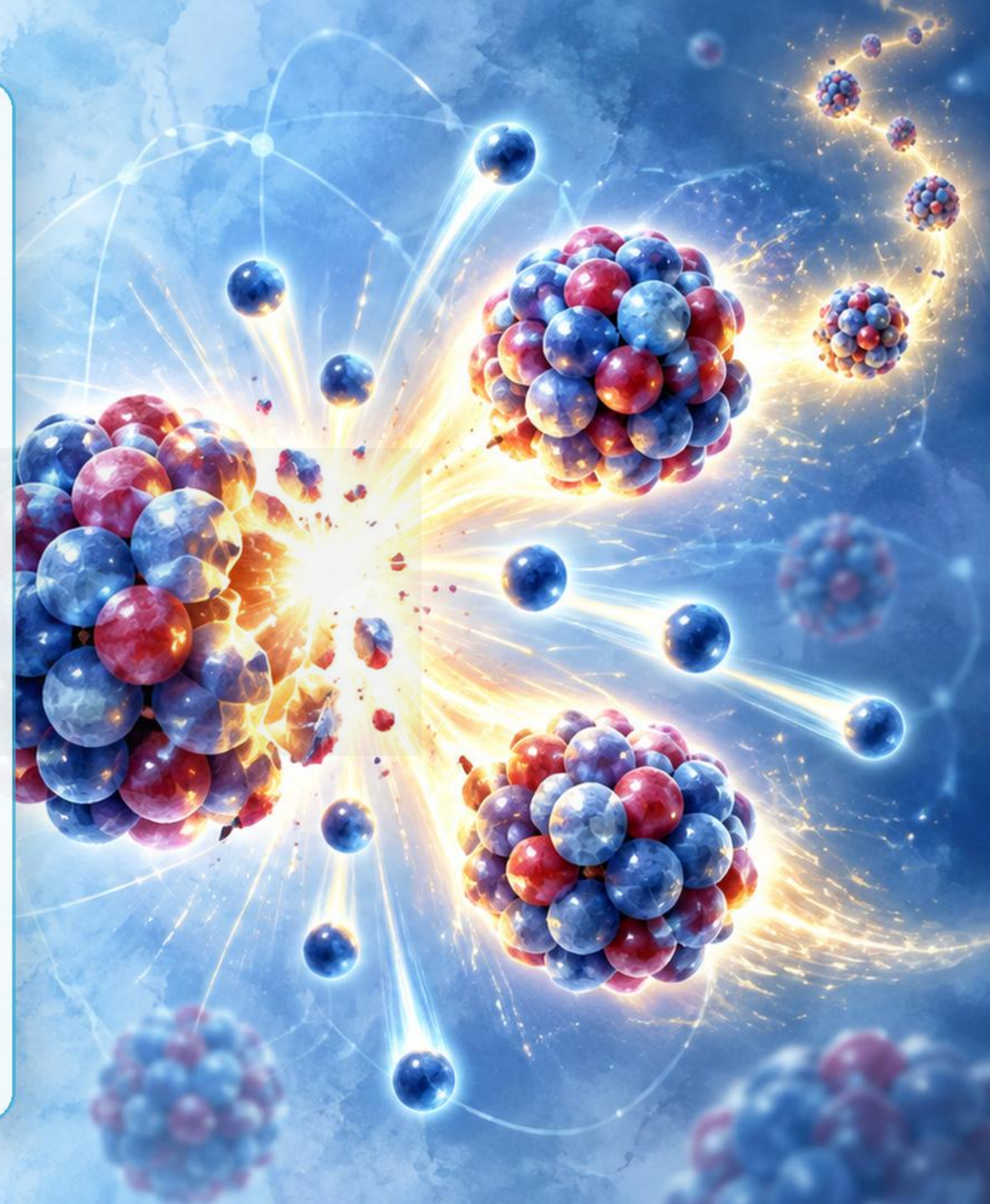


PHYSICS • CLASS 12

CHAPTER 13

Nuclei

CHAPTER NOTES



NUCLEI — STRUCTURE, STABILITY & ENERGY

The nucleus is tiny, yet it contains more than 99.9% of an atom's mass and controls nuclear identity and energy.

