

Jedro, masni defekt, vezavna energija

1. Koliko energije ustreza 1 atomski masni enoti? In kolikšna masi elektrona?

$$W = mc^2 = uc^2 = 1,660 \cdot 10^{-27} \text{ kg} \cdot 931,5 \text{ MeV/u} = 931,5 \text{ MeV}$$

$$W_{el} = mc^2 = 0,000549 \text{ u} \cdot 931,5 \text{ MeV/u} = 0,511 \text{ MeV}$$

2. Oцени gostoto atomskih jeder! $\rho = m/4\pi r^3/3 = 3u/4r_0^3 = 4 \cdot 10^{17} \text{ kg/m}^3$ $m = \text{Au}$, $r = r_0 A^{1/3}$

3. Določi vezavno energijo devterona ${}^2\text{H}$. Atomske mase vodika, nevtrona in devterija so: 1,007825 u, 1,008665 u, 2,0141018 u. Masa protona je 1,007276 u, masa nevtrona 1,008665 u in masa devterona je 2,013553 u. Devterij je atom težkega vodika, devteron pa njegovo jedro, u je atomska masna enota. Vsaj kolikšno valovno dolžino mora imeti foton, da razbije devteron?

z jedrskimi masami: (običajno jedrskih mas nimamo podanih)

$$\Delta m = m_p + m_n - m_j = (1,007276 + 1,008665 - 2,013553) \text{ u} = 0,002388 \text{ u}$$

$$W_v = \Delta mc^2 = 0,002388 \text{ uc}^2 = \mathbf{2,2 \text{ MeV}}$$
 ($uc^2 = 931,494013 \text{ MeV}$)

z atomskimi masami:

$$\Delta m = m_{p+e} + m_n - m_{j+e} = m_H + m_n - m_{\text{devterij}}$$

$$\Delta m = (1,0078250 + 1,008665 - 2,0141018) \text{ u} = 0,002388 \text{ u}$$

$$W_v = \Delta mc^2 = \mathbf{2,2 \text{ MeV}}$$
 ($uc^2 = 931,494013 \text{ MeV}$)

$$W_v = W_f = hc/\lambda \quad \rightarrow \lambda = hc/W_v = 563 \text{ fm}$$

4. Določi specifično vezavno energijo na nukleon jedra ${}^{12}\text{C}$.

$$\Delta m = 6m_p + 6m_n - m_j = 6(m_H + m_n) - m_C$$

$$\Delta m = [6(1,007825 + 1,008665) - 12,000000] \text{ u} = 0,098940 \text{ u}$$

$$W_v = \Delta mc^2 = \mathbf{92,1 \text{ MeV}} \quad w_v = W_v / A = 92,1 \text{ MeV}/12 = \mathbf{7,7 \text{ MeV / nukleon}}$$

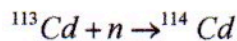
5. Kolikšna sta masni defekt in vezavna energija jedra helijevega atoma? Masa helijevega atoma ${}^4\text{He}$ je 4,00260 u, masa protona 1,007276 u, masa nevtrona 1,008579 u, masa elektrona 0,000549 u in masa vodika ${}^1\text{H}$ je 1,007825 u.

$$\Delta m = 2m_p + 2m_n - m_j = 2m_p + 2m_n - (m_{He} - 2m_e)$$

$$\Delta m = 2m_H + 2m_n - m_{He}$$

$$\Delta m = 0,03 \text{ u} \quad W_v = \Delta mc^2 = \mathbf{27,9 \text{ MeV}}$$

6. Kadmij ${}^{113}\text{Cd}$ absorbira počasni nevtron. Koliko energije se pri tem sprosti? Koliko energije pa bi se sprostil v 1 g ${}^{113}\text{Cd}$, če je izkoristek pretvorbe v ${}^{114}\text{Cd}$ enak 10^{-8} . Atomske mase ${}^{113}\text{Cd}$, ${}^{114}\text{Cd}$ in nevtrona so 112,9406 u, 113,94013 u in 1,00898 u.



