CHEMWHIZ QUICK REFERENCE

TOPIC 08

The Mole & Chemical Formulas

Moles, molar mass, Avogadro's number, percent composition, and empirical/molecular formulas.

01 What you're counting — CORE RULE

Molecular compounds: count molecules (H_2O, CO_2). Ionic compounds: count formula units (NaCl). Elements: atoms (Na, Fe) or molecules (H_2, O_2, P_4, S_8).

02 Moles of each element — CORE RULE

Each subscript = moles of that element per mole of compound. 1 mol $Al_2(SO_4)_3$ = 2 mol Al, 3 mol S, 12 mol O. Hydrate waters add to the count.

03 Molar mass — CORE RULE

Sum the atomic masses of every atom in one formula unit (expand parentheses, include hydrate water), in g/mol. $Al_2(SO_4)_3$ = 2(26.98) + 3(32.06) + 12(16.00) = 342.14 g/mol.

04 Mass ↔ moles — CORE RULE

Mass → moles: × (1 mol / molar mass). Moles → mass: × (molar mass / 1 mol). g/mol cancels; carry units to self-check.

05 Avogadro's number — CORE RULE

$N_a = 6.022 \times 10^{23}$ entities/mol. Moles → particles: × N_a. Particles → moles: ÷ N_a. Atoms of an element = mol compound × subscript × N_a.

06 Hydrates — CORE RULE

Use the full hydrate molar mass (including water). 1 mol $CuSO_4 \cdot 5H_2O$ = 1 mol anhydrous $CuSO_4$ + 5 mol H_2O.

Atom count includes the waters: $CuSO_4 \cdot 5H_2O$ has 9 O (4 + 5) and 10 H (2 × 5).

Dissociation uses the anhydrous ions only: $CuSO_4 \cdot 5H_2O \rightarrow Cu^{2+} + SO_4^{2-} + 5H_2O$ (2 ions, not 7).

07 Percent composition — CORE RULE

Mass % of X = (atomic mass of X × subscript) / molar mass × 100%. All element percents sum to 100.00% (± 0.05% rounding).

08 Empirical vs molecular formula — CORE RULE

Empirical formula = smallest whole-number atom ratio. Molecular formula = actual atoms = $(\text{empirical})_n$, where n is a positive integer (n = 1 if they match).

09 Empirical formula from % or mass — METHOD

Assume 100 g (so % = g); convert each element to moles; divide all by the smallest; if a ratio isn't near an integer, multiply all by 2 (for .5), 3 (.33/.67), or 4 (.25/.75).

10 Combustion analysis — METHOD

All C → CO_2 (mass C = mol CO_2 × 12.01), all H → H_2O (mass H = 2 × mol H_2O × 1.008). For C-H-O, mass O = sample − C − H (by difference).