The Simple AP® Chemistry Unit 1 Cheat Sheet

1.1 Moles & Molar Mass

Why Moles

Can't count particles in lab → measure mass, convert to moles to link mass ↔ # of particles.
Avogadro's #: $N_A = 6.022\times10^{23}$ per mol, the # of particles in 1 mole of any substance.
amu ↔ g/mol: 1 H_2O = 18.02 amu; 1 mol H_2O = 18.02 g. Same number, new unit.

Conversion Map

From → To	Do this
grams → moles	÷ molar mass (n = m/M)
moles → grams	× molar mass
moles → particles	× 6.022×10^{23}
particles → moles	÷ 6.022×10^