

## Atomic Species

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

$$(A, Z) = {}^A_ZX = {}^A_ZX_N$$

## Nucleon

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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  $(-1/3)$

proton = uud

neutron = udd

Both of them are fermion with mass

$$m_e = 939.56 \text{ MeV}/c^2$$

$$m_p = 938.27 \text{ MeV}/c^2$$

$$m_n - m_e = 1.29 \text{ MeV}/c^2$$

The magnetic moment projected by both are

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

where  $\mu_N$  denote nuclear magneton

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

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

Properties	Atom	Nucleus
Radius	Angstrom ( $10^{-10} \text{ m}$ )	Femto ( $10^{-15} \text{ m}$ )
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

$$B(A, Z) = Nm_n c^2 + Zm_p c^2 - m(A, Z)c^2$$

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

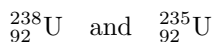
$$1 \text{ u} = \frac{m(^{12}\text{C})}{12}$$

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

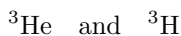
## Nuclear Relative

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**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



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



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

