FYS3500 Spring 2024 - Problem set 1

Topic: Basic concepts in Nuclear Physics

Concepts of the week

Explain these concepts: Chart of Nuclei, Isotopes, Nuclear size, Binding energy

Problem 1: Get to know the Chart of Nuclides

Use the notation $^A_Z X_N$ with mass number A, element number Z and neutron number N.
Hint: Charts of known nuclides and their properties can be found at `https://www.nndc.bnl.gov/nudat3/` or at `https://www-nds.iaea.org/livechart`.

a) How many neutrons do ^{232}Th and ^{235}U have?

b) List all **stable** nuclei with mass number 20.

c) List all **stable** nuclei with element number 82.

d) List all **stable** polonium (Po) nuclei.
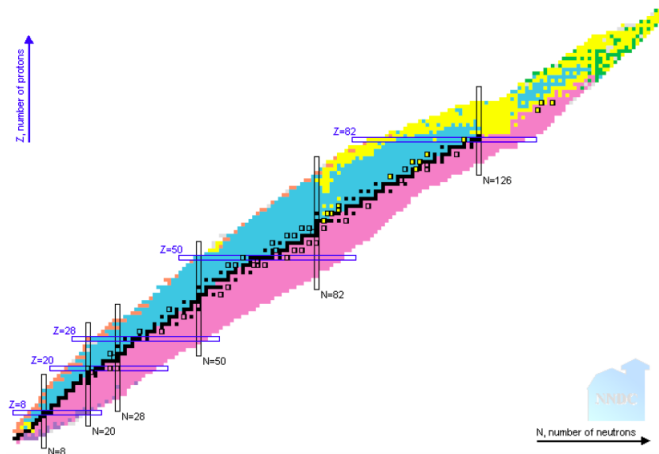
e) What does the colours of chart in figure **??** tell us?

Figure 1: Chart of nuclides

Problem 2: Isotopes, isotones and isobars

Of the following nuclei: ^{16}O, ^{15}N, ^{16}C, ^{16}Ne, ^{14}C, ^{20}N and ^{20}Ne.

a) Write out the full $^A_Z X_N$ notation for all the listed nuclei.

b) Which of the nuclei above are **isotopes**?

c) Which of the nuclei above are **isotones**?

d) Which of the nuclei above are **isobars**?

Problem 3: Nuclear size

a) What do we mean by the nuclear radius? Also explain the differences between the mass and charge radius, and why the two give approximately the same value.

b) When analysing the scattering of α-particles on medium and heavy nuclei we can learn about the nuclear radius. How?

c) Approximate the size of the nucleus ^{208}Pb.

d) Figure **??** shows the measured differential scattering cross section for the reaction ^{16}O + ^{208}Pb at the energy $E_{LAB} = 130$ MeV. At this energy, the cross section is well decribed by the Rutherford cross section (equation 2.26 in Martin&Shaw2019). If we keep increasing E_{LAB}, what will eventually happen to $\frac{d\sigma}{d\Omega}$?
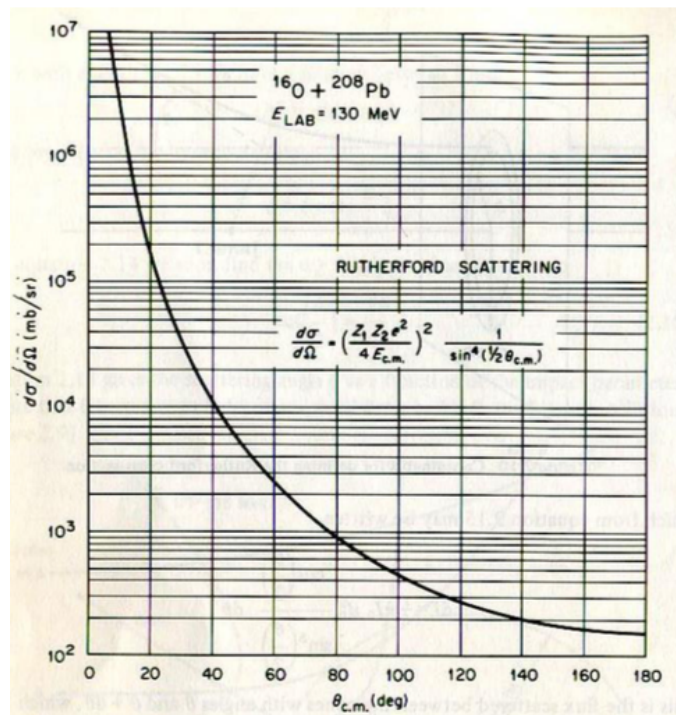

