from the nucleus

Ex. $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^0_{-1}\beta + \bar{\nu}$ Anti Neutrinos No charge, & no mass

$^1_0n \rightarrow {}^1_1p + {}^0_{-1} + \bar{\nu}$

γ Gamma - After emission, the nucleus has less energy, but its mass number & atomic number have not changed. Changed from an excited state to a lower energy state

$^A_ZN^* \rightarrow {}^A_ZN + \gamma$

Excited State — Low Energy state

Radio Active Decay

Beta particles emit less KE th predicted
Saw energy lost dur beta decay
Pauli - New Particle, very hard to detect that was carrying away mass, KE & moment = Nuetrino
Nuetral ≈0 mass, travel speed of light

Radio Active Decay Law

$$N = N_o e^{-\lambda t}$$

N_o - Original numb of atoms in the sample
N - Number of atoms remaining after time t
λ - Decay Constant
e - Math Constant

Relationship Between Decay Constant & half life

$$\frac{N}{N_o} = \frac{N_o e^{-\lambda t}}{N_o} \rightarrow \frac{N}{N_o} = e^{-\lambda t} \rightarrow \frac{N_o}{N} = e^{\lambda t}$$

When time = half life, N will be half of N_o

$$t = T_{\frac{1}{2}} \text{ then } N = \frac{N_o}{2} \rightarrow 2 = \frac{N_o}{N} \text{ So } 2 = e^{\lambda T_{1/2}}$$

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Natural log both Side

$$\ln 2 = \ln e^{\lambda T_{1/2}} \qquad \frac{\ln 2}{\lambda} = \frac{\lambda T_{1/2}}{\lambda}$$

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

A sample of radioactive isotope originally contains 1.0×10^{24} atoms & it has a half-life of 6.0 hours. Find

a) Decay constant

b) Number of atoms remaining after 30 minutes

a) $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ or $\lambda = \frac{\ln 2}{T_{1/2}}$

$N_o = 1.0 \times 10^{24}$ atoms

$T_{\frac{1}{2}}$ (in Sec) $= 6 hrs \times \frac{3600 sec}{1 hr}$

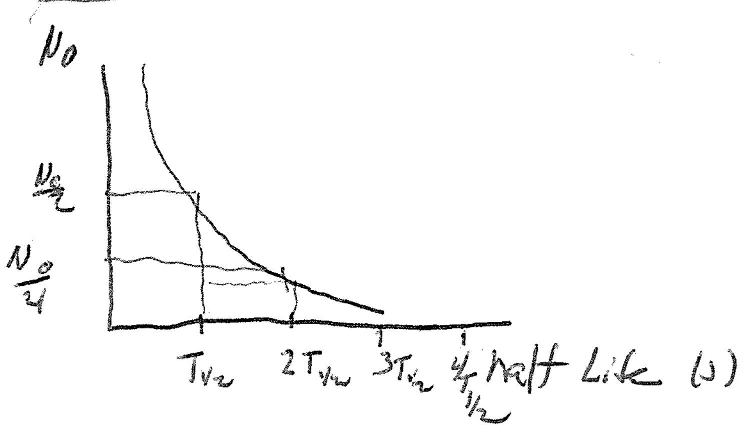
$\lambda = \frac{\ln 2}{21600 s} = 3.2 \times 10^{-5} s^{-1}$

b) $N = N_o e^{-\lambda t}$

$t = 30 min \times \frac{60 s}{1 min} = 1800 s$

$(1.0 \times 10^{24} atoms) e^{(-3.2 \times 10^{-5} s^{-1} \times 1800 s)}$

$N = 9.4 \times 10^{23}$ atoms



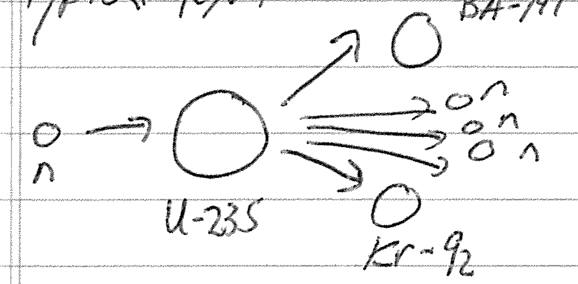
5/1/06 Nuclear Fission, Fusion, & Antimatter

<u>Fission</u> - Nuclear Rxn whereby large nuclei are induced to break-up into smaller nuclei & release energy in the process (ie. Nuclear Reactor / Atomic Bomb)

- Ex. use $^{235}_{92}U$

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}BA + ^{92}_{36}Kr + 3\,^{1}_{0}n + E$$

Typical Rxn

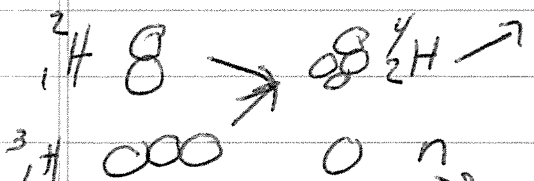


Chain Rxn - 3 new neutrons to break apart other U-235

<u>Fusion</u> - Small nuclei are induced to join together into larger nuclei & release energy in the process (ie. Sun)

Ex. - 2 isotopes of hydrogen to produce He

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{1}_{0}n + Energy$$



<u>Binding Energy</u> - When a nuclear rxn occurs the products are in a lower energy state than the reactants. Mass loss must be the source of this energy

<u>AntiMatter</u> - Every form of matter has its equivalent form of anti-matter. If matter & anti-matter came together, they would annihilate each other. Antimatter is rare but exists

$$\underset{\text{proton}}{^{1}_{1}P} \rightarrow \underset{\text{neutron}}{^{1}_{0}n} + \underset{\text{Positron}}{^{0}_{+1}\beta} + \text{Neutrino}$$