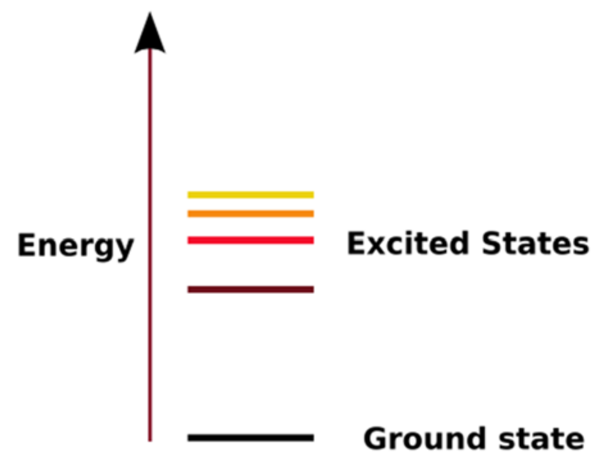
Chemical Engineering 412

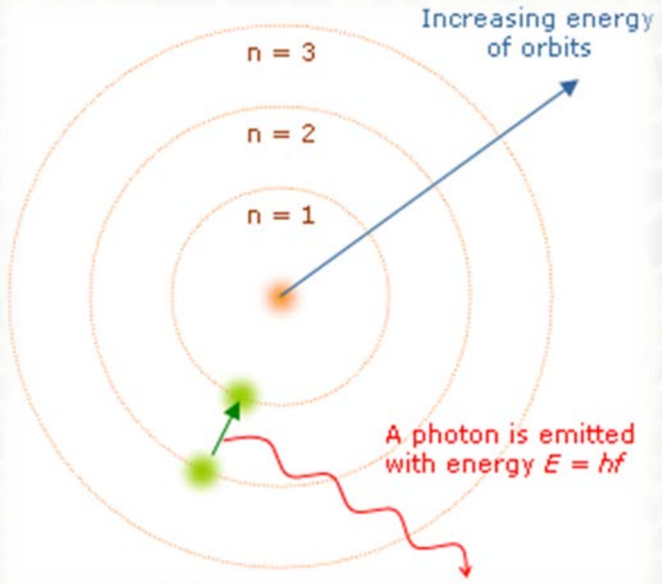
Introductory Nuclear Engineering

Lecture 4:

Atomic & Nuclear Models

Electron Energy States (a review)

