Nuclear Physics

$E = mc^2$ → speed of light (C 3×10^8 m/s)
↓
Kg

If a mass m changes into energy then the energy released is given by the formula

$$E = mC^2$$

Binding Energy

consider $^{56}_{26}Fe$

$m(p) = 1.673 \times 10^{-27}$ Kg

$m(n) = 1.675 \times 10^{-27}$ Kg

$m(Fe) = 9.288 \times 10^{-26}$ Kg

mass of 26 protons $= 4.35 \times 10^{-26}$

mass of 26 neutrons $= 5.025 \times 10^{-26}$

The mass of the protons & neutrons is much greater than the weight of the iron nucleus. This difference in mass is called the mass defect // & this mass has been used as energy to hold the protons & neutrons together in the nucleus. It is called as the binding energy.

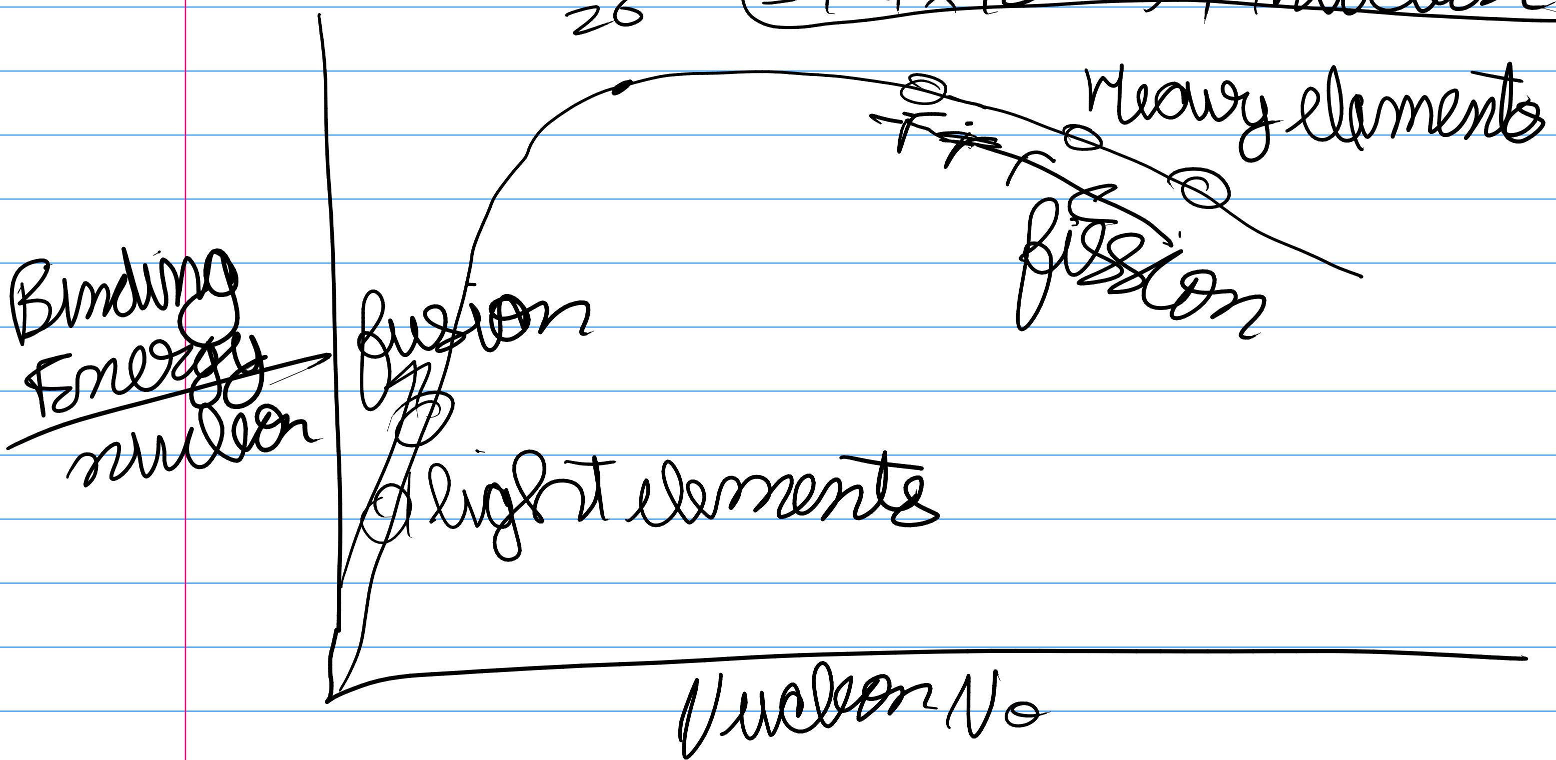
Difference in mass b/w Fe & (N&P) — mass defect

mass defect $= 9.373 \times 10^{-26} - 9.288 \times 10^{-26}$
$= 8.7 \times 10^{-28}$

