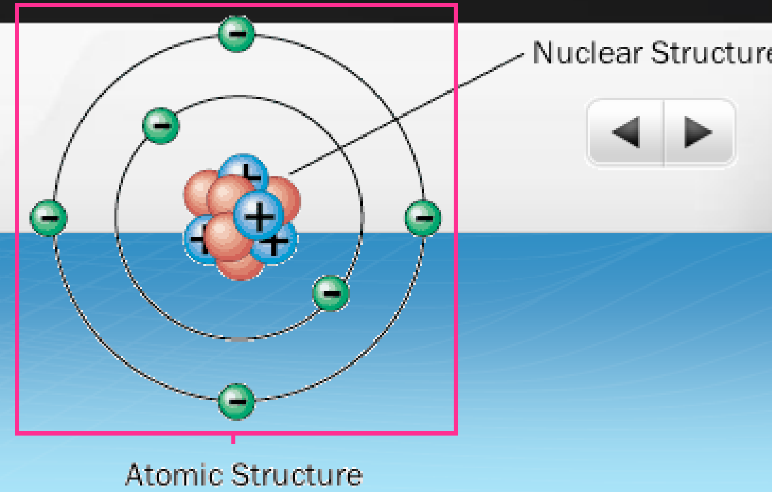
These are pages 18 - 19. The rest of the chapter is more Chemistry based – reactions, but the physics aspects of them.

EMAIL ME if you have questions.

Nuclear Physics



- **Nuclide**: a particular type of nucleus
- **Nucleon**: a proton or a neutron
- **Atomic number (Z) (proton number):** number of protons in nucleus
- **Mass number (A) (nucleon number):** number of protons + neutrons
- **Neutron number (N):** number of neutrons in nucleus ($N = A - Z$)
- **Isotopes**: nuclei with same number of protons but different numbers of neutrons
- **Unified atomic mass unit (u):** $1/12^{th}$ the mass of a carbon-12 nucleus
- **Atomic mass** $\approx$ $A * u$

Nuclear Physics

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

$1\ u = 1\ g/mol$

$1\ u = 931\ MeV/c^2$

Nuclear Physics

$^{A}_{Z}X$ $^{56}_{26}Fe$ $^{27}_{13}Al$ $^{12}_{6}C$ $^{14}_{6}C$

Atomic Number				
Mass Number				
Neutron Number				
Atomic Mass				
Molar Mass				

Nuclear Physics

$^{A}_{Z}X$	$^{56}_{26}Fe$	$^{27}_{13}Al$	$^{12}_{6}C$	$^{14}_{6}C$

Atomic Number	26	13	6	6
Mass Number	56	27	12	14
Neutron Number	30	14	6	8
Atomic Mass	56 u	27 u	12 u	14 u
Molar Mass	56 g	27 g	12 g	14 g

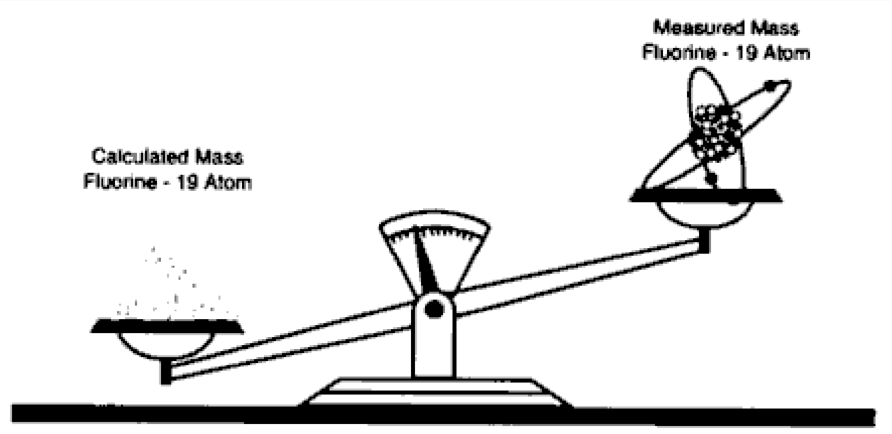
Interactions in the Nucleus

- **Gravitational:** (long range) attractive but very weak/negligible
- **Coulomb or Electromagnetic:** (long range) repulsive and very strong between protons
- **Strong nuclear force:** (short range) attractive and strongest – between any two nucleons
- **Weak nuclear force:** (short range) involved in radioactive decay

We covered this last year – the mass of the whole nucleus is less than the sum of the parts