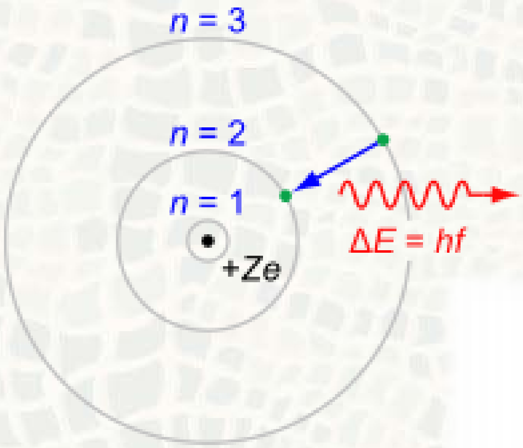


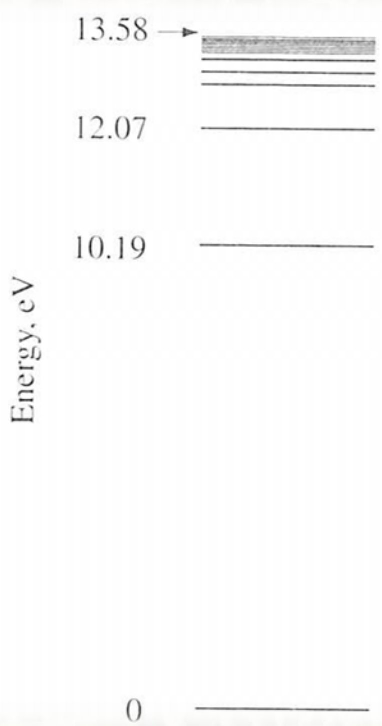


Bound, atomic electrons live in specific energy levels

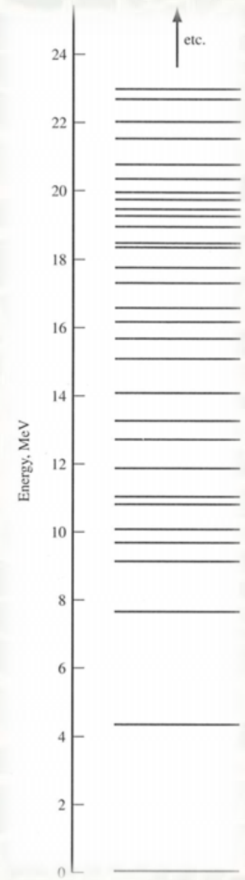
Nuclei Energy States

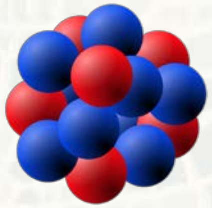
(a surprise?)





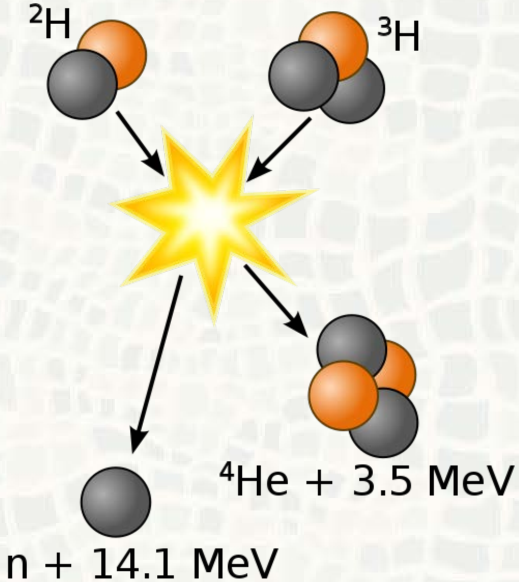
Atomic Energy Levels (H)