Binding energy $= 8.7 \times 10^{-28} \times (3 \times 10^{8})^{2}$
$= 7.83 \times 10^{-11} J$

Binding energy per nucleon $= \frac{7.83 \times 10^{-11}}{56}$

$^{56}_{26}Fe$ $= 1.4 \times 10^{-12} J$ / nucleon

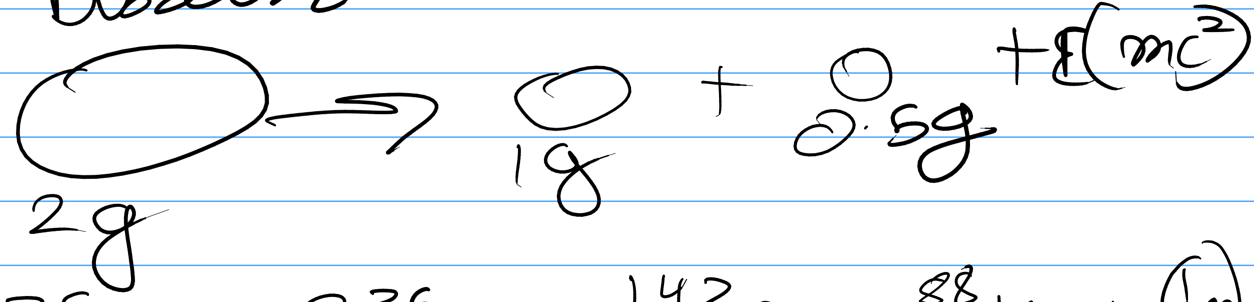


The graph does not pass through 0 because if an atom had 0 nucleon number, then it would have 0 binding energy.

The peak of the graph occurs for ($^{56}_{26}Fe$)

This means that this atom is the strongest atom among all other elements.

Nuclear Fission



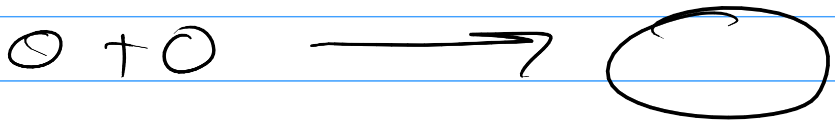
$$^{1}_{0}n + ^{235}_{92}U - ^{236}_{92}U \rightarrow ^{142}_{56}Ba + ^{88}_{36}Kr + 3\,^{1}_{0}n + E$$

Nuclear fission occurs when a heavy nucleus breaks up into smaller nucleis this is normally accompanied by the release of energy.

