

Term 2 Week 10

Nuclear Recap

Recall

*The mass of the nucleus is **less** than the total mass of the individual particles that it contains!*

This is true for all nuclei containing more than one nucleon.

The missing mass is known as the **mass difference** or the **mass defect**.

Values

As the masses involved are very small we usually measure them in atomic mass units u, where:

$$1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg}$$

Example 1

Using the data in the table opposite, calculate the mass difference for a helium nucleus in atomic mass units, and in kilograms.

	Mass (atomic mass units)
proton	1.00728 u
neutron	1.00867 u
helium nucleus	4.00151 u

$$1 \text{ u} = 1.6605 \times 10^{-27} \text{ kg}$$

$$\begin{aligned} \text{Mass of } 2p + 2n &= (2 \times 1.00728 \text{ u}) + (2 \times 1.00867 \text{ u}) \\ &= 4.03190 \text{ u} \end{aligned}$$

$$\text{But mass of helium nucleus} = 4.00151 \text{ u}$$

Example 1 continued

$$\therefore \text{Mass difference} = 4.03190 \text{ u} - 4.00151 \text{ u}$$

$$= 0.03039 \text{ u}$$

$$= 0.03039 \times 1.6605 \times 10^{-27} \text{ kg}$$

$$= 5.046 \times 10^{-29} \text{ kg}$$

$$E = m c^2$$

E is the energy equivalent (in joules, J) of a mass m (in kilograms, kg).
 c is the velocity of light ($3.00 \times 10^8 \text{ m s}^{-1}$).

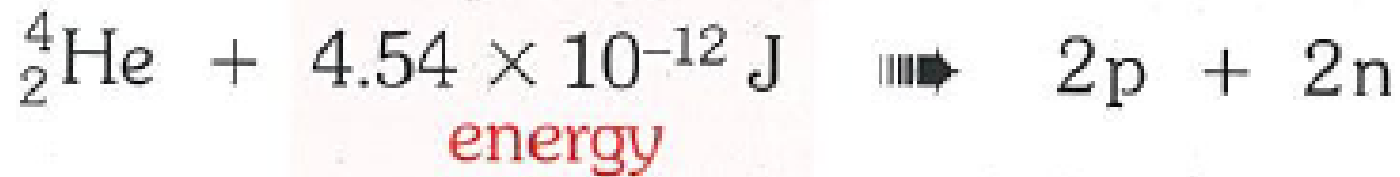
Example 2

Calculate the energy equivalent of the mass difference for the helium nucleus calculated in Example 1.

$$E = m c^2 = 5.046 \times 10^{-29} \text{ kg} \times (3.00 \times 10^8 \text{ m s}^{-1})^2$$

$$= 4.54 \times 10^{-12} \text{ J} \quad (3 \text{ s.f.})$$

This is the energy that is needed to separate the helium nucleus into individual protons and neutrons.



Energy equivalent of 1 u

mass in kilograms and energy in joules

atomic mass units (u) and electron-volts (eV)

energy equivalent (in eV) of 1 u

$$\begin{aligned} E = m c^2 &= 1.6605 \times 10^{-27} \text{ kg} \times (2.9979 \times 10^8 \text{ m s}^{-1})^2 \\ &= 1.4924 \times 10^{-10} \text{ J} \end{aligned}$$