**Nuclear Binding Energy Calculations SOLUTIONS**

1. Calculate the binding energy per nucleon of a Be-9 atom with a mass of 1.4960 × 10‑26 kg. Give your answer in MeV.

*Alternative approach: convert Δ*m *to amu then calculate Δ*E *using 1 u = 931 MeV.
Your answer should be similar but may be slightly different due to the rounding involved. This also applies to many of the questions below.*

1. When an alpha particle bombards nitrogen-14, oxygen-17 is formed. Calculate the binding energy per nucleon, firstly in MeV and then in joules, of one oxygen-17 nucleus.
*m*p = 1.00728 u
*m*n = 1.00867 u
*m*O-17 = 16.999131 u

7.51 MeV

1.20 × 10-12 J

1. Fe-56 is one of the most tightly bound nuclei. What is its binding energy per nucleon in MeV? The mass of an Fe-56 atom is 55.934938 u.

8.55 MeV

1. The oxygen atom O has an isotope, O. Find the binding energy of each nucleus and thus determine which is more stable. (*m*O-16 = 15.994915 u)

O-16: 7.72 MeV per nucleon

O-17: 7.51 MeV per nucleon

∴ O-16 is more stable

1. Write a nuclear equation for the alpha decay of U-238 and calculate the energy released from one such decay.
*m*U-238 = 238.05078826 u; *m*Th-234 = 234.04360 u; *m*α = 4.001506 u

 (or )

 5.29 MeV

1. There are about 6.023 × 1023 atoms in 235 g of pure uranium-235.
	1. Calculate the energy released by one atom of U-235 when it is struck by a neutron and splits into barium-139, krypton-94, and three neutrons. Give your answer in joules and MeV. (You may wish to write a nuclear equation first.) *m*U-235 = 235.0439299 u; *m*Ba-139­ = 138.908841 u; *m*Kr-94 = 93.93436 u

171 MeV; 2.73 × 10-11 J

* 1. Little Boy, the bomb that was dropped on Hiroshima, contained 64 kg of uranium. However, it is estimated that only 80% of that uranium was U-235, and only 1 kg of that U-235 underwent nuclear fission. Calculate the energy released by this amount of U-235, assuming that all of it underwent fission as described in part a.

7.00 × 1013 J = 70.0 TJ

* 1. TNT has an energy density of 4.6 million J kg-1. How much TNT would be required to match the energy output of Little Boy?

1.52 × 107 kg = 15.2 kt

1. H-3 (*m* = 3.016049 u) and H-2 (*m* = 2.014102 u) can fuse to form He-4 (*m* = 4.002603 u) and one neutron.
	1. Calculate the mass difference.

0.018878 u

* 1. How much energy will one fusion reaction release? Give your answer in joules and MeV.

17.6 MeV

2.81 × 10-12 J

* 1. How does this compare with the energy released by the fission reaction described in question 6a?

The energy output of a single D+T fusion is approximately 10 times less than that of a single U-235 fission. (However, the mass of fuel required is almost 50 times less, so hydrogen’s energy density is significantly higher.)