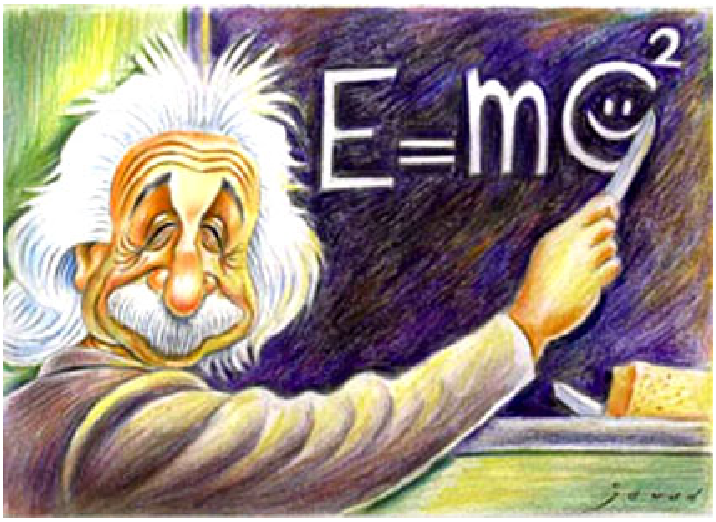
Einstein's Big Idea ...Mass changes into Energy...E = mc^2 at last

In a nucleus, E is the energy that holds the nucleus together - *binding energy*.

The mass of an intact nucleus is *less than* the sum of the masses of the individual nucleons (protons and neutrons).

This difference in mass is called the *mass defect*.



http://holbert.faculty.asu.edu/eee460/massdefect.html

In a chemical reaction the mass defect is small and the energy released is relatively small
~0.5 GJ/mol.

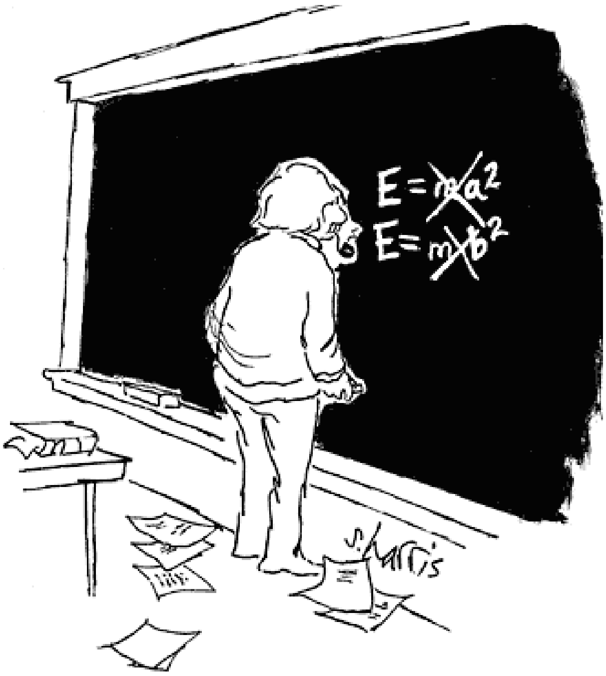
In nuclear reactions the energy released is much larger.

Nuclear Fission:

A heavy nucleus **splits** into two lighter nuclei and releases nuclear potential energy.
Nuclear fission ~ 100 GJ/mol
The mass of the products is less than the mass of the reactants.

Nuclear Fusion:

Two lighter nuclei **join** together (fuse) to form a heavier element. This is the main source of energy production on the sun, and releases about 4 times as much energy as a comparable fission reaction.
Nuclear fusion ~ 400 GJ/mol



E=ma²
E=mb²
S.Harris

Using $E = mc^2$...

1. Find the mass defect and binding energy released when a fluorine nucleus breaks apart.

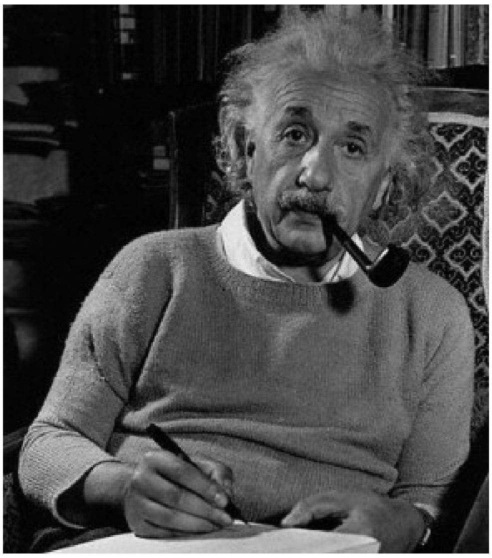
   atomic mass of $^{19}_{9}Fl = 3.1537344 \times 10^{-26}$ kg

2. Radium-226 undergoes the radioactive decay shown below. How much energy is released?

$$^{226}_{88}\text{Ra} \longrightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$$

Isotope	Mass(u)
$^{226}_{88}\text{Ra}$	226.0244
$^{222}_{86}\text{Rn}$	222.0164
$^{4}_{2}\text{He}$	4.0026

Unit of mass defined by the convention that the atom ^{12}C has a mass of exactly 12 u; the mass of 1 u is 1.66×10^{-27} kg.



3. (a) How much energy is released during the fusion reaction below?

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{2}He + ^{1}_{0}n + \text{energy}$$

	Mass (u)
$^{2}_{1}H$	2.014102
$^{3}_{2}He$	3.016029
$^{1}_{0}n$	1.008665

This is the energy released during the production of one $_{3}$He nuclei.

(b) If this reaction produces just 1.00g of ${}^{3}_{2}$He, how much energy would be released?

$$\# \text{ nuclei} = \frac{\text{mass}}{\text{mass/nuclei}}$$