1st SERIES OF EXERCISES – PROPERTIES OF NUCLEI

1 – For the following nuclei, give their atomic number (Z), their mass number (A) and their number of neutrons:

a) ^{1}H b) ^{4}He c) ^{13}C d) ^{32}S e) ^{57}Fe f) ^{82}Kr g) ^{224}Ra h) ^{235}U i) ^{238}U j) ^{236}Pu

2 – Of the following nuclei, indicate which are isotopes of one another, and which are isobars:

^{3}H ; ^{14}C ; ^{236}Pu ; ^{235}U ; ^{3}He ; ^{236}Np ; ^{236}U ; ^{4}He ; ^{14}N ; ^{240}Am

3 – Determine, for the following nuclei, their *nuclear masses*:

^{11}B ; ^{23}Na ; ^{56}Fe ; ^{27}Al ; ^{197}Au ; ^{238}U

a) In atomic mass units (consult tables).

b) Using the result from a), convert those masses into kilograms;

c) Using the Einstein equation, calculate, in Joules, the energy equivalent to each of these masses.

d) Convert the results from c) into MeV.

e) Re-obtain the results from d) directly from a).

4 – a) Calculate, in MeV, the *binding energies* **B** of each of the nuclei from exercise 3.

b) Order these nuclei by increasing order of stability.

5 – The *semi-empirical mass formula* gives us the binding energy of a nucleus ${}^{A}_{Z}X$, according to

$$B(Z,A) = a_V A - a_S A^{2/3} - a_C\, Z\,(Z-1)\,A^{-1/3} - a_{Sim}\,\frac{(A-2Z)^2}{A} + \delta,$$

with

$$\delta = \begin{cases} +a_P A^{-3/4}, \text{se } N \text{ e } Z \text{ pares} \\ -a_P A^{-3/4}, \text{se } N \text{ e } Z \text{ ímpares} \\ 0, \text{se } A \text{ ímpar} \end{cases}$$

and where the constants a_i have the following values:

$a_V = 15.5\ MeV$; $a_S = 16.8\ MeV$; $a_C = 0.72\ MeV$; $a_{Sim} = 23\ MeV$; $a_P = 34\ MeV$

a) Calculate, in MeV, the binding energies of the following nuclei using the semi-empirical mass formula.

I) ^{6}Li II) ^{12}C III) ^{14}N IV) ^{103}Rh V) ^{235}U VI) ^{236}U

b) Order these nuclei by increasing order of stability.

c) Calculate, in MeV, the nuclear mass of each of these nuclei.

1 u = 931.502 MeV
proton mass: 938.280 MeV = 1.007276 u
neutron mass: 939.573 MeV = 1.008664 u
electron mass: 0.511 MeV = 5.4858×10^{-4} u