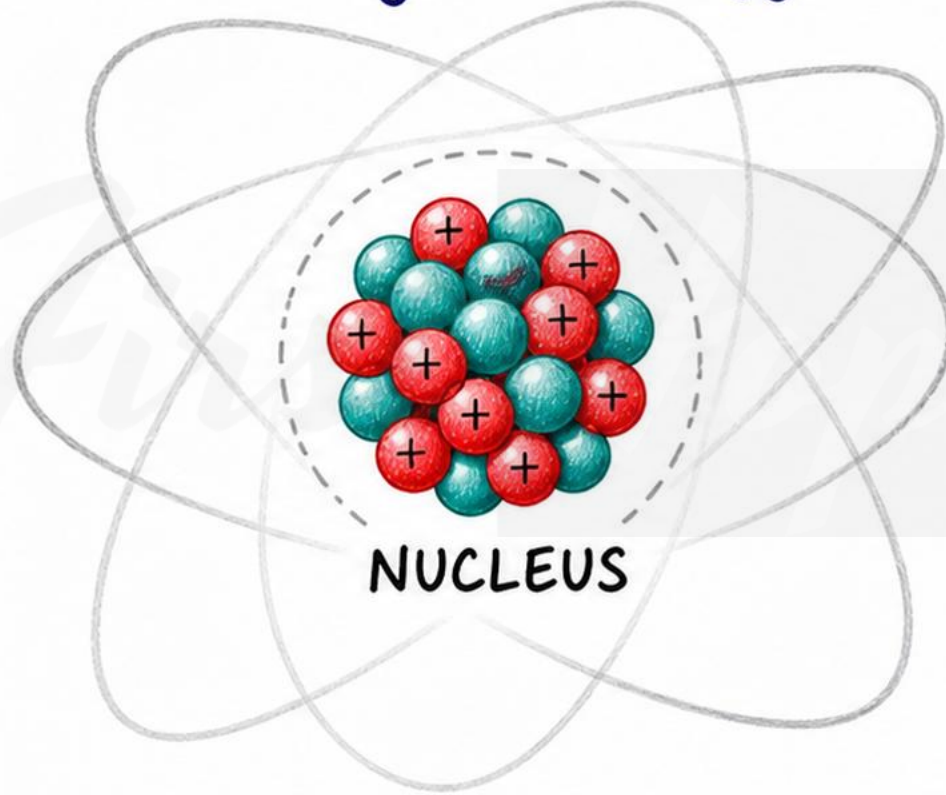
COMPOSITION

protons + neutrons;

$$A = Z + N$$

STABILITY

binding energy and nuclear force decide whether a nuclide is stable or radioactive



