

# Re: how is it that the Atomic Mass Unit is less than either the

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  - *Date:* Wed, 20 Sep 2006 09:29:41 +0000 (UTC)
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In article <C1322FB8.1A7E%rbj@xxxxxxxxxxxxxxxxxxxxxxxx>, robert  
bristow-johnson <rbj@xxxxxxxxxxxxxxxxxxxxxxxx> writes:

the amu is defined to be 1/12 the mass of a carbon-12 atom, i presume  
complete with 6 protons, 6 neutrons, and 6 electrons.

even if the electrons weighed nothing, each proton and neutron is more  
than the amu so it must add to more than 12 amu. how can this be?? i  
know that this is a definition, but it seems to me that the definition  
does not square with CODATA values of the most massive components of a  
carbon-12 atom and the conservation of mass principle. how does  
sticking these 6 neutrons and 6 protons together, toss in 6 electrons  
and maybe some binding energy/c<sup>2</sup> add up to less than the total? i  
don't get it.

The binding energy is negative. Thus, if we put 6 protons and 6  
neutrons together, energy is released. As a result, the mass of a  
carbon nucleus is less than the sum of its parts. The resulting energy  
is radiated away. This is how the sun produces energy, for example. In  
the sun, through intermediate steps, hydrogen is converted into heavier  
elements such as helium, carbon, oxygen, neon etc.

The process (fusion) stops at iron-56. After that, rather than having  
energy released when the mass of the nucleus increases, one has to add  
energy. Thus, fusion doesn't produce anything heavier. However, if  
there is an external (to the nucleus being transformed) source of  
energy, such as in a supernova explosion, then this energy can go into  
making heavier elements, which indeed is how they are formed. This  
energy, in turn, can be released by decreasing the mass of the nucleus.  
This happens in radioactive decay and in fission.

Note that there is no conservation of mass. (This is an approximate  
law, codified by Lavoisier, which holds for low-energy transformations,  
such as chemistry (one of the many fields in which Lavoisier was  
active). The general law is the conservation of energy, taken to  
include mass via  $E = mc^2$ .)

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