Nuclear Fusion

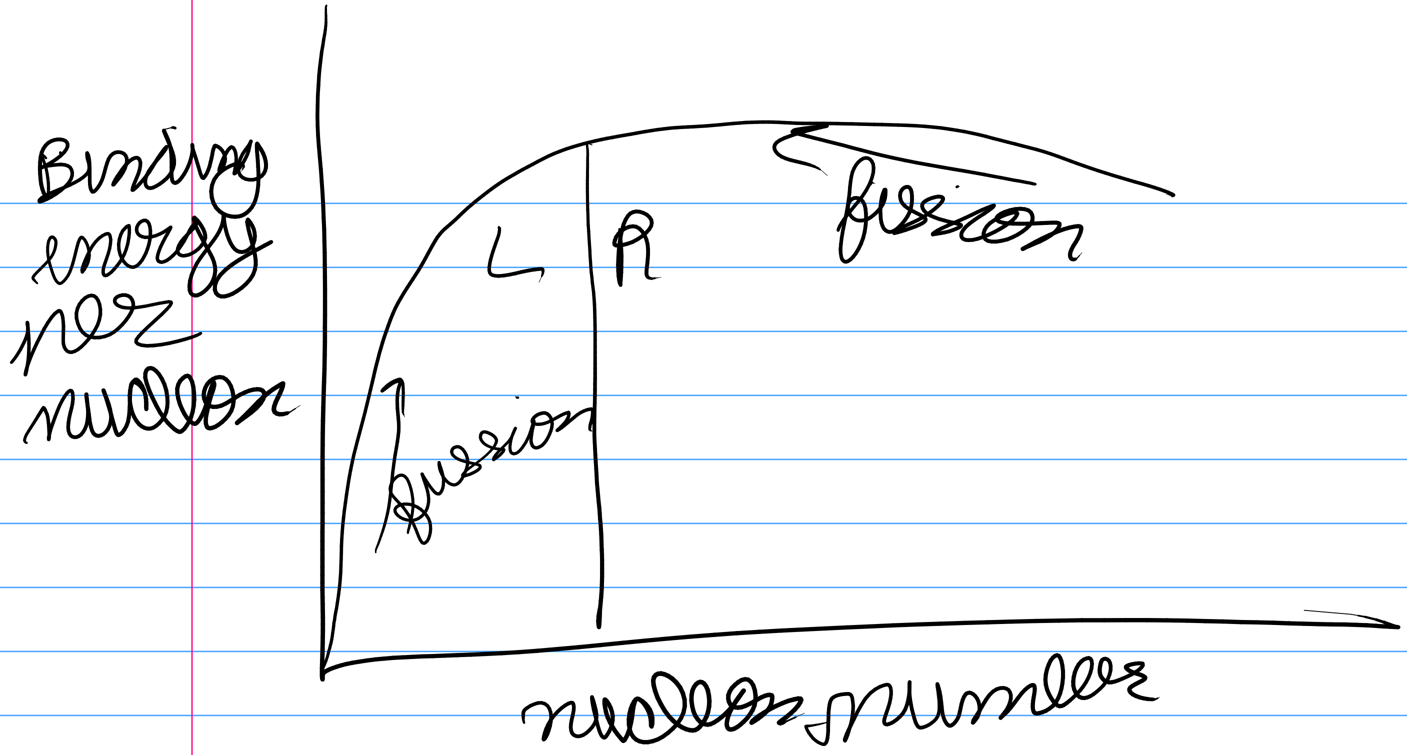
Nuclear fusion takes place when 2 light nuclei join together to form a heavier nucleus

eg.



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

Fusion requires a lot of energy because the nuclei contain protons which repel each other, therefore once a fusion reaction starts, it is difficult to sustain it as the energy produced is not enough. Nuclear fusion takes place in the sun.



A fusion reaction can only take place on the left side of the binding energy curve, this is because the lighter nuclei join up to give you a heavier nucleus of greater binding energy so energy can be released.

A fission reaction can only take place on the right side of binding energy curve because the products of the fission have a greater binding energy than the original nucleus.

$$\underbrace{{}^{1}_{0}n + {}^{235}_{92}U}_{235.0439\ldots} \rightarrow {}^{236}_{92}U \rightarrow \underbrace{{}^{142}_{56}Ba + {}^{88}_{36}Kr}_{143.9992+88-9178} + 3\,{}^{1}_{0}n + \text{Energy}$$

$+(3\times1.0008)$

$= 0.18887)93MeU$

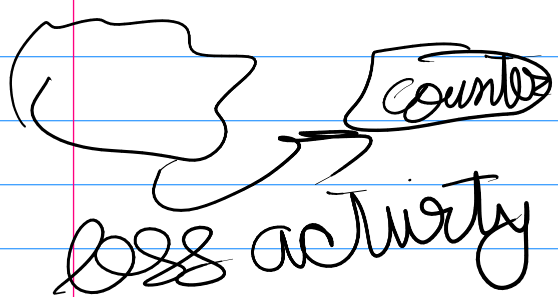
$${}_{1}^{2}H + {}_{1}^{3}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n + \text{Energy}$$

