

# Problemler

1-)  $^{15}_8\text{O}$  ve  $^{15}_7\text{N}$ 'nin bilinen kütlelerinden bağlanma enerjilerindeki farkı hesaplayınız. Bunun Coulomb enerjisiindeki farktan oluştuğunu kabul ederek bu izotopların çekirdek yarıçaplarını hesaplayınız.

$$\begin{aligned} BE \ ^{15}_8\text{O} &= [8m_p + 7m_n - m \ ^{15}_8\text{O}] c^2 \\ &= [8 \cdot (1,007825 \text{ u}) + 7(1,008665 \text{ u}) - 15,003065 \text{ u}] \times 931,5 \frac{\text{MeV}}{\text{u}} \\ &= 111,957 \text{ MeV} \end{aligned}$$

$$\begin{aligned} BE \ ^{15}_7\text{N} &= [7 \cdot (1,007825 \text{ u}) + 8(1,008665 \text{ u}) - 15,00069 \text{ u}] \times \\ & \quad 931,5 \frac{\text{MeV}}{\text{u}} \\ &= 115,493 \text{ MeV} \end{aligned}$$

$$\Delta B = 3,536 \text{ MeV}$$

Coulomb Enerjisi  $E_C = \frac{3}{5} \frac{e^2}{4\pi\epsilon_0 R} (2Z-1)$

$$\Delta B = E_C$$

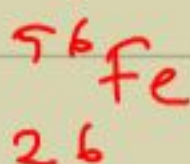
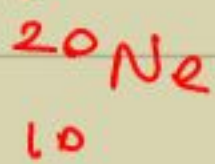
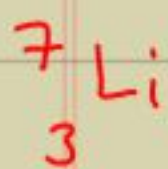
$$R = \left( \frac{3}{5} \right) \left( \frac{e^2}{4\pi\epsilon_0} \right) \left( \frac{2Z-1}{\Delta B} \right)$$

$$R = \frac{3}{5} \cdot 9 \times 10^9 \cdot (1,6 \times 10^{-19})^2 \cdot \frac{2 \cdot 8 - 1}{3,536 \times 10^6 \cdot 1,6 \times 10^{-19}}$$

$$R = 36,6516 \times 10^{-16} \text{ m} \times 10^{15} \text{ fm}$$

$$R = 3,66516 \text{ fm}$$

2-) Aşağıdaki çekirdekler için bağlanma enerjisini ve nükleon bağlanma enerjisini bulunuz.



$${}^7\text{Li için: } BE = (3m_p + 4m_n - m^7\text{Li})c^2$$

$$= [3(1,007825u) + 4(1,008665u) - 7,016003u] \times$$

$$= 39,246 \text{ MeV}$$

$$931,5 \frac{\text{MeV}}{u}$$

$$B/A = \frac{39,246}{7} = 5,607 \text{ MeV/nükleon}$$

$${}^{20}_{10}\text{Ne için; } M^{{}^{20}\text{Ne}} = 19,992436u \text{ Kütle tablo}$$

$$BE = 160,651 \text{ MeV}$$

$$B/A = \frac{160,651}{20} = 8,033 \frac{\text{MeV}}{\text{nükleon}}$$

$${}^{56}_{26}\text{Fe için; } M^{{}^{56}\text{Fe}} = 55,934939u$$

$$BE^{{}^{56}\text{Fe}} = 492,262 \text{ MeV}$$

$$B/A = \frac{492,262}{56} = 8,79 \frac{\text{MeV}}{\text{nükleon}}$$

$${}^{235}_{92}\text{U için; } BE = 1783,892 \text{ MeV}$$

$$B/A = 7,591 \text{ MeV/nükleon}$$

3-)  $^{32}_{16}\text{S}$ ,  $^{20}_{10}\text{F}$  ve  $^{238}_{92}\text{U}$  çekirdekleri için kütle eksikliğini bulunuz.