$$\Delta m = (m_{{}^{113}\text{Cd}} + m_n) - (m_{{}^{114}\text{Cd}}) = 0,009135 \text{ u}$$

$$W_1 = \Delta mc^2 = 0,009135 \text{ u} \cdot 931,5 \text{ MeV/u} = 8,51 \text{ MeV}$$

$$N = \frac{m}{M} N_A = \frac{1 \text{ g}}{113 \text{ g/mol}} \cdot 6,02 \cdot 10^{23} \text{ atomov/mol} = 5,33 \cdot 10^{21} \text{ atomov}$$

$$W = N \eta W_1 = 4,54 \cdot 10^{20} \text{ eV} = 72,6 \text{ J}$$



1.

Verona enyija $W = \Delta m c^2$

Atomula anota mool: $u = \frac{1}{12} C^{12} = 1,660565 \cdot 10^{-27} \text{ kg}$

$m_e = 5,4857 u$

$W_u = m u \cdot c^2$

$N_A [\text{mol}^{-1}]$

$W_u = 1 \cdot 1,660565 \cdot 10^{-27} \text{ kg} \cdot 300 \cdot 10^8 \text{ m/s}$

$1 \text{ g} = N_A u$

$\left. \begin{array}{l} \text{eV} / \div \\ \downarrow \end{array} \right\} \begin{array}{l} W_u = 1,49244 \cdot 10^{-10} \text{ J} \Rightarrow \text{eV} \\ \text{eV} = 1,60217733 \cdot 10^{-19} \text{ J} \end{array}$

$W_u = \frac{1,49244 \cdot 10^{-10} \text{ J}}{1,60217733 \cdot 10^{-19} \text{ J}} = 931,51 \cdot 10^6 \text{ eV} = 931,51 \text{ MeV}$

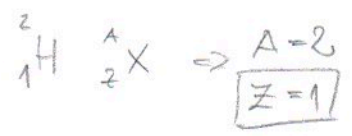
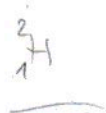
$W_e = m_e \cdot u \cdot c^2 = 1,35952 \cdot 10^{-40} \text{ J}$

$\Rightarrow W_e = 510999 \text{ eV} = 0,511 \text{ MeV}$



3.

u-atomsko masa enote [kg]



$W_b = ?$ $\lambda_{\text{min}} = ?$ da uspije deuteron? ($W_b = W_f$)

$A = Z + N \Rightarrow N = A - Z = \boxed{1}$

$m_H = 1,007825 \text{ u}$

$m_m = 1,008665 \text{ u}$

$m_{\text{deut.}} = 2,0141018 \text{ u}$

$m_p = 1,007276 \text{ u}$

$m_{\text{deut.}} = m_n = 2,013553 \text{ u}$

$W_b = \Delta m_H \cdot c^2$

$\Delta m = Z \cdot m_p + N \cdot m_n - m_d$

$\Delta m = (1,007276 + 1,008665 - 2,013553) \text{ u}$

$\boxed{\Delta m = 0,002388 \text{ u}}$

$W_b = 0,002388 \text{ u} \cdot \left(300 \cdot 10^6 \frac{\text{m}}{\text{s}}\right)^2$

$\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2} = \text{J}$

[J] $W_b = 3,56389 \cdot 10^{-13} \text{ J} \quad /: 1 \text{ eV} = 1,60217 \cdot 10^{-19} \text{ J} / \text{ eV}$

[eV] $W_b = \boxed{2,2244 \text{ MeV}}$

$\lambda_{\text{min}} = ?$

$W_b = W_f \rightarrow$ minimalna energija za uspije deuterona.