Binding Energy

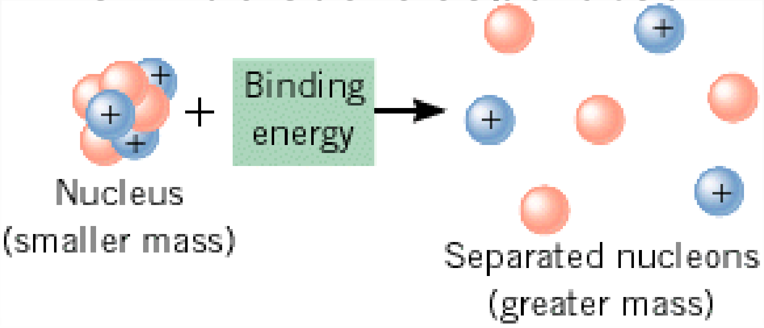
- **Mass defect (mass deficit) (Δm)**
- Difference between the mass of the nucleus and the sum of the masses of its individual nucleons



The missing mass converts to energy which binds the nucleus

Binding Energy

- **Nuclear binding energy (ΔE)**
- energy released when a nuclide is assembled from its individual components
- energy required when nucleus is separated into its individual components



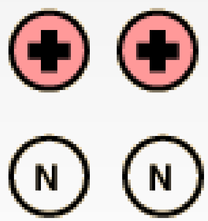
These equations help us find the missing mass, or the amount of energy.

Binding Energy

$$m_{nucleus} + Dm = m_{nucleons}$$

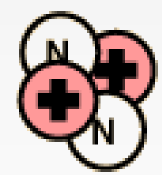
$$Dm = DE$$

$$\boxed{E = mc^2}$$



protons 2 x 1.00728 u

neutrons 2 x 1.00866 u



Alpha particle

Mass of parts 4.03188 u

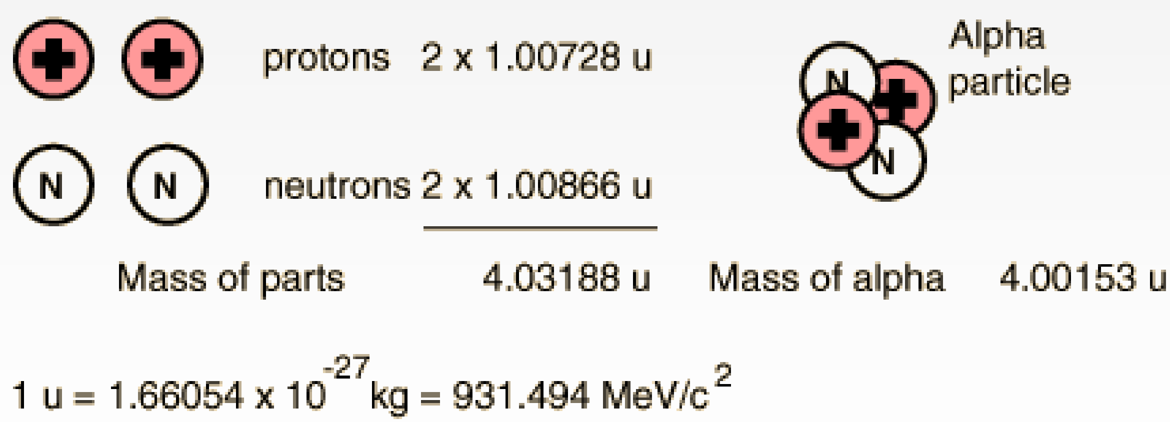
Mass of alpha 4.00153 u

$1\ u = 1.66054 \times 10^{-27}\ kg = 931.494\ MeV/c^2$

Last year to said mass defect = mass of nucleons minus the mass of the nucleus. Here they add mass nucleus to other side

