

Question 4 (Includes Coding Component) / 10

In this question, you'll be calculating the binding energies of the following seven isotopes using the SEMF equation (liquid drop model) and comparing these to their actual binding energies.

(a) Fill out the table below for each of the nuclides (2 marks)

Isotope	Number of Protons (Z)	Number of Neutrons (N)
^1H		
^3He		
^4He		
^6Li		
^{12}C		
^{14}C		
^{40}S		
^{40}Ca		
^{240}Pu		

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(b) Using Python, write a code that calculates the binding energies of each of the nuclides from the list above. Automate as much of this calculation as possible.

Option #1: Traditional List Approach

One approach is to make lists with the input parameters (e.g., a list for the atomic mass numbers of all the isotopes in part(a) and another list with all the atomic numbers). An empty list can then be used to append the BE for each isotope as you loop through all of the isotopes, performing the SEMF calculation for each nucleus. E.g., using the zip function to loop through both Z and A lists, performing the BE calculation inside the loop, may be useful.

Option #2: periodictable Package Approach

If you feel like you have a good handle on using lists in Python and would like to try something a little more advanced in addition to this, try the following

Under Assignment 1 on D2L is an optional pdf guide to installing external packages, using the example of the package periodictable as an example ("Package Import Instructions"). The guide includes some useful examples of applying the periodictable package that may be handy here. You will still rely on lists to complete your BE calculations for now; however, the periodictable package will remove the need to manually input isotope properties such as Z, A, etc.

Note: there are no extra/bonus marks associated with selecting this option, and the content presented here will be covered by everyone in the next CE. This is only for those who are itching to do a little more now 😊.

There is no one correct approach to writing a functional code (using either option), as long as your code carries out the necessary calculations and is well-documented and clear. In writing your code, try to avoid repeatedly writing out the same commands. **(4 marks)**

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- (c) Now that you've calculated the binding energies from the SEMF in part (b), we want to compare the values to the actual binding energies of these isotopes.

Using Python, make a list of the actual (eg., from the Chart of the Nuclides) BEs for all the isotopes from part (a). Calculate the percent error between the true BEs and your calculations from the SEMF in part (b).

Add a print statement(s) to the end of your code that shows each isotope, its binding energy (calculated and actual), and the percent error. Make sure all binding energies are rounded to 3 decimal places, e.g., using Pu-240 as an example,

Isotope	BE/A MeV	BE/A (LDM) MeV	% error
240-Pu	7.556035	7.541	0.199

(2 marks)

- (d) Are there any isotopes that have a greater difference between the calculated and actual binding energies than you would expect (especially when compared to similar isotopes)? Use your understanding of the liquid drop model and the nuclear shell model to try and explain these differences. It may be useful to consider each of the terms in the SEMF individually when justifying sources of error. **(2 marks)**