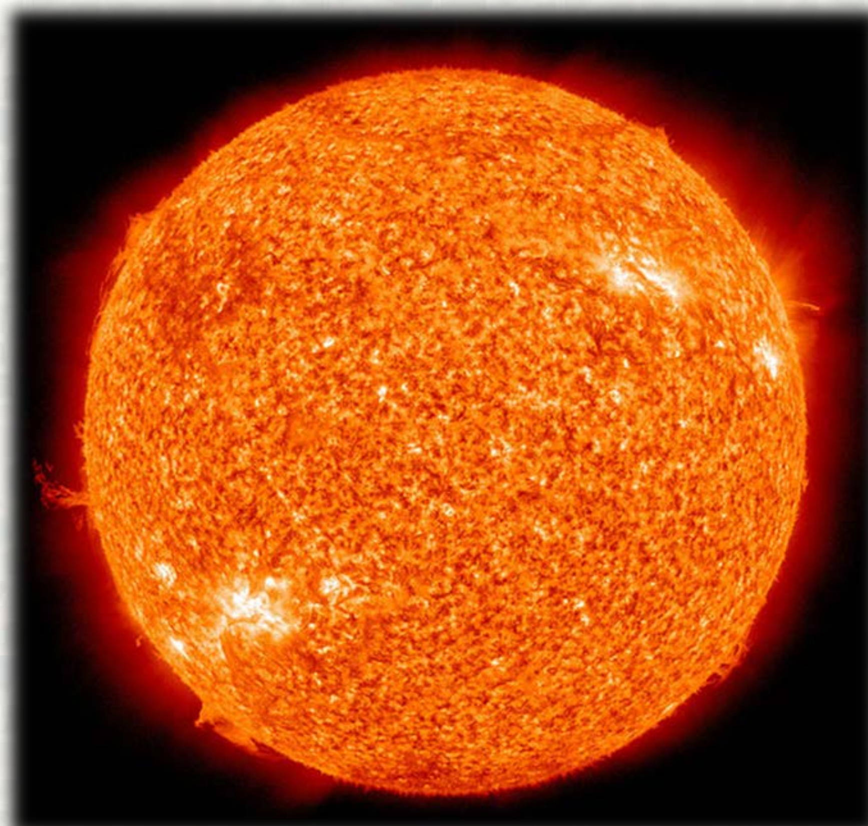


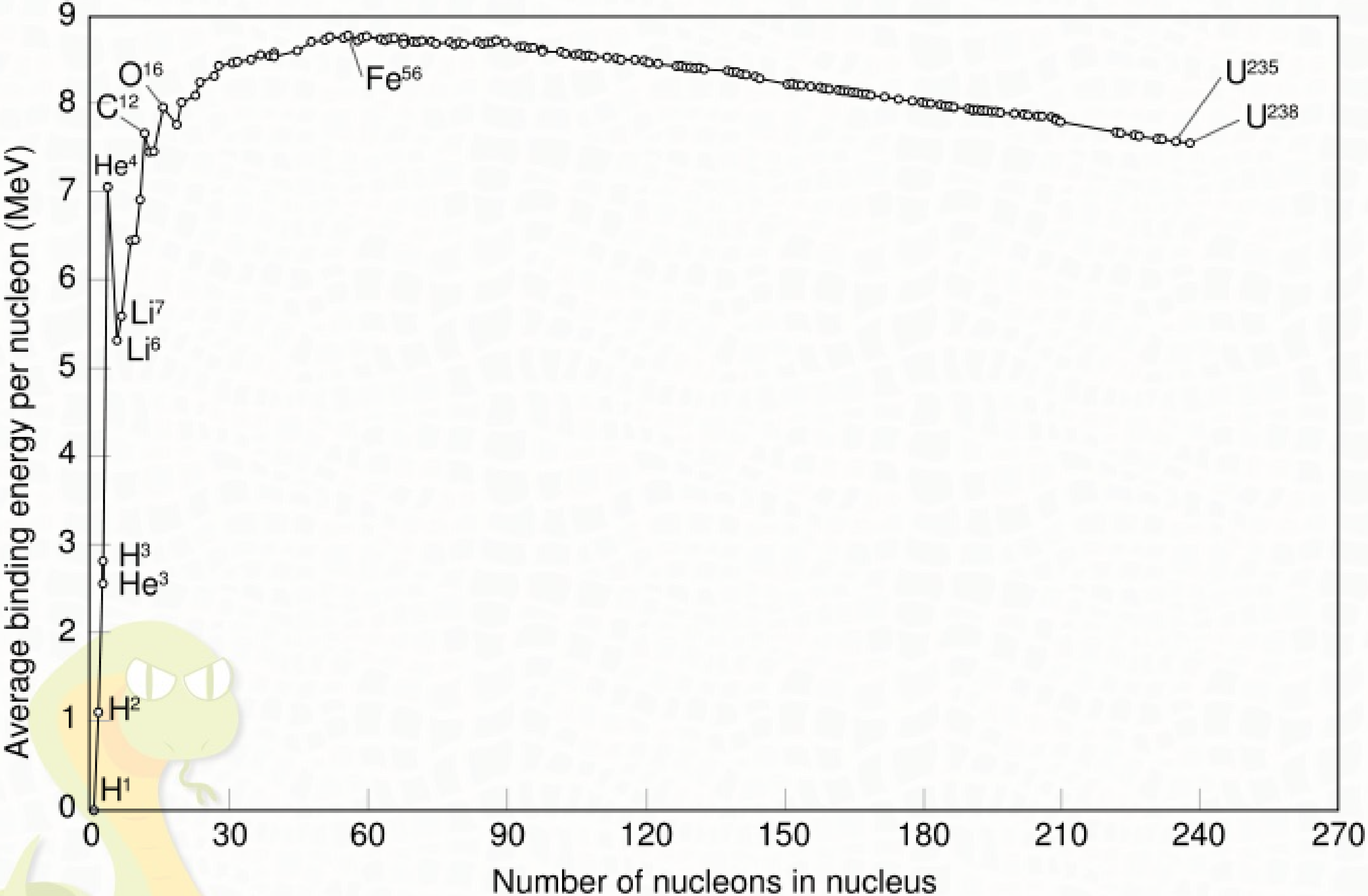


Nuclear Energy Levels (^{12}C)

