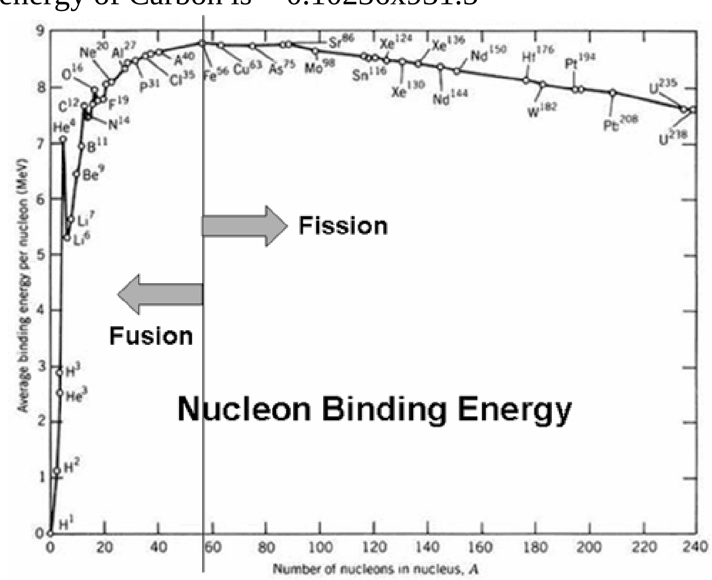
Chapter 7

Nuclear Chemistry

Day - 1

NUCLEAR CHEMISTRY

1. Difference between chemical reactions of nuclear reaction
   a. In chemical reaction the nucleus does not table part, only the electrons take part.
   b. In nuclear reaction, mainly the nucleus takes part.
2. Why the nucleus is stable, when so many positive charges are so close together
3. Binding energy.
   a. Let's take C^{12} isotope Atoms mass = 12.00 amu
   b. Mass of one proton = 1.00758 amu
   c. Mass of one neutron = 1.00893 amu
   d. Mass of one electron = 1.00055 amu
   e. C^{12} has of proton + 6 neutrons + 6 electrons
   f. So total mass = 6 (1.00758 + 1.00893 + 0.0055) = 12.10236 amu
   g. Δm =12.10236 – 12.0 = 0.10236 amu
   h. $E = mc^2 = 0.10236 \times 1.66 \times 10^{-27}$ kg x $(3 \times 10^8$ m/s$) = 1.52593 \times 10^{-11}$ J
4. 1 amu = 1.66×10^{-27} kg
   a. If we convert all this to energy
   b. $E = 1.66 \times 10^{-27}$ kg x $(3 \times 10^8 \text{ m/s})^2 = 1.494 \times 10^{-10}$ J
5. Let's define new unit of energy = 1 eV
   a. 1 eV = 1.6×10^{-19} coulombs x 1 V = 1.6×10^{-19} J
   b. So 1 amu $= \frac{1.494\times10^{-10}}{1.6\times10^{-19}} = 931.5 \times 10^6 \text{eV} = 931.5 \text{ MeV}$
6. So Binding energy of Carbon is = 0.10236x931.5 =



TYPE OF NUCLEAR REACTION

a. Nuclear fission when an bigger atom nuclear by itself or by bombardment of elementary particles like α, β or η to produce two or more smaller atoms

i.ex. Fission $\Rightarrow {}_{92}U^{235} + {}_{o}n^{1} \rightarrow {}_{56}Ba^{100} + {}_{36}Kr^{92} + 3\,{}_{o}n^{1}$

b. Nuclear fusion when to smaller atoms combines to produce a bigger atom. In both cases moving energy is released

i. Fission $\Rightarrow 4\,{}_{1}H^{1} \rightarrow {}_{2}He^{4} + 2\,{}_{+1}e^{o} + 24.7$ MeV

UNIT OF RADIOACTIVITY

dps = disintegration per second

dpm = disintegration per minute

1 curie = 3.7 x 10^{10} dps

1 Rutherford = 1x10^{6} dps

1 Becquerel = 1 dps

Radioactive disintegration has kinetic of first order reaction

Rate of disintegration $= -\frac{dN}{dt} = \lambda N$

N = no of particles at any given time 't'

N_0 = no or particle at start i.e. t = 0

$\Rightarrow \frac{N}{No} = e^{-\lambda t}$

$\Rightarrow \lambda = \frac{2.303}{t} \log \frac{No}{N}$

$\Rightarrow t^{1/2} = \frac{0.693}{\lambda}$

$\Rightarrow$ Average time of disintegration = 1.44 x $t^{1/2}$

THEORY OF RADIOACTIVE DISINTEGRATION

The ratio of n/p determines the stability of nucleus. There is a band above and below which n/p ratio makes the element radioactive.

1. The disintegration taken place in the manner that n/p ratio reaches towards stability.
2. The disintegration is not effected by external factor like pressure, temperature etc.
3. If n/p ratio is higher than nuclear have tendency to emit β-rays

ex. ${}_{6}C^{14} \rightarrow {}_{7}N^{14} + {}_{-1}\beta^{o}$

4. If n/p ratio is lower than following can happen.

A. emission of ∝ particle

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

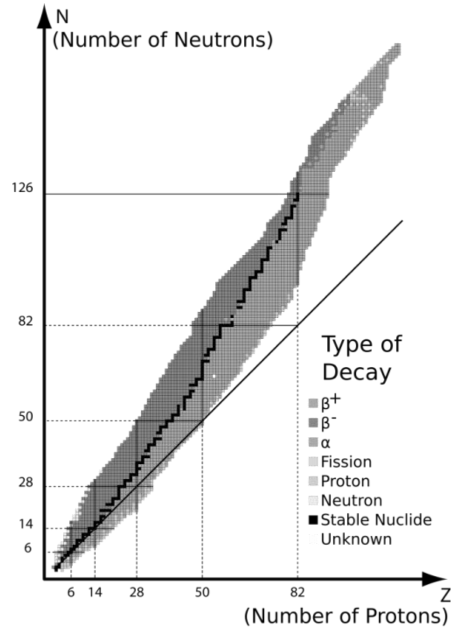
$^{n}/_{p}$ 1.58 1.60

B. emission of positron

${}_{7}N^{13} \rightarrow {}_{6}C^{13} + {}_{+1}e^{o}$

C. K-electron capture

${}_{71}Av^{194} + {}_{-1}e^{o} \rightarrow {}_{78}pt^{194}$



CARBON DATING

This method is used to determine the age of fossils like wood and other living things.

It works on the principle that C^{14} to C^{12} ratio in the atmosphere has not changed in last 10,000 years. If we can determine C^{14} (radioactive element with half-life of 5770 years) content in any old structure we can we determine its' age.

ex. C^{14} in an old chair is 12.5% of its original value. If $t^{1/2}$ of C^{14} is 5770 years. How old is the wood.

$$t = \frac{2.303}{\lambda}\log\frac{100}{12.5} \qquad \lambda = \frac{0.693}{t^{1/2}}$$

$$= \frac{2.303 \times t^{1/2}}{0.693} \times \log 8 = 17{,}316.8 \text{ years}$$

ROCK DATING

This method is used when carbon is not present example rocks etc. Here radioactive U235 is present which disintegrates into Lead. We assume no lead was present in the rock in the beginning.

Ex. A sample of rock of 1 lead atom is present for every 3 atoms of U^{235} atom. Find the age of rock $t^{1/2}$ of $U^{235} = 4.5 \times 10^9$

$$t = \frac{2.303}{0.693} \times 4.5 \times 10^9 \log\frac{4}{3} = 1.87 \times 10^9 \text{ years}$$