$$\Delta = M(A, Z) - A \text{ mass defect}$$

$$\Delta^{32}_{16}\text{S} = (31,972071 - 32)931,5 = -26,016 \text{ MeV}$$

$$\Delta^{20}_{10}\text{F} = (19,99981 - 20)931,5 = -0,018 \text{ MeV}$$

$$\Delta^{238}_{92}\text{U} = (238,050785 - 238)931,5 = 47,306 \text{ MeV}$$

4-)  $^{20}_{10}\text{Ne}$ ,  $^{55}_{25}\text{Mn}$  ve  $^{197}_{79}\text{Au}$  için proton ayrılma enerjilerini hesaplayınız.

$$S_p = [m(A-1, Z-1) - m(A, Z) + m_H]c^2$$

$$S_p = (m^{19}_{9}\text{F} - m^{20}_{10}\text{Ne} + m_H)c^2$$

$$S_p(^{20}_{10}\text{Ne}) = 18,998403 - 19,992436 + 1,007825)931,5$$

$$S_p(^{20}_{10}\text{Ne}) = 12,847 \text{ MeV}$$

$$S_p(^{55}_{25}\text{Mn}) = (m^{54}_{24}\text{Cr} - m^{55}_{25}\text{Mn} + m_H)c^2$$

$$S_p(^{55}_{25}\text{Mn}) = 53,938882 - 54,93047 + 1,007825)931,5$$

$$= 8,067 \text{ MeV}$$

$$S_p(^{197}_{79}\text{Au}) = (m^{196}_{78}\text{Pt} - m^{197}_{79}\text{Au} + m_H)c^2$$

$$= (195,964926 - 196,966543 + 1,007825)931,5$$

$$S_p(^{197}_{79}\text{Au}) = 5,783 \text{ MeV}$$

5-)  ${}^7\text{Li}$ ,  ${}^{91}\text{Zr}$  ve  ${}^{236}\text{U}$  için nötron ayrılma enerjilerini hesaplayınız.

$$S_n = [m(A-1, Z) - M(A, Z) + m_n]c^2$$

$$S_n = [m({}^6\text{Li}) - m({}^7\text{Li}) + m_n]c^2$$

$$S_n = (6,015131 - 7,016003 + 1,008665) 931,5$$

$$S_n = 7,25 \text{ MeV} \rightarrow {}^7\text{Li} \text{ için}$$

${}^{91}\text{Zr}$  için;

$$S_n({}^{91}\text{Zr}) = [m({}^{90}\text{Zr}) - m({}^{91}\text{Zr}) + m_n]c^2$$

$$S_n = [89,904703 - 90,905644 + 1,008665] 931,5$$

$$S_n = 7,195 \text{ MeV}$$

${}^{236}\text{U}$  için;

$$S_n({}^{236}\text{U}) = (235,043924 - 236,045563 + 1,00866) \times 931,5$$

$$S_n = 6,945 \text{ MeV}$$

6-)  ${}^{21}\text{Ne}$ ,  ${}^{57}\text{Fe}$  ve  ${}^{256}\text{Fm}$  için toplam bağlanma enerjisini ve Coulomb enerjisini yarı ampirik kütle formülünü kullanarak hesaplayınız.

$$B(A, Z) = a_v A - a_s A^{2/3} - a_c \frac{(Z-1)^2}{A^{1/3}} + \delta(A, Z)$$

$$a_v = 15,6 \text{ MeV} \quad a_s = 23,3 \text{ MeV} \quad a_c = 17,3 \text{ MeV}$$

$$a_c = 0,70 \text{ MeV} \quad -3/4$$

$$\delta(A, Z) = 33,5 A \text{ MeV} \rightarrow Z \text{ ve } N \text{ çift}$$

$$\delta(A, Z) = -33,5 A^{3/4} \text{ MeV} \rightarrow Z \text{ ve } N \text{ tek}$$

$$\delta(A, Z) = 0 \rightarrow A \text{ Tek}$$

$$E_c = 0,70 Z(Z-1) A^{-1/3}$$

$${}^{21}\text{Ne} \text{ için } Z=10 \text{ ve } N=11$$

$$B({}^{21}\text{Ne}) = 15,6(21) - 17,3(21)^{2/3} - 0,70(10)(9)(21)^{-1/3} - 23,3 \frac{(21-20)^2}{21} + 0$$