Binding Energy

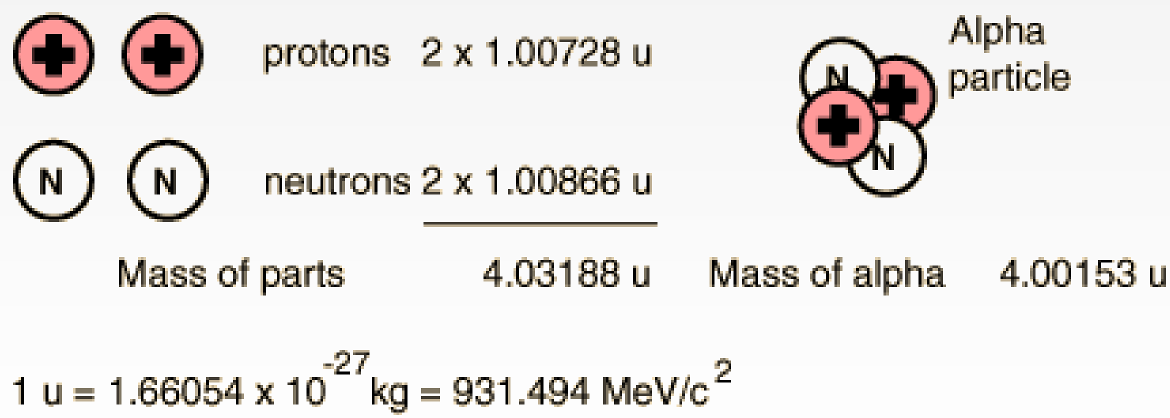
$$m_{nucleus} + Dm = m_{nucleons}$$



Binding energy IS mass defect

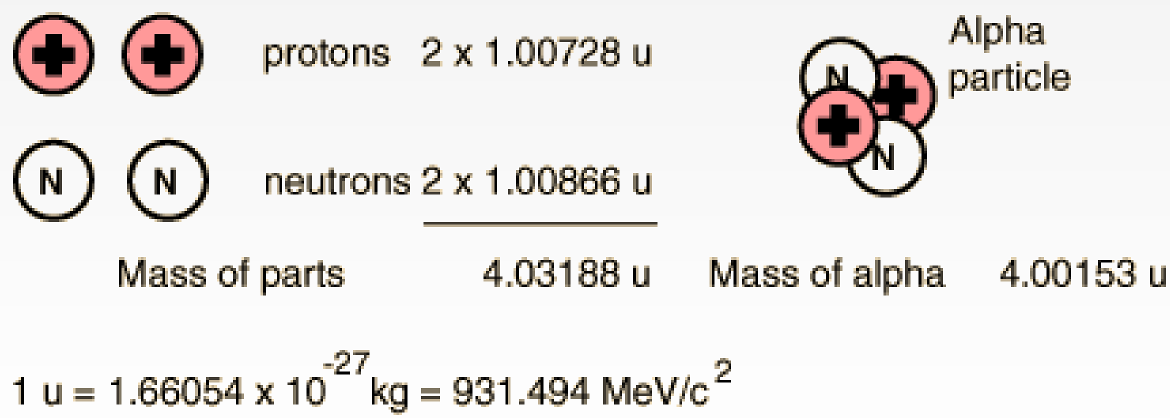
Binding Energy

Dm = DE



Why Einstein is famous – matter and energy are interchangeable.

Binding Energy

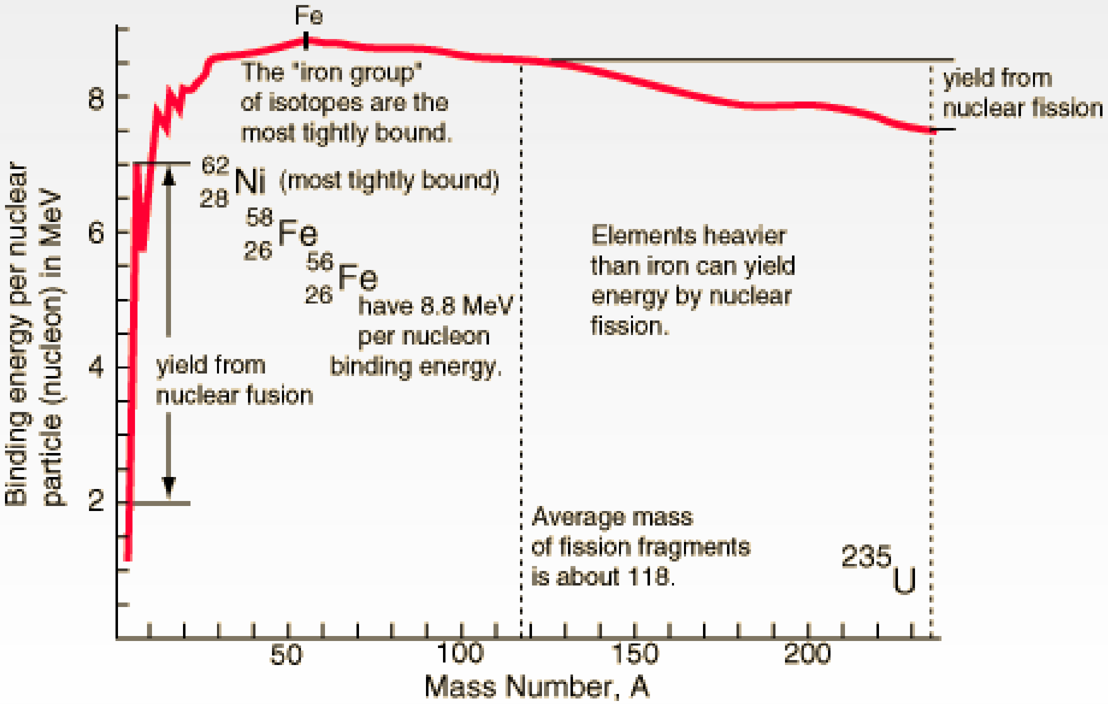


$$\boxed{E = mc^2}$$

Binding Energy

- Different nuclei have different total binding energies. As a general trend, as the atomic number increases . . .