atom not to scale

SIZE

$$\frac{R_{\text{nucleus}}}{R_{\text{atom}}} \approx 10^{-4}$$

$$\frac{V_{\text{nucleus}}}{V_{\text{atom}}} \approx 10^{-12}$$

ENERGY

fission and fusion move nuclei toward more tightly bound states

COMPOSITION → BINDING → STABILITY → NUCLEAR ENERGY

ATOMIC MASS UNIT & ISOTOPIC MASSES

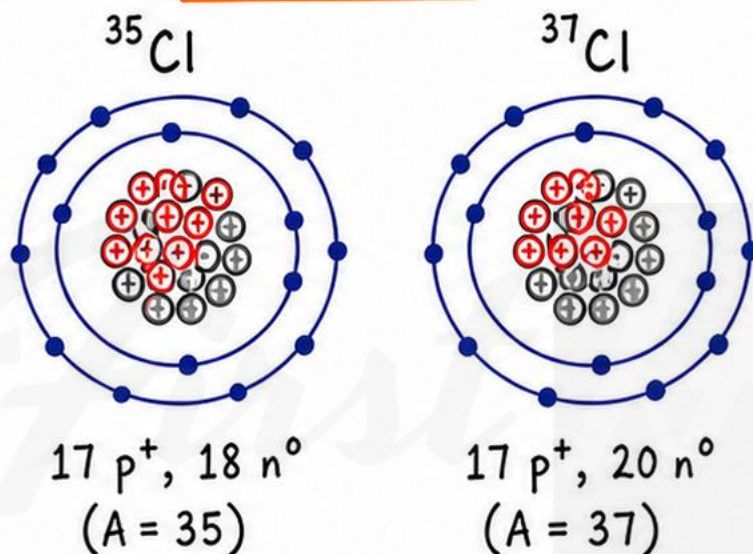
ATOMIC MASS UNIT

$1 \text{ u} = \left(\frac{1}{12}\right)$ mass of one carbon-12 atom

$$1 \text{ u} = 1.66054 \times 10^{-27} \text{ kg}$$

u is convenient for atomic and nuclear masses.

ISOTOPES



- same element $\rightarrow$ same proton number Z
- different neutron number $N \rightarrow$ different mass
- mass spectrometers separate isotopic masses

WEIGHTED ATOMIC MASS – CHLORINE

$$^{35}\text{Cl} \quad 34.98 \text{ u} : \boxed{\text{75.4\%}}$$

$$^{37}\text{Cl} \quad 36.98 \text{ u} : \boxed{\text{24.6\%}}$$

$$\begin{aligned} \text{average mass} &= 0.754(34.98) + 0.246(36.98) \\ &= (26.37492) + (9.09708) \\ &= 35.47200 \text{ u} \end{aligned}$$

$$\boxed{= 35.47 \text{ u}}$$

A periodic-table atomic mass is usually an abundance-weighted mean, not the mass number of one isotope.

PROTONS, NEUTRONS & NUCLIDE NOTATION

NUCLEONS

p proton (p)

$$m_p = 1.00727 \text{ u} \approx 1.6726 \times 10^{-27} \text{ kg}$$

$$q_p = +e$$

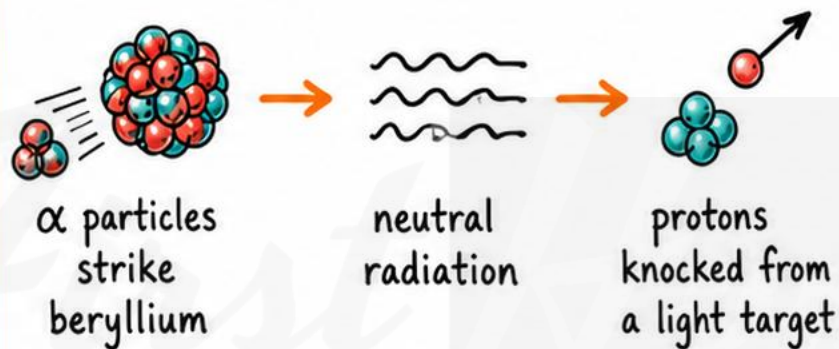
n neutron (n)

$$m_n = 1.00866 \text{ u} \approx 1.6749 \times 10^{-27} \text{ kg}$$

$$q_n = 0$$

proton or neutron = nucleon

NEUTRON CLUE



energy-momentum analysis ruled out ordinary photons and revealed a neutral particle with nearly proton mass.



free mean lifetime ≈ 15 min;
neutrons can be stable in suitable nuclei.