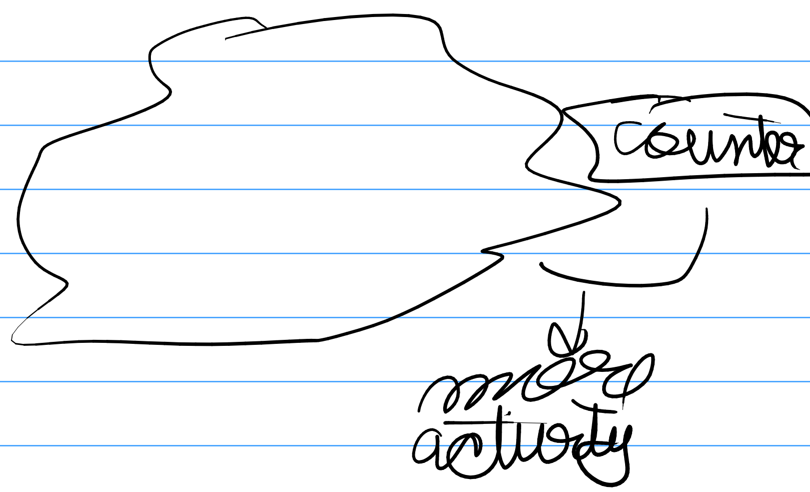
$$2.01402 + 3.016 - 4.002 + 1.008665$$
$$= 0.0189U = (0.0189 \times 931.5)\ MeV$$
$$17.6 \times 10^{6} \times 1.6 \times 10^{-19}\ J$$

Radioactive Decay

1) Radioactive decay gives out radiation which is not regular in nature. This is because radioactivity is a random process & so if a counter is placed in front of radioactive substance, it will show readings which are absolutely irregular.

2) Radioactive decay is spontaneous (any atom can give out a radioactive substance at any time decay) & random (the atom giving out the radiation can be from any part of the radioactive substance)





The countrate from a given sample is also called the activity of the sample (a). The activity depends on the no. of atoms present in the radioactive material.

Activity (A) α No. of atoms in the sample

$$A \alpha N$$
$$A = \lambda N$$

$\lambda \rightarrow$ Decay constant

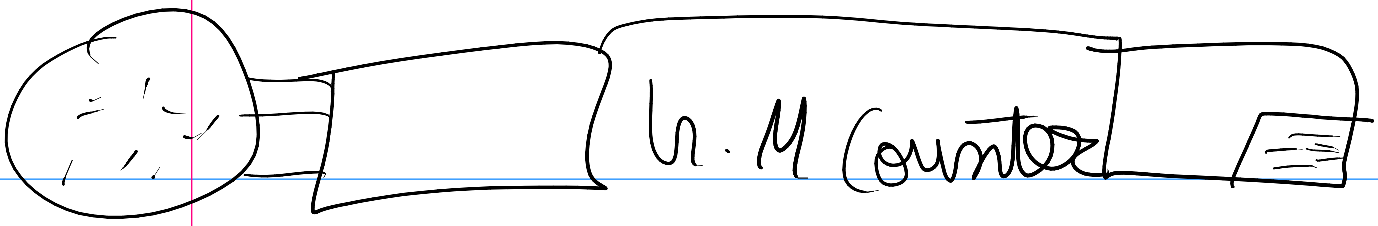
Half Life $\rightarrow$ The time taken by half the number of atoms present in a given sample to decay.

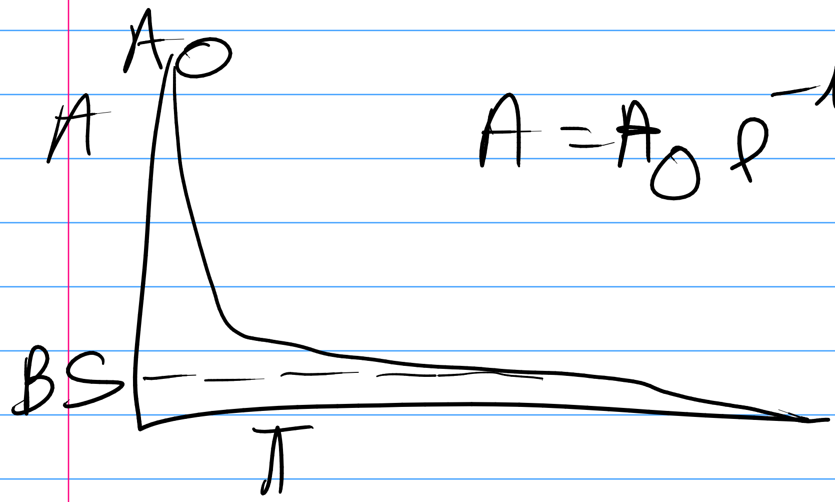
Decay constant (λ) $\rightarrow$ The probability per unit time that a particular nucleus will undergo decay.