$$\left[ \begin{aligned} B({}^{21}\text{Ne}) &\approx 173,04 \text{ MeV} \\ E_c &= 0,70(10)(9)(21) \approx 23,49 \text{ MeV} \end{aligned} \right]$$

$$\left[ \begin{aligned} B({}^{57}\text{Fe}) &\approx 502,98 \text{ MeV} \\ E_c &\approx 121,61 \text{ MeV} \end{aligned} \right]$$

$$\left[ \begin{aligned} {}^{256}_{100}\text{Fm} \text{ için } \delta &= +33,5(256)^{-3/4} \\ B({}^{256}\text{Fm}) &\approx 1886,86 \text{ MeV} \\ E_c &\approx 1122,79 \text{ MeV} \end{aligned} \right]$$

7-) a)  ${}^7\text{Li}$ ,  ${}^{236}\text{U}$ 'nun nötron ayırma enerjisini  
b)  ${}^{20}\text{Ne}$ ,  ${}^{55}\text{Mn}$  ve  ${}^{197}\text{Au}$ 'nun proton ayırma enerjisini hesaplayınız.

$$\text{Nötron Ayırma Enerjisi; } S_n = B({}^A_Z X_N) - B({}^A_{Z-1} X_{N-1})$$

$$\text{Proton Ayırma Enerjisi; } S_p = B({}^A_Z X_N) - B({}^A_{Z-1} X_N)$$

$$M_{\text{Atom}}(Z, A)c^2 - Zm_e c^2 = Zm_p c^2 + Nm_n c^2 - B$$

$$B = Z(m_p + m_e)c^2 + Nm_n c^2 - M(A, Z)c^2$$

$$\Rightarrow S_n = Z(m_p + m_e)c^2 + Nm_n c^2 - M(Z, A)c^2 - [Z(m_p + m_e)c^2 + (N-1)m_p c^2 - M(Z, A-1)c^2]$$

$$= m_n c^2 + M(Z, A-1)c^2 - M(Z, A)c^2$$

$$\Rightarrow S_p = Z(m_p + m_e)c^2 + Nm_n c^2 - M(Z, A)c^2 - [(Z-1)(m_p + m_e)c^2 + Nm_p c^2 - M(Z-1, A-1)c^2]$$

$$= (m_p + m_e)c^2 + M(Z-1, A-1)c^2 - M(Z, A)c^2$$

$$= M(^1\text{H})c^2 + M(Z-1, A-1)c^2 - M(Z, A)c^2$$

$$a) {}^7_3\text{Li}; S_n = m_n c^2 + M({}^6_3\text{Li})c^2 - M({}^7_3\text{Li})c^2$$

$$= [m_p + M({}^6\text{Li}) - M({}^7\text{Li})]c^2$$

$$= [1,00866501 + 6,015121 - 7,016003]931,5$$

$$= 7,250 \text{ MeV}$$

$$g) \text{Zr}; S_n = (m_n + M({}^{90}_{40}\text{Zr}) - M({}^{91}_{40}\text{Zr}))c^2$$

$$S_n = (1,00866501 + 89,904703 - 90,905644)931,5$$

$$S_n = 7,195 \text{ MeV}$$

$${}^{236}_{92}\text{U}; S_n = [m_n + M({}^{235}_{92}\text{U}) - M({}^{236}_{92}\text{U})]c^2$$

$$S_n = (1,00866501 + 235,043924 - 236,045563)931,5$$

$$= 6,545 \text{ MeV}$$

Not: sihirli sayılardan bu 18 MeV kadar olabilir.

$$b) {}^{20}_{10}\text{Ne}; S_p = [M(^1\text{H}) + M({}^{19}_{9}\text{F}) - M({}^{20}_{10}\text{Ne})]c^2$$

