Atomic Species

Characterized by the number of neutron N, number of proton Z, and mass number $A = N + Z$

$$(A, Z) = {}^{A}_{Z}X = {}^{A}_{Z}X_N$$

Nucleon

Defined as bound state of atomic nuclei. The two type are positively charged proton and neutral neutron. Nucleon constitutes three bound fermions called quark: up with charge $(2/3)$ and down with charge $(-1/3)$

$$\begin{aligned} \text{proton} &= \text{uud} \\ \text{neutron} &= \text{udd} \end{aligned}$$

Both of them are fermion with mass

$$\begin{aligned} m_e &= 939.56 \text{ MeV}/c^2 \\ m_p &= 938.27 \text{ MeV}/c^2 \\ m_n - m_e &= 1.29 \text{ MeV}/c^2 \end{aligned}$$

The magnetic moment projected by both are

$$\mu_p = 2.792847386 \, \mu_N \quad \mu_n = -1.91304275 \, \mu_N$$

where μ_N denote nuclear magneton

$$\mu_N = \frac{e\hbar}{2m_p} = 3.15245166 \, 10^{-14} \text{ MeV/T}$$

Here are the difference in unit used to describe nucleus compared to atom

Properties	Atom	Nucleus
Radius	Angstrom (10^{-10} m)	Femto (10^{-15} m)
Energy	eV	MeV

Radii. In terms of their mass number A, their radius may be approximated as

$$R = r_0 A^{1/3} \quad \text{with} \quad r_0 = 1.2 \text{ fm}$$

This approximation comes from assuming the radius is proportional to the volume which is also assumed to be spherical. Then $\mathcal{V} = 4\pi R^3/3 \approx A$.

Binding energy. Defined as the difference of the sum of nuclei mass and the nuclear mass

$$B(A, Z) = N m_n c^2 + Z m_p c^2 - m(A, Z) c^2$$

Mass. Three unit most common are atomic mass unit (u), the kilogram (kg), and the electron-volt (eV). The atomic mass unti id defined as the mass of ^{12}C atom divided by 12

$$1 \text{ u} = \frac{m(^{12}C)}{12}$$

electron volt is defined as the kinetic energy of an electron after being accelerated from rest through a potential difference of 1 V.

Nuclear Relative

Isotope. Same number of charge Z, but different number of neutron N. Isotope has identical chemical properties, since they have the same electron, but different nuclear properties. Example are

$$^{238}_{92}\text{U} \quad \text{and} \quad ^{235}_{92}\text{U}$$

Isobar. Same mass A. Frequently have the same nuclear properties due to the same number of nucleon. Example are

$$^{3}\text{He} \quad \text{and} \quad ^{3}\text{H}$$

Isotone. Same number of neutron N, but different number of proton Z. Example are

$$^{14}\text{C}_6 \quad \text{and} \quad ^{16}\text{O}_8$$