Activity $\rightarrow$ The rate of decay of the substance

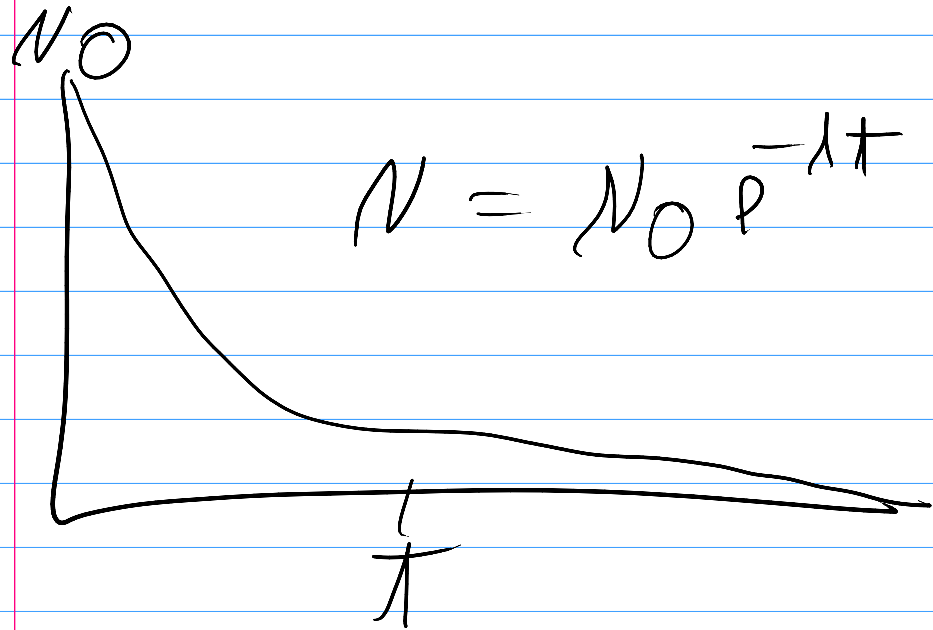
$$A = \frac{dN}{dt}$$

$$\lambda = \frac{0.693}{t_{1/2}}$$

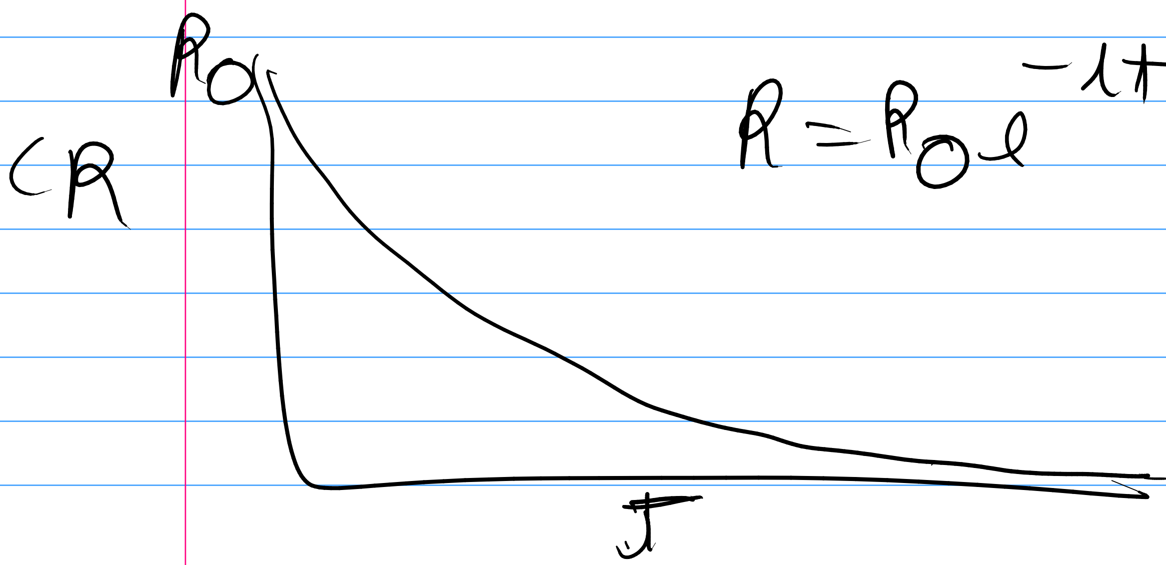




$$A = A_0 e^{-\lambda t}$$



$$N = N_0 e^{-\lambda t}$$



$$R = R_0 e^{-\lambda t}$$