$$= (1,00782505 + 18,998403 - 19,992436)931,5$$

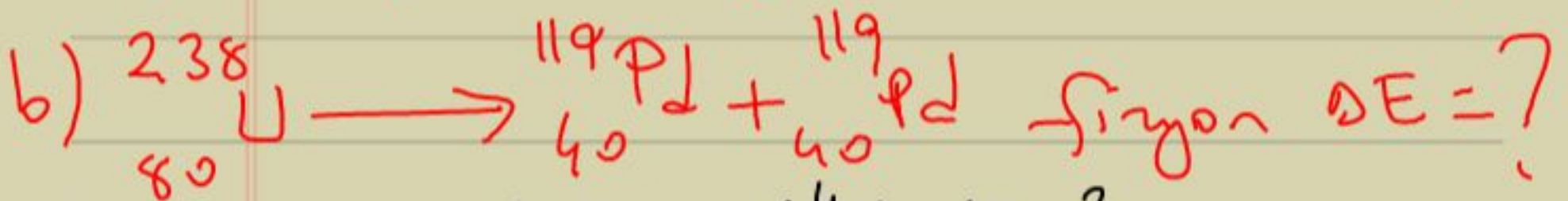
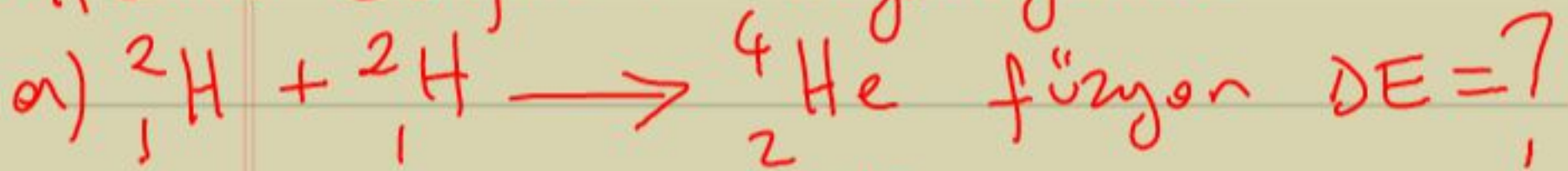
$$= 12,847 \text{ MeV}$$

$${}_{25}^{55}\text{Mn}; S_p = [m({}^1_1\text{H}) + m({}^{54}_{24}\text{Cr}) - M({}^{55}_{25}\text{Mn})]c^2 = 8,067 \text{ MeV}$$

$${}_{79}^{197}\text{Au}; S_p = [m({}^1_1\text{H}) + m({}^{196}_{78}\text{Pt}) - M({}^{197}_{79}\text{Au})]c^2$$

$$S_p = 5,783 \text{ MeV}$$

8-) Fizyon ve füzyon sonucunda açığa çıkan enerjileri karşılaştırınız.



$$a) \Delta E = [2 \times M({}^2_1\text{H}) - M({}^4_2\text{He})]c^2$$

$$= (2 \times 2,014102 - 4,002603) 931,5$$

$$\Rightarrow \Delta E = 23,85 \text{ MeV}$$

Diğer bir yol;

$$M(Z, A)c^2 - Zm_e c^2 = Zm_p c^2 + Nm_n c^2 - B(Z, A)$$

$$B(1, 2) = [(m_p + m_e)c^2 + m_n c^2 - M(1, 2)]c^2$$

$$= M({}^1_1\text{H})c^2 + m_n c^2 - M(1, 2)c^2 = 2,224 \text{ MeV}$$

$$B/A = 1,112$$

Eğer  $m_e$  ihmal edilirse  $B(1, 2) = 1,713 \text{ MeV}$   
 Çok az nükleon olduğundan  $m_e$ 'yi ihmal etmiyoruz. (edemiyoruz)

$$\begin{aligned}
 B(2,4) &= Z(m_e + m_p)c^2 + Nm_n c^2 - M(2,4)c^2 \\
 &= [2(1,00782505) + 2,1,00866501 - 4,002603]931,5 \\
 &= 28,296 \text{ MeV}
 \end{aligned}$$

$$B/A = 7,074$$

$$DE = B(2,4) - 2 \cdot B(1,2)$$

$$= 28,296 - 4,448 = 23,848 \text{ MeV}$$

$$B/A \rightarrow 5,96$$

$$b) DE = 2 \times B\left(\begin{smallmatrix} 119 \\ 40 \end{smallmatrix} \text{Pd}\right) - B\left(\begin{smallmatrix} 238 \\ 80 \end{smallmatrix} \text{U}\right)$$

$$= 190,4 \text{ MeV}$$

$$B/A = 0,8 \text{ MeV}$$