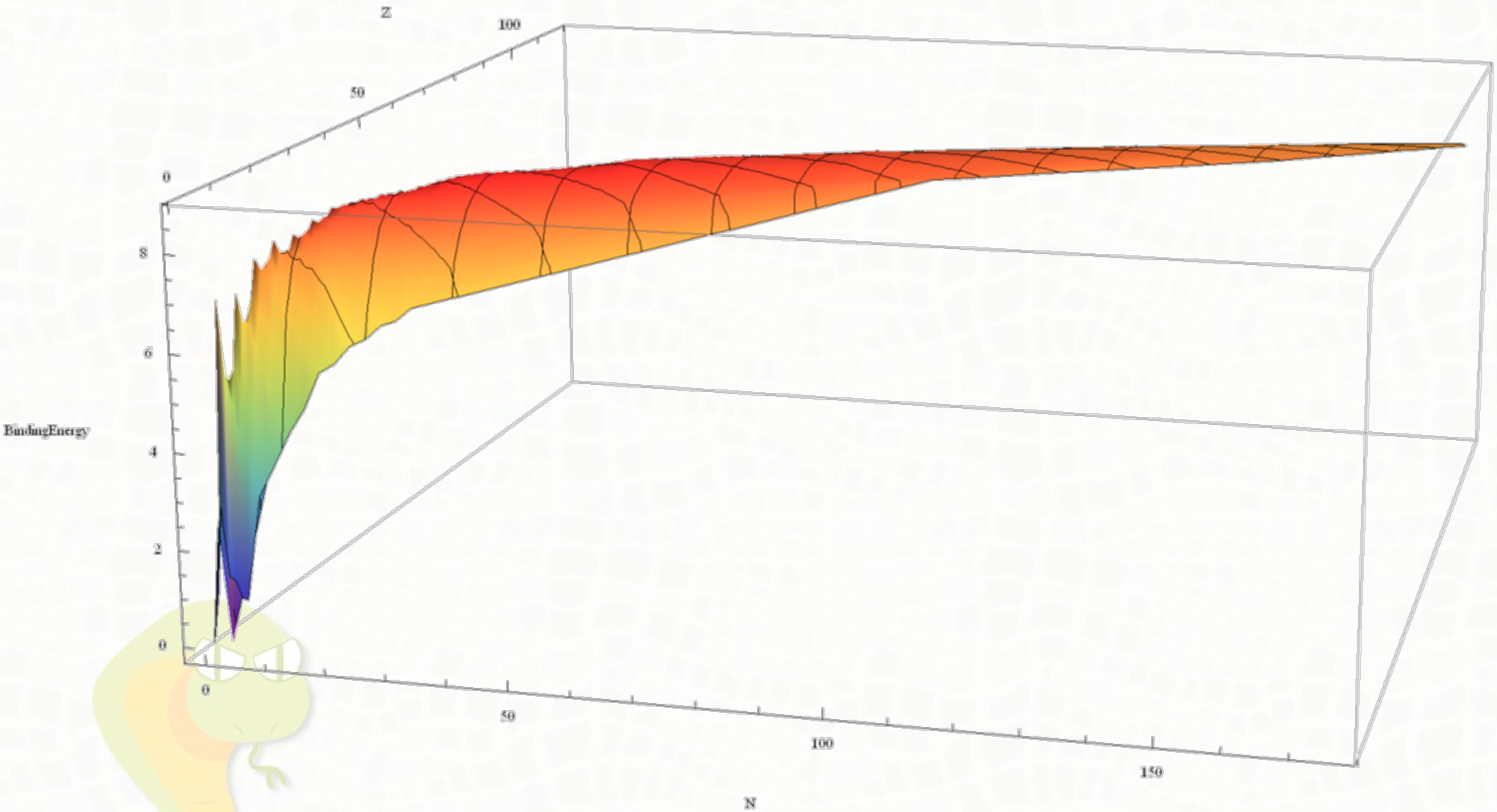
Binding Energy

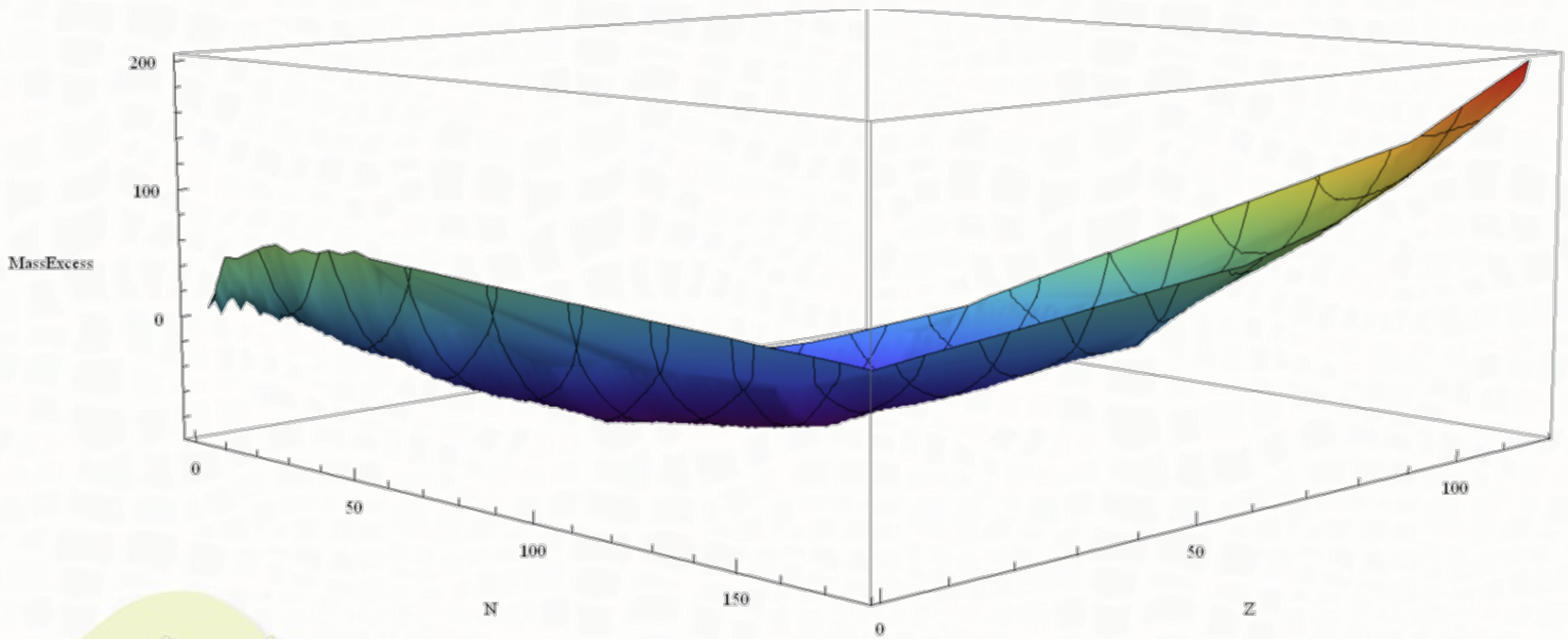






Average binding energy per nucleon (MeV)
Number of nucleons in nucleus
0
1
2
3
4
5
6
7
8
9
0
30
60
90
120
150
180
210
240
270
H1
H2
H3
He3
He4
Li6
Li7
C12
O16
Fe56
U235
U238


