Gases & Gas Laws

Pressure units, the gas laws, PV=nRT, partial pressures, molecular speeds, and gas stoichiometry.

01 Pressure units — REFERENCE

1 atm = 101,325 Pa = 760 mmHg = 760 torr ≈ 1.01325 bar ≈ 14.696 psi. torr ≡ mmHg; 1 bar = 100,000 Pa exactly. Chain conversions by dimensional analysis.

02 Always use Kelvin — WATCH OUT

Every gas-law plug-in needs absolute T: T(K) = T(°C) + 273.15. Never put °C or °F into a gas-law equation. STP here = 0 °C (273.15 K) and 1 atm.

03 The simple gas laws — REFERENCE

Law	Held constant	Relation
Boyle	T, n	$P_1V_1 = P_2V_2$
Charles	P, n	$V_1/T_1 = V_2/T_2$
Gay-Lussac	V, n	$P_1/T_1 = P_2/T_2$
Avogadro	T, P	$V_1/n_1 = V_2/n_2$

04 Combined gas law — CORE RULE

$P_1V_1/T_1 = P_2V_2/T_2$ when P, V, and T all change (n fixed). T in Kelvin; P and V units just have to match between the two states.

05 Ideal gas law — CORE RULE

PV = nRT for a single state with 3 of 4 knowns. T in Kelvin. P = nRT/V, V = nRT/P, n = PV/RT, T = PV/nR. Pick the R whose units match P and V.

06 Choosing R — REFERENCE

R value	Use when
0.08206 L·atm/(mol·K)	P in atm, V in L
8.314 J/(mol·K)	SI; and all u_rms / KMT speeds
0.08314 L·bar/(mol·K)	P in bar, V in L
62.36 L·torr/(mol·K)	P in torr, V in L

07 Molar mass & density — CORE RULE

M = mRT/(VP); density ρ = PM/(RT). At STP one mole occupies 22.4 L, so ρ_STP = M / 22.4 (g/L). Match R to the pressure unit.

08 Partial pressures (Dalton) — CORE RULE

P_total = Σ P_partial. Mole fraction X_A = n_A/n_total = P_A/P_total, so P_A = X_A·P_total. Gas over water: P_gas = P_total − P_{H_2O}(T) (supplied).

09 Molecular speeds — CORE RULE

u_rms = √(3RT/M), with M in kg/mol and R = 8.314 to get m/s. Ratio (same T): u_rms,A / u_rms,B = √(M_B/M_A). (Mean = √(8RT/πM); most probable = √(2RT/M).)

10 Graham's law — CORE RULE

Effusion/diffusion: rate_A / rate_B = √(M_B/M_A): lighter gases move faster. Time scales the other way: time_A / time_B = √(M_A/M_B). Same temperature required.

11 Gas stoichiometry — METHOD

mass → moles → mole ratio → moles of gas → V via PV=nRT (or 22.4 L/mol at STP). If reactants and products are all gases at the same T, P, mole ratios equal volume ratios directly.