Figure 2: Measured differential scattering cross section for the reaction ^{16}O + ^{208}Pb at $E_{LAB} = 130$ MeV.

Problem 4: Binding energy per nucleon

Explain briefly some of the main features of the plot in figure **??** and estimate the mass of ^{130}Xe. What is the relation to fission and fusion?

Extra, will come back to this later: How was the elements heavier than iron created (keyword: nucleosynthesis)?
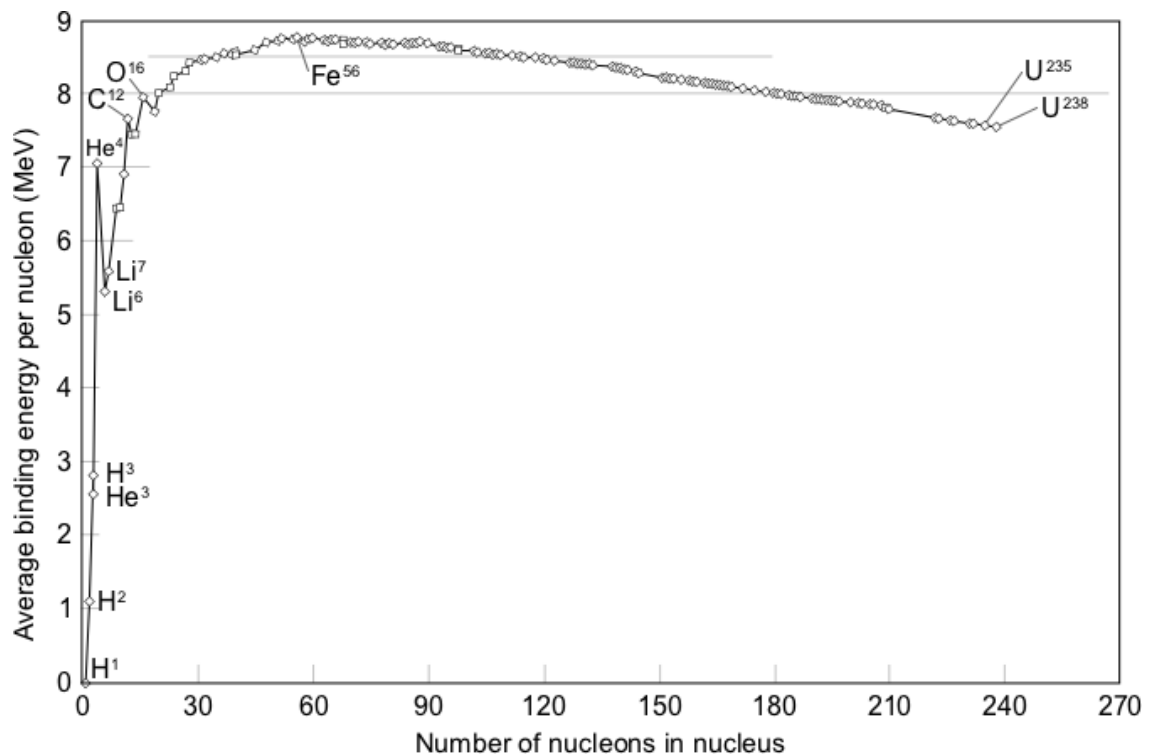

Figure 3: Average binding energy per nucleon for stable nuclei as a function of the mass number.