Z
100
50
0
8
6
BindingEnergy
4
2
0
0
50
100
150
N

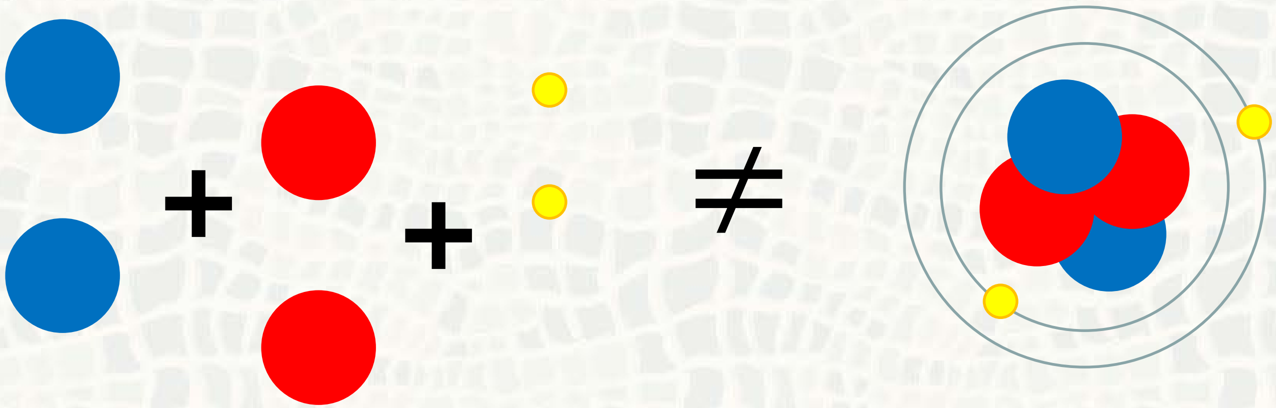

200
100
0
MassExcess
0
50
100
150
N
0
50
100
Z

Practice Problems

Ionization and Binding Energies

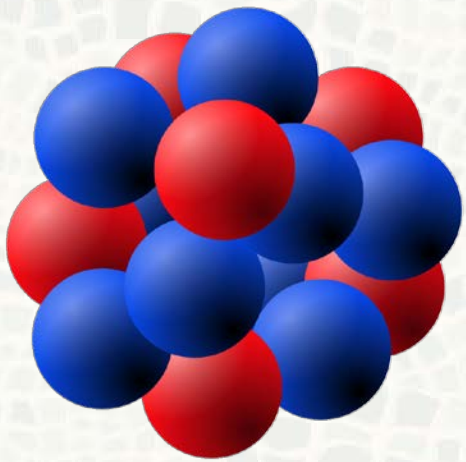
You need to be able to find this two ways:

1. Bohr's ionization energy method (p.55-56)
2. Mass/energy equivalency



Estimating Nucleus Mass

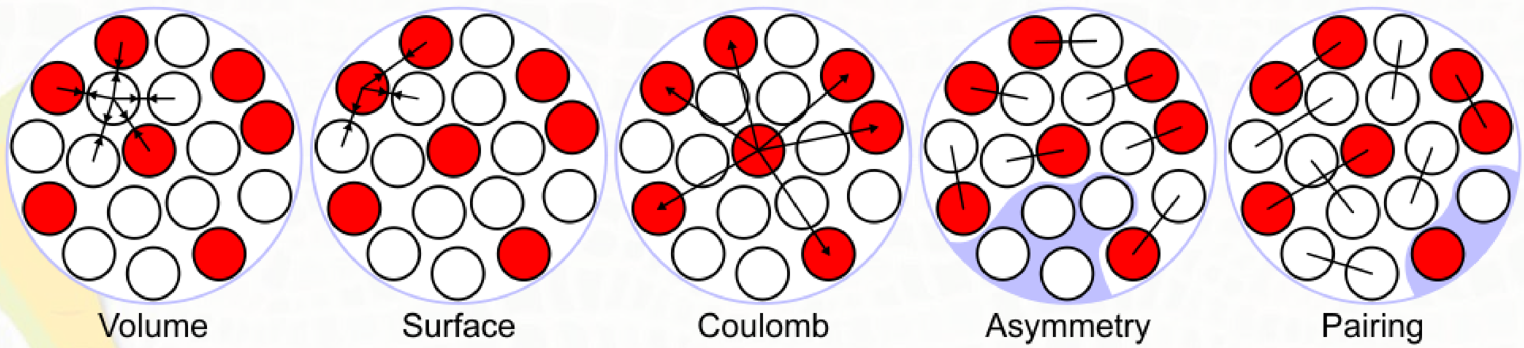
Liquid Drop Model



Liquid Drop Model, continued
(pp. 66-68)