$W_f = \frac{hc}{\lambda_{\text{min}}} \Rightarrow \lambda_{\text{min}} = \frac{hc}{W_b}$
[Jm] / [J]

$\lambda_{\text{min}} = \frac{6,626 \cdot 10^{-34} \text{ Js} \cdot 300 \cdot 10^6 \frac{\text{m}}{\text{s}}}{3,56389 \cdot 10^{-13} \text{ J}} = \boxed{557,38 \text{ nm}}$



(h.)

$$\begin{aligned} A &= Z + N \\ Z &= X \\ N &= A - Z = \boxed{6} \end{aligned}$$



$$W_v = \Delta m c^2$$

$$m_c = 12u$$

$W_v = ?$

$$\Delta m = Z \cdot m_p + N \cdot m_n - m_c$$

$$\Delta m = Z \cdot m_H + N \cdot m_n - m_c$$

$$\Delta m = (6 \cdot 1,007825 + 6 \cdot 1,008665 - 12)u$$

$$\boxed{\Delta m = 0,09894 \text{ u / kg}}$$



$$W_v = \Delta m c^2$$

$$W_v = 0,09894 \cdot u [\text{kg}] \cdot (300 \cdot 10^6 \cdot [\frac{m}{s}])^2$$

$$\boxed{W_v = 1,476599 \cdot 10^{-11} \text{ J}}$$

$$\boxed{W_v = 92,162 \text{ MeV}}$$



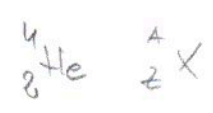
! stupni
vebej!

$$w_n = \frac{W_v}{A} = \frac{92,162 \text{ MeV}}{12} = \boxed{7,68 \text{ MeV}}$$

na nukleon



5.



- $m_{\text{He}} = 4,00260 \text{ u}$
- $m_p = 1,007276 \text{ u}$
- $m_n = 1,008665 \text{ u}$
- $m_e = 0,000549 \text{ u}$
- $m_H = 1,007825 \text{ u}$

$$\Delta m = Z \cdot m_H + N \cdot m_n - m_{\text{He}}$$

$$\Delta m = (2 \cdot 1,007825 + 2 \cdot 1,008665 - 4,00260) \text{ u}$$

$$\Delta m = 0,030208 \text{ u}$$

$\Delta m_{\text{He}} = ?$
 $W_v = ?$

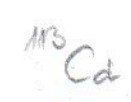
$$W_v = \Delta m \cdot c^2$$

$$W_v = 0,030208 \text{ u} [\text{kg}] \cdot (300 \cdot 10^8 \left[\frac{\text{m}}{\text{s}}\right])^2$$

$$W_v = 4,508299 \cdot 10^{12} \text{ J}$$

$$W_v = 28,139 \text{ MeV}$$

6.



$$\eta = 1 \cdot 10^{-8}$$

$$m = 1 \text{ g} = 1 \cdot 10^{-3} \text{ kg}$$

$$m_{113\text{Cd}} = 112,9406 \text{ u}$$

$$m_{114\text{Cd}} = 113,9403 \text{ u}$$

$$m_n = 1,008665 \text{ u}$$

$$\Delta m = m_{113\text{Cd}} + m_n - m_{114\text{Cd}}$$

$$\Delta m = (112,9406 + 1,008665 - 113,9403) \text{ u}$$

$$\Delta m = 0,008968 \text{ u}$$

$$W_{\text{atom}} = 0,008968 \text{ u} [\text{kg}] \cdot (300 \cdot 10^8 \left[\frac{\text{m}}{\text{s}}\right])^2$$

$$W_{\text{atom}} = 1,410336 \cdot 10^{12} \text{ J}$$

$$W_{\text{atom}} = 8,80262 \text{ MeV}$$

$W_{\text{atom}} = ?$ ~ energija neutrona
 $W_{1\text{g}} = ?$ ~ energija neutrona
 u 1g

Štirnba nukleona u 1g;

tu isto izračunati u energiji
 posredstvom:

$$N = \frac{m}{A} \cdot N_A = \frac{1 \text{ g}}{113 \frac{\text{g}}{\text{mol}}} \cdot 6,02 \cdot 10^{23} \frac{\text{atom}}{\text{mol}}$$

$$N = 5,3293 \cdot 10^{21} \text{ atom}$$

$$W_{1\text{g}} = N \cdot \eta \cdot W_{\text{atom}} = 4,6912 \cdot 10^{20} \text{ eV} = 7,916 \cdot 10^7 \text{ J}$$

