$^{8}/_{10}$

J4 Energy in Nuclear Reactions

Mass defects, binding energies or energy yields in nuclear reactions require high precision data as calculations involve subtracting two very similar numbers. Use only data here (& on page iv), to **all** significant figures given:

take $c = 2.998 \times 10^{8}$ m s^{-1}, **and the electronic charge as** 1.602×10^{-19} C.

J4.1 Calculate the mass defect of $^{56}_{26}$Fe in kilograms. The ^{56}Fe **nucleus** has a mass of 55.92068 u.

J4.2 Calculate the mass defect of $^{12}_{6}$C in kilograms. The ^{12}C **atom** has a mass of 12.00000 u.

J4.3 Calculate the binding energy of ^{56}Fe in MeV.

J4.4 Calculate the binding energy per nucleon of ^{12}C in MeV.

J4.5 One nuclear fusion reaction is $^{2}_{1}\text{H} + ^{3}_{1}\text{H} \rightarrow ^{4}_{2}\text{He} + ^{1}_{0}\text{n}$. The masses of the **nuclei** are given below:

Deuterium (^{2}H) mass	$2.013\,55$ u
Tritium (^{3}H) mass	$3.015\,50$ u
Helium (^{4}He) mass	$4.001\,51$ u

Calculate the energy released by this reaction in MeV (it appears as the kinetic energy of the reaction products).

J4.6 One nuclear fission reaction is $^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{147}_{57}\text{La} + ^{87}_{35}\text{Br} + 2^{1}_{0}\text{n}$. The masses of the **atoms** are given in the table below. Calculate the energy released by this reaction in MeV.

^{235}U	$3.903\,00 \times 10^{-25}$ kg
^{147}La	$2.439\,81 \times 10^{-25}$ kg
^{87}Br	$1.443\,35 \times 10^{-25}$ kg

J4.7
a) Using the J4.5 data of nuclear masses, calculate the binding energy per nucleon in deuterium.
b) Calculate the energy released in the fusion reaction of J4.5, using the result in (a) and: Binding energy per nucleon of tritium is 2.8273 MeV, and of helium-4 is 7.0739 MeV.

J4.8
a) Using the J4.6 data table of atomic masses, calculate the binding energy per nucleon in ^{235}U in MeV.
b) Calculate the energy released in the fission reaction of J4.6, now using the result in (a) and the following data: The binding energy per nucleon for ^{147}La is 8.2227 MeV, and for ^{87}Br is 8.6055 MeV.