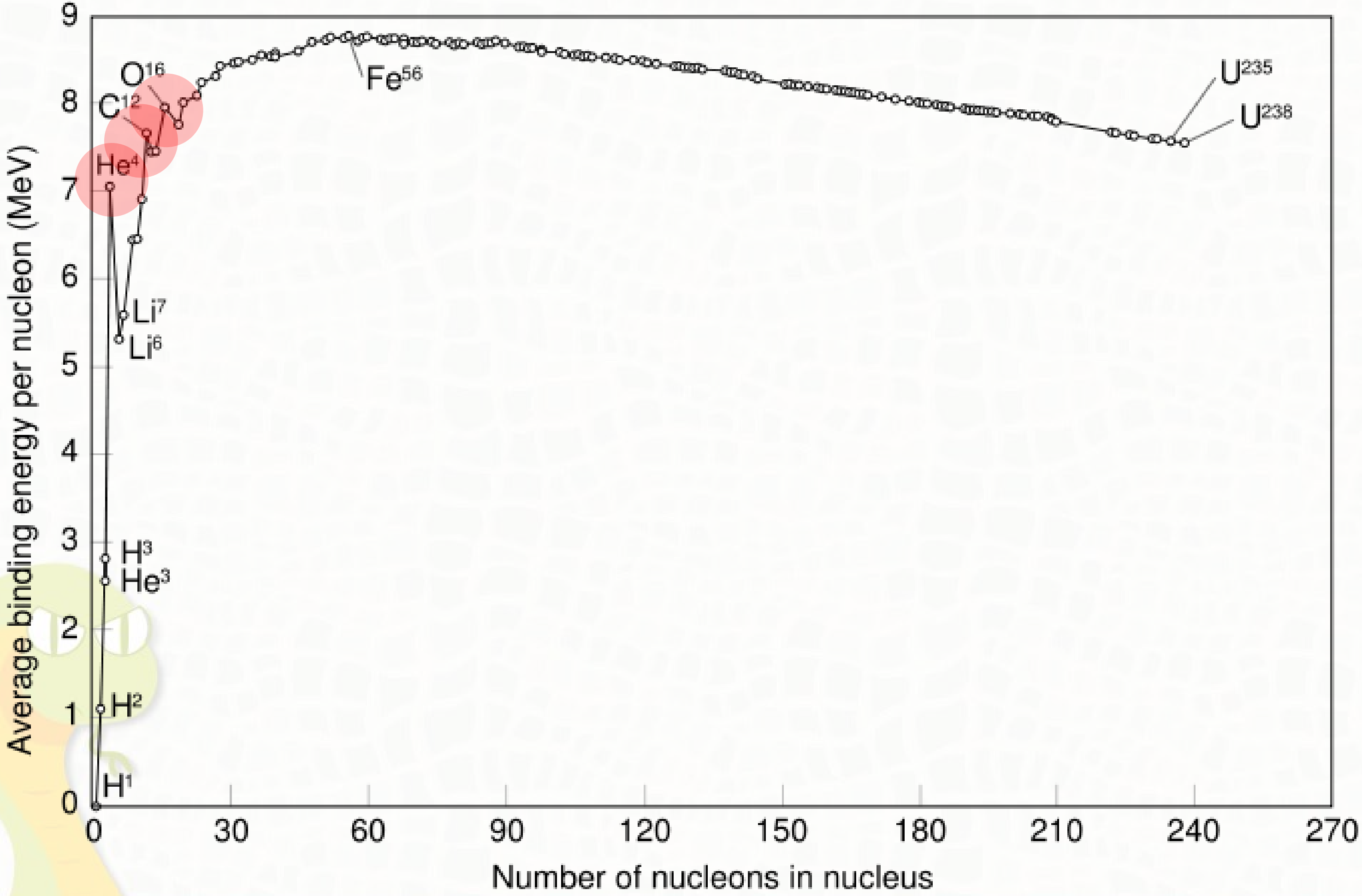
$$m({}^{A}_{Z}X) = Zm_p + (A - Z)m_n - \frac{BE}{c^2}$$

$$BE = a_v A - a_s A^{\frac{2}{3}} - a_c \frac{Z^2}{A^{\frac{1}{3}}} - a_a \frac{(A - 2Z)^2}{A} - \frac{a_p[(-1)^Z + +(-1)^N]}{2\sqrt{A}}$$

