Introduction to Reactor System

K.S. Rajan

Professor, School of Chemical & Biotechnology

SASTRA University

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1 Quiz

1.1 Questions

1. Determine the number of nucleons in $^{238}_{92}U$.

2. What is the equivalent of 1 J in MeV?

3. Write Einstein's mass-energy relationship.

4. From Einstein's mass-energy relationship, prove that binding energy corresponding to mass defect of 1 amu is approximately 931 MeV.

5. Determine the binding energy of the nucleus in $^{233}_{90}Th$.The mass of Th-233 is 233.041581 amu.

6. Determine the average binding energy of the nucleus in $^{4}_{2}He$. The mass of ^{4}He is 4.002603 amu.

7. Calculate the velocity of a neutron whose kinetic energy is 2 MeV.

1.2 Answers

1. Number of nucleons = number of particles heavier than electron = number of protons + number of neutrons

Number of protons = 92
Number of neutrons = 238-92 = 146
Number of nucleons = 146 + 92 = **238**

2. 1 MeV = 1.6×10^{-13} J

Therefore, 1 J = 6.25×10^{12} MeV

3. $E = mc^2$ (E is the energy, m is the mass and c is the velocity of light)

4. $E = m_d c^2$

$c = 2.998 \times 10^8$ m/s; md = 1 amu = 1.66×10^{-24} g=1.66×10^{-27} kg
$E = 1.66 \times 10^{-27} * (2.998 \times 10^8)^2 = 932.5$ MeV
The difference between the calculated and target values is very small. This could be due to errors in rounding off.

5. Recalling Eq. (2), $m_d = Z(1.007825)+N(1.008665)-M$

Z= 90; A = 233; N = A-Z = 143, M = 233.041581 amu

Substituting above in Eq. (2) yields a mass defect (m_d) of 1.90176 amu.

Recalling that 1 amu corresponds to 931 MeV, the binding energy of U-235 is 1770.5 MeV

6. Recalling Eq. (2), $m_d = Z(1.007825)+N(1.008665)-M$

Z= 2; A = 4; N = A-Z = 2, M = 4.002603 amu

Substituting above in Eq. (2) yields a mass defect (m_d) of 0.030377 amu.

Recalling that 1 amu corresponds to 931 MeV, the binding energy of U-235 is 28.281 MeV

Average binding energy = Binding energy/A = 28.281/4 = 7.07025 MeV

7. From Eq. (6), we have $0.5 m_n u_n^2 = E_n$

$m_n = 1.008665$ amu = 1.6744×10^{-27} kg

$E_n = 2$ MeV = 3.2×10^{-13} J

Substituting for m_n and E_n in Eq. (6), we get the velocity of neutron as 19550 km/s