Nuclides

Basic information:

A nuclide (called nuclear species) is a species of atom that characterized by the following specific constitution of its nucleus:

1- ***Proton*** (atomic) number (Z)

2- ***Neutrons*** number (N)

3- The ***energy*** of the nuclear state

Both proton and neutrons are called ***nucleons***, and thus, nuclides are composite particles of nucleons. The basic components of nucleons are elementary particles called ***quarks***. Therefore, nuclides can be considered composite particles of quarks

Let A to be the number of nucleons in a nuclide, A is called also ***mass number,*** i.e N = A – Z.

- The notation for a nuclide with mass number A and atomic number Z is represented by a symbol of its element X, as ${}^{A}_{Z}X$

- According to A, Z, and the nuclear energy state of a nuclide, we can characterized the following categories of nuclides:

1- ***Isotopes***: nuclides of the same element (same Z) but different in A

Example: ${}^{12}_{6}C, {}^{13}_{6}C \; and \; {}^{14}_{6}C$ are isotopes of Carbon element.

2- ***Isobars*** : nuclides with the same A (equal in weight) but different in Z (different elements)

Example: ${}^{14}_{6}C \; and \; {}^{14}_{7}N$ are isobars.

3- ***Isotones:*** Nuclides with the same N,

Example: $^{13}_{6}C\ and\ ^{14}_{7}N$ are isotones.

4- ***Isomers***: nuclides with the same Z and A, (i.e same isotopes) but different in their nuclear energy state (excitation state).

Example: Technetium nuclides: $^{99}_{43}Tc\ and\ ^{99m}_{43}Tc$

5- ***Mirror Nuclides***: neutron number (Z) and proton number (Z) is exchanged.

Example:$^{3}_{1}He\ and\ ^{3}_{2}He$.

Mass defect, Binding energy and Stability of nuclides:

Mass defect: This is the different in the masses of the nucleons of a nuclide and the mass of nuclide.

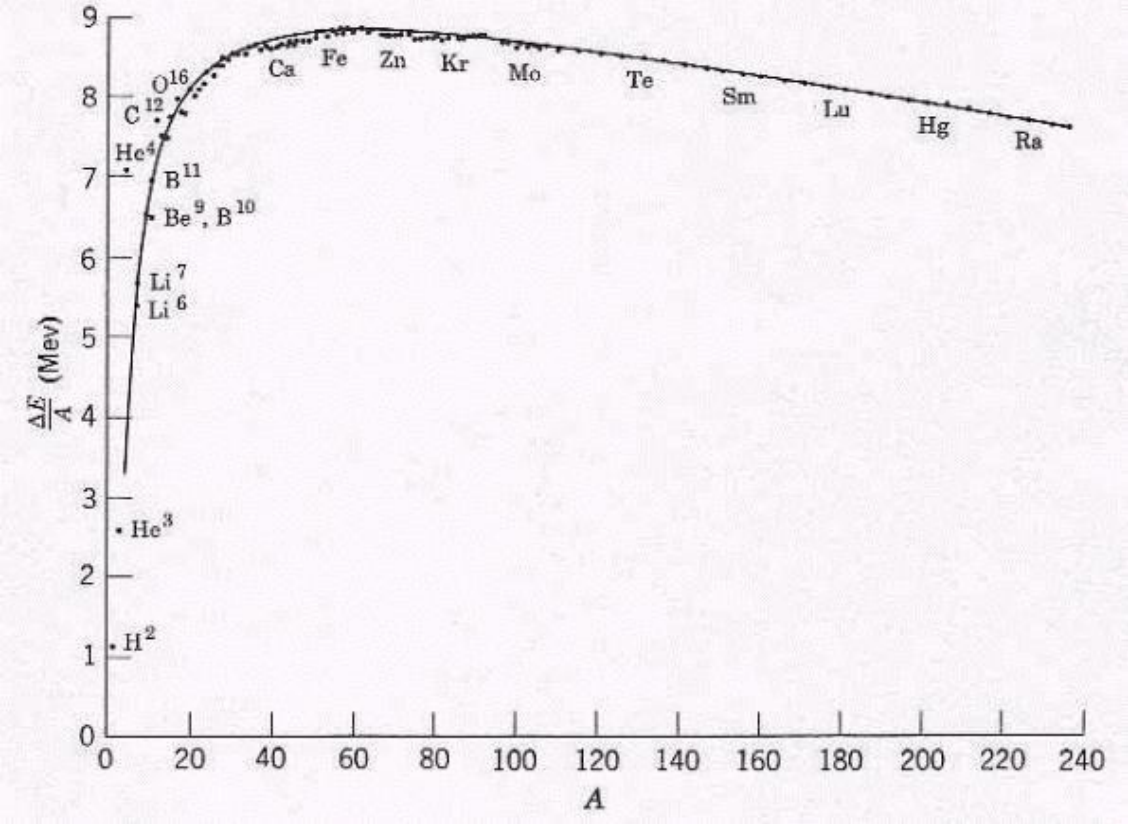
Let m_p , m_n and m_j to be the proton, neutron and nuclide mass respectively. The mass of the nuclide m_j is lower than the mass of its containt of protons and nutrons, and Mass defect (Δm) of the nuclide is, then, given by

$$\mathbf{\Delta m = (Z.m_p + N.m_n) - m_j}$$

Binding energy: There is very strong interaction between the nucleons in nuclides, and the composition of the nuclide is help together by the so called ***nuclear binding energy (ΔE).*** The binding energy is , related to the mass defect of the muclide, given by :

$$\mathbf{\Delta E = \Delta m C^2}$$

The stability of nuclide is measured by the ***binding energy per each of its nucleons.*** Figure 1 shows the graphical representation of the binding energy per nucleon (ΔE/A) versus the number of nucleaons (A).



According to the stability, the nuclides are classified as ***Stable and unstable*** nuclides

- **<u>Stable nuclides</u>**: are stable over time, due to their binding energy is capable to remain their composition unchanged for an indefinite period of time, and thus these nuclide exist for an indefinite period of time.
  <u>Unstable nuclides:</u> are nit stable over time , due to their binding energy is not enough to keep their composition over time, thus they emit subatomic particles (alpha, beta, gamma, or proton) therefore, they called ***radioactive nuclides***, and they eventually convert to stable nuclides by undergoing **radioactive decay**.

- The ***heavy*** radioactive nuclides (right part of Fig. 1) can be converted to stable one by the so called nuclear ***fission*** and produced high quantity of

energy. However, the light radioactive isotopes (left part of Fig. 1) can be converted to stable nuclides by ***fusion*** process and energy is released.

Radionuclides in medicine:

Due to these nuclides capable of radioactive decay, they have been used in wide range of application in both ***diagnostic*** and **therapeutic** methods

Examples of some ***diagnostic methods*** in which radioactive nuclides are used:

- ***Tracing method:*** radioactive nuclides (iodine-125, iron-59) are employed.
- ***Scintigraphy*** is used for examination of thyroid gland and kidneys (iodine-131)
- ***Single photon emission computed tomography (SPECT):*** (iodine-131, technetium-99m) are used.
- ***Positron emission tomography (PET)***

The **therapeutic** application of the radioactive nuclides is known as ***Radiotherapy: Examples:***

- Therapy of thyroid gland tumours by radioactive iodine I-131
- Radioactive nuclides Cobalt (Co-60) and caesium (Cs-137) are used for tumour treatment by different way of applications

Referances:

1- http://en.wikipedia.org
2- http://www.science.uwaterloo.ca
3- http://www.epa.gov/radiation/understand/isotopes.html