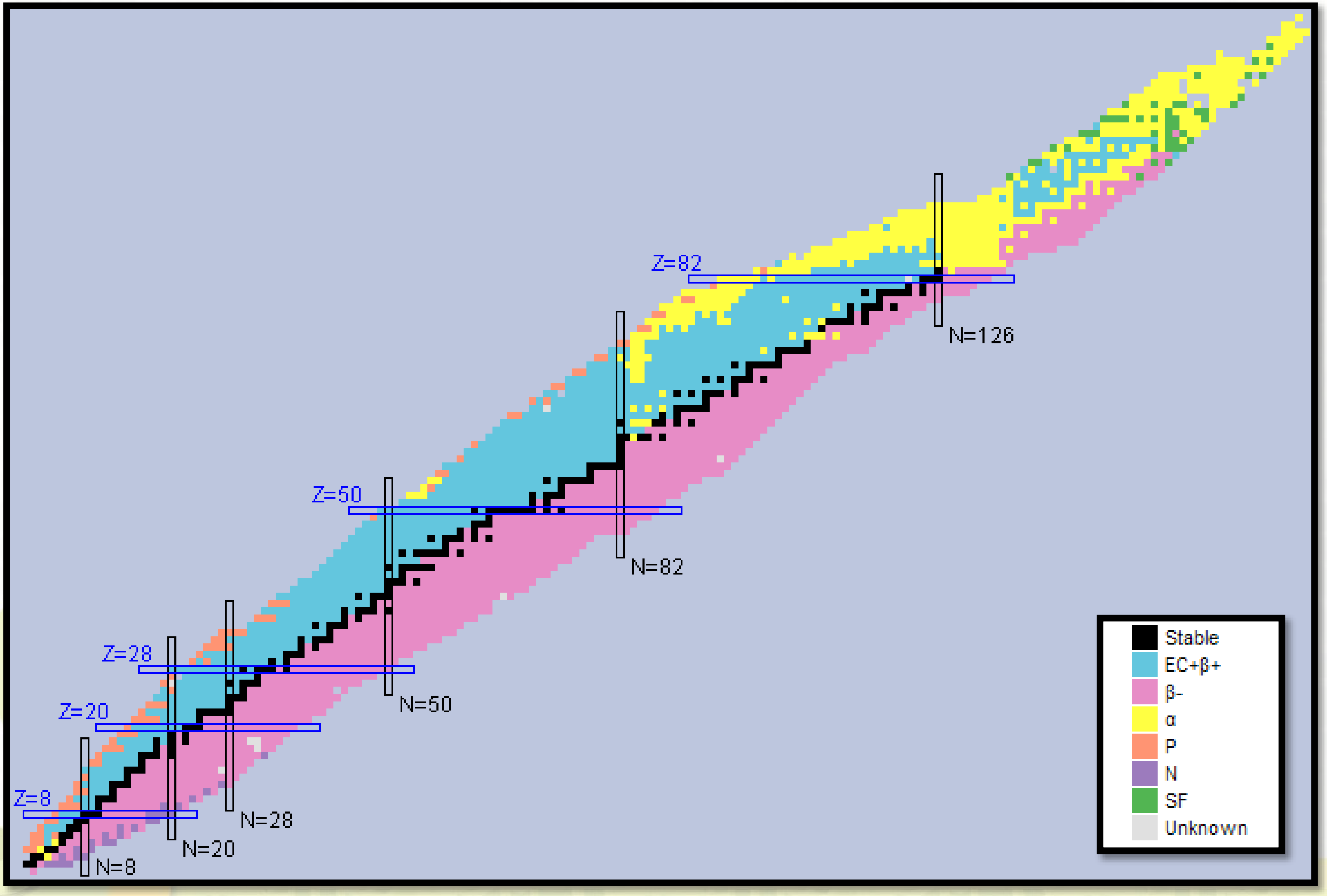


Explaining “Magic Numbers”

Shell Model (pg. 70)



Predicting Stability (pp. 64-66)



Predicting Most Stable Isobar

Two routes:

Compare mass defects using data in Appendix B

Predict using liquid drop model (Eq. 3.18)

$$Z_{stable}(A) = \left(\frac{A}{2}\right)\frac{1 + (m_n - m_p)c^2/(4a_a)}{1 + a_c A^{\frac{2}{3}}/(4a_a)}$$

Image Attributions

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- Chart of nuclides: National Nuclear Data Center, information extracted from the NuDat 2 database, http://www.nndc.bnl.gov/nudat2/