  The total binding energy for the nucleus increases



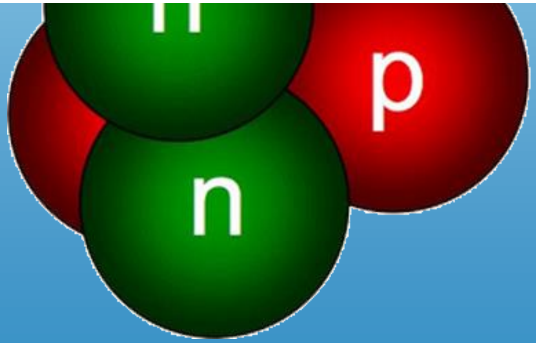
The most abundant isotope of helium has a ${}_{2}^{4}He$ nucleus whose mass is 6.6447×10^{-27} kg. For this nucleus, find the mass defect and the binding energy.

Step 1 = mass defect

Step 2 = Energy calculation

When mass is in kg use $E = mc^2$.

When mass is in u use 1 u = 931 MeV.



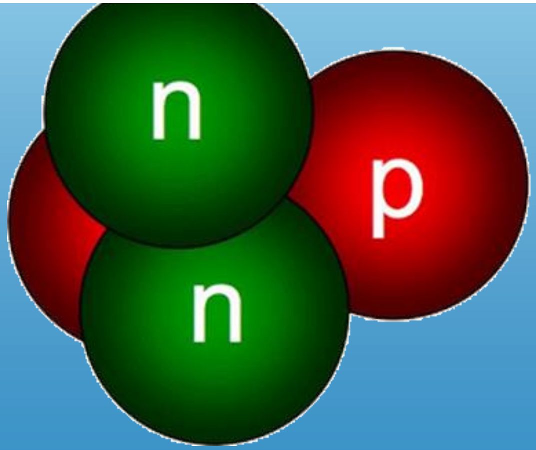
The most abundant isotope of helium has a ${}_2^4He$ nucleus whose mass is 6.6447×10^{-27} kg. For this nucleus, find the mass defect and the binding energy.

$$\Delta m = m_{nucleons} - m_{nucleus}$$
$$\Delta m = 2(1.673\times10^{-27}\,kg) + 2(1.675\times10^{-27}\,kg) - 6.6447\times10^{-27}\,kg$$
$$\Delta m = 0.0513\times10^{-27}\,kg = 5.13\times10^{-29}\,kg$$

$$E = (\Delta m)c^2$$
$$E = (5.13\times10^{-29}\,kg)(3.00\times10^{8}\,\tfrac{m}{s})^2$$
$$E = 4.62\times10^{-12}\,J$$

m in kg needs to use E=mc²

Do not use u when using E = mc²



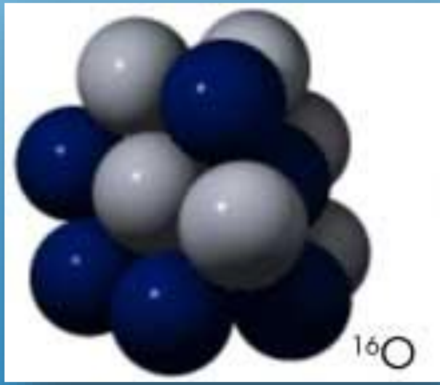
Calculate the binding energy and mass defect for $_{8}^{16}O$ whose measured mass is 15.994915 u.

Step 1 = mass defect

Step 2 = Energy calculation

When mass is in kg use $E = mc^2$.

When mass is in u use 1 u = 931 MeV.



Calculate the binding energy and mass defect for $_{8}^{16}O$ whose measured mass is 15.994915 u.

$$\Delta m = m_{nucleons} - m_{nucleus}$$

$$\Delta m = 8(1.007276\ u) + 8(1.008665\ u) - 15.994915\ u$$

$$\Delta m = 0.132613\ u$$

m in u needs to use 1u = 931 MeV

$$\Delta E = \Delta m = 0.132613\ u \left(\frac{931\ MeV/c^2}{1\ u} \right) = 123.5\ MeV$$