

one nucleus, a set of shells, and rules for who lives where

Three subatomic particles

Electron

e^- , J.J. Thomson, 1897, cathode-ray tube. charge -1 , mass $\approx 1/1837$ of a proton's

Proton

Rutherford, 1911-1919, alpha scattering and nitrogen transmutation. charge $+1$, mass ≈ 1 u

Neutron

Chadwick, 1932, paraffin bombarded by beryllium radiation. no charge, mass ≈ 1 u, a shade above a proton's

Rutherford's alpha-scattering experiment

- a beam of α particles fired at a thin gold foil, only a few atoms thick
- most passed straight through undeflected: the atom is mostly empty space
- a small fraction deflected through large angles, about 1 in 20,000 bounced almost straight back
- that rebound meant a tiny, dense, positively charged core: the nucleus
- 1919: fast α particles turned nitrogen into oxygen, always releasing hydrogen, later renamed the proton

each model fixed the one thing the last couldn't explain: Thomson gave neutrality, Rutherford gave a nucleus, Bohr gave the atom stability

Atomic number, mass number, notation

atomic number, fixes the element

$Z = p = e$ (in a neutral atom)

mass number, protons + neutrons

$$A = Z + N$$

standard notation for a nuclide



protons decide WHICH element it is; neutrons can vary without changing the element at all. an atom with a unique (Z,A) pair is called a nuclide

Rutherford's nuclear model, and where it broke

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- mass and positive charge sit in a tiny nucleus ($\sim 10^{-15}$ m), electrons revolve outside ($\sim 10^{-10}$ m)
- modelled electrons like planets orbiting the nucleus under electrostatic attraction
- problem 1: an orbiting charge must radiate energy, so it should spiral in instantly, yet atoms don't
- problem 2: says nothing about why an electron sits at a given distance or hydrogen's line spectrum

Isotopes, isobars and isotones

- isotopes: same Z, different A, identical chemical behaviour, e.g. ${}^{35}_{17}\text{Cl}$ and ${}^{37}_{17}\text{Cl}$
- isobars: same A, different Z, different elements, different chemical properties, e.g. ${}^{40}_{18}\text{Ar}$ and ${}^{40}_{20}\text{Ca}$
- isotones: same neutron number N, different Z and A, e.g. ${}^{11}_5\text{B}$ and ${}^{12}_6\text{C}$, both N=6
- don't confuse: iso-**TOPES** share a spot, iso-**BARS** a weight, iso-**TONES** a neutron count