

Noteset 1E (Part 2)

Atomic Stability

Atomic Stability

Z-Ratio

Ratio of the $\# n^0$ to $\# p^+$ in the atomic structure.

$$Z_{\text{ratio}} = \frac{\# n^0}{\# p^+}$$

$$n^0 = \text{Mass\#} - \text{Atomic\#}$$

Stability and Z-Ratio

Small Atoms (1-20)

Zratio : 1 - 1.2

Medium Atoms (21-54)

Zratio : 1.2 - 1.4

Large Atoms (55-82)

Zratio : 1.4 - 1.5

Zratio > 1.5 (83+) Not Stable

Atomic Stability

$p^+ - e^-$ interactions

nucleus

orbitals

p^+ and n^0

e^-

$(p^+) + \xleftarrow{\text{attraction}} - (e^-)$
Full attract

$(p^+) + \xleftarrow{n^0} - (e^-)$
Reduced Attract shielding

Ratio too low

not enough n^0 (reduced shielding)

$${}^6_6\text{C} : Z_{\text{ratio}} = \frac{5}{6} = 0.83$$

Ratio too high

too many n^0 (increased shielding)

$${}^{14}_6\text{C} : Z_{\text{ratio}} = \frac{8}{6} = 1.33$$

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Nuclear Stability

Atomic Size

Small: $Z_{\text{ratio}} \approx 1.0 - 1.1$

Medium: $Z_{\text{ratio}} \approx 1.2 - 1.3$

Large: $Z_{\text{ratio}} \approx 1.4 - 1.5$

Above Pb: Not Stable

Small $Z = 1.0$

${}^{12}_6\text{C} : 6p^+ \text{ and } 6n^0$

Medium $Z = 1.2$

${}^{65}_{29}\text{Cu} : 29p^+ \text{ and } 36n^0$

Large $Z = 1.5$ last stable

${}^{205}_{82}\text{Pb} : 82p^+ \text{ and } 123n^0$

Atoms above Pb

Atomic # > 82

${}^{238}_{92}\text{U} : 92p^+ \text{ and } 146n^0$

$$Z_{\text{ratio}} = \frac{146n^0}{92p^+} = \underline{1.56}$$

Above $Z = 1.5$ Not Stable

$Z_{\text{ratio}} > 1.5$

Atom is TOO LARGE

${}^{235}_{92}\text{U} : 92p^+ \text{ and } 143n^0$

$$Z_{\text{ratio}} = \frac{143n^0}{92p^+} = 1.55$$

Above $Z_{\text{ratio}} = 1.5$ Not Stable

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Stability of LARGE Atoms ($Z_{ratio} > 1.5$)

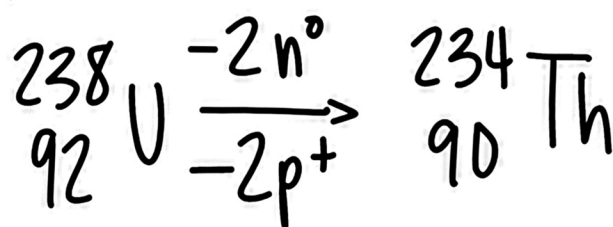
Alpha (α) Decay: Make atoms smaller

Alpha (α) : He nucleus
Decay : ($2p^+$ and $2n^0$)



Result

Atom loses $2p^+$ and $2n^0$



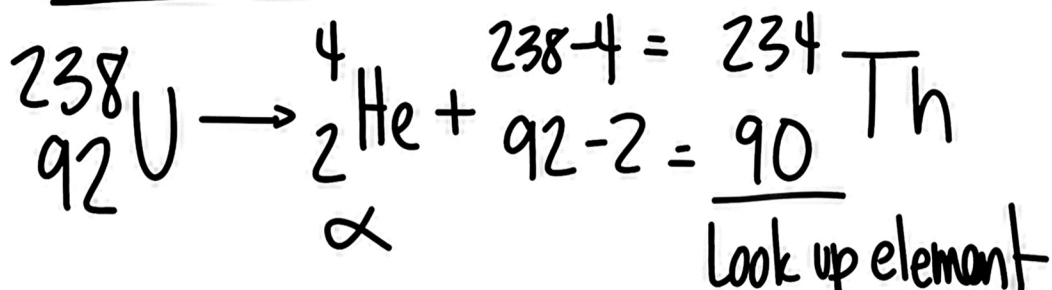
Mass# -4 Atomic# -2

Alpha Decay Equations

α decay: $\begin{array}{c} 4 \\ 2 \text{ He} \end{array}$
 $2p^+$ and $2n^0$

Decay Equation

$\xrightarrow{\text{start}} \begin{array}{c} 4 \\ 2 \text{ He} \\ \alpha \end{array} + \xrightarrow{\text{final}}$
Reactant yields Products



90
Th
Thorium

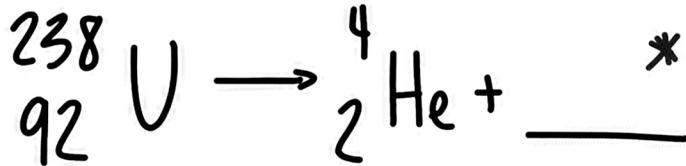
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Atomic Stability

Nuclear Equations

given starting isotope

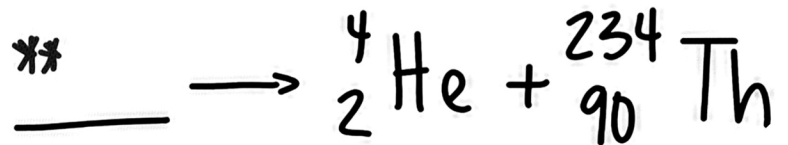
Subt. Values



$$\begin{aligned} * \quad 238 - 4 &= 234 \\ 92 - 2 &= 90 \end{aligned} \text{Th}$$

given final isotope

Add Values



$$\begin{aligned} ** \quad 4 + 234 &= 238 \\ 2 + 90 &= 92 \end{aligned} \text{U}$$