NUCLIDE SYMBOL

A X Z

$A = \text{mass number} = Z + N$
 $Z = \text{atomic number} = \text{protons}$
 $X = \text{element symbol}$

$$N = A - Z$$

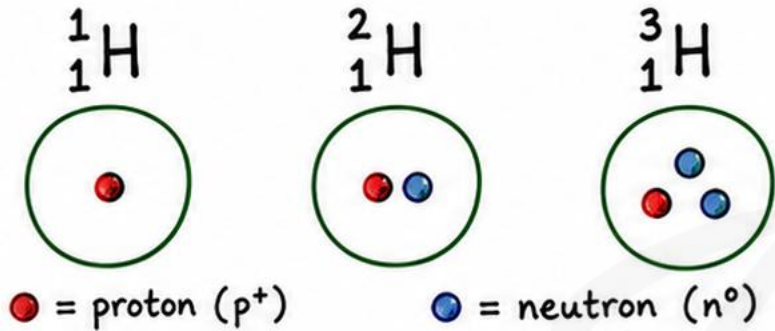
N is the neutron number.

gold-197: $^{197}_{79}\text{Au}$

$$A = 197, Z = 79, N = 118$$

ISOTOPES, ISOBARS & ISOTONES

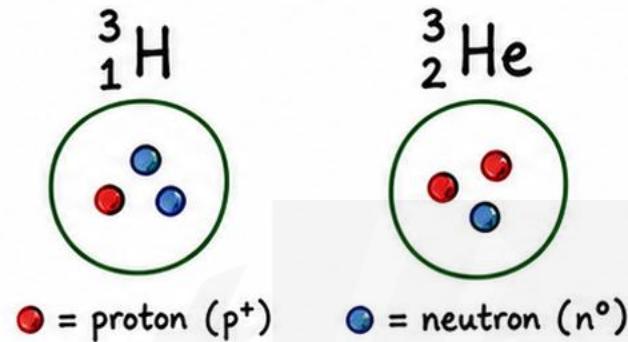
ISOTOPES — SAME Z



Nuclide	${}^1_1\text{H}$	${}^2_1\text{H}$	${}^3_1\text{H}$
A (mass number)	1	2	3
Z (protons)	1	1	1
N (neutrons)	0	1	2

- same electron structure when neutral → nearly identical chemistry; different masses.

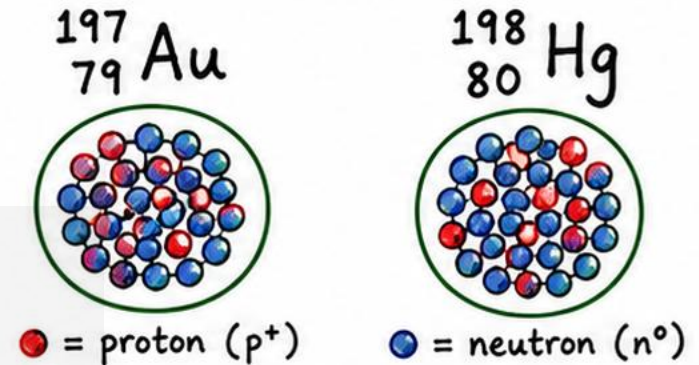
ISOBARS — SAME A



Nuclide	${}^3_1\text{H}$	${}^3_2\text{He}$
A (mass number)	3	3
Z (protons)	1	2
N (neutrons)	2	1

- same mass number A, different Z and N.

ISOTONES — SAME N



Nuclide	${}^{197}_{79}\text{Au}$	${}^{198}_{80}\text{Hg}$
A (mass number)	197	198
Z (protons)	79	80
N (neutrons)	118	118

- same number of neutrons N, different A and Z.



Do not confuse mass number A (an integer for one nuclide) with average atomic mass (an abundance-weighted value).

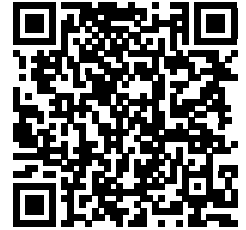


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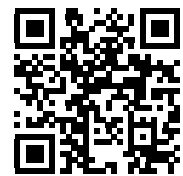


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