CHEMWHIZ QUICK REFERENCE

TOPIC 28

Nuclear Chemistry

Balancing nuclear equations, decay modes, decay kinetics, binding energy, and fission/fusion.

01 Conserve A and Z

CORE RULE

Both mass number A (top) and atomic number Z (bottom) are conserved: the sums must match on each side of a nuclear equation.

02 Particles

REFERENCE

Particle	Symbol (A, Z)
alpha	$^{4}_{2}He$ (4, 2)
beta-minus	$^{0}_{-1}e$ (0, −1)
positron	$^{0}_{+1}e$ (0, +1)
neutron	$^{1}_{0}n$ (1, 0)
proton	$^{1}_{1}p$ (1, 1)
gamma	$^{0}_{0}\gamma$ (0, 0)

03 Decay modes

REFERENCE

Mode	Effect on nucleus
alpha	A − 4, Z − 2
beta-minus	A same, Z + 1 (n → p)
positron	A same, Z − 1 (p → n)
electron capture	A same, Z − 1 (e^- on left)

04 Multi-step decay counting

CORE RULE

For x alphas + y betas: solve 4x = mass difference and 2x − y = atomic-number difference simultaneously.

05 Decay kinetics (first order)

CORE RULE

Decay is first-order: $k = \ln 2 / t_{1/2} = 0.693 / t_{1/2}$ (units of inverse time).

Fraction remaining: $N/N_0 = e^{(-kt)} = (1/2)^{(t/t_{1/2})}$. Use the half-life form when $t/t_{1/2}$ is a simple ratio.

06 Activity & dating

CORE RULE

Activity is proportional to the atom count, so $\ln(A/A_0) = -kt$ substitutes directly, the basis of radiocarbon and other radiometric dating.

07 Mass defect & binding energy

CORE RULE

Mass defect Δm = (mass of free protons + neutrons) − (actual nuclear mass). Binding energy BE = $\Delta m \cdot c^2$ ($c = 2.998 \times 10^8$ m/s).

08 Binding energy per nucleon

CORE RULE

BE/A = total binding energy ÷ A (MeV/nucleon). The curve peaks near iron-nickel (Fe-56 ≈ 8.8 MeV/nucleon), the most stable nuclei.

09 Fission vs fusion

CORE RULE

Fission: a heavy nucleus splits into two mid-mass nuclei + neutrons. Fusion: light nuclei combine. Both release energy when products sit higher on the BE/A curve (toward iron-nickel).

10 Activity A = λN

CORE RULE

Activity $A = \lambda N$, $\lambda = \ln 2/t_{1/2}$, N = number of radioactive atoms (from mass via molar mass and N_a). SI unit: becquerel (1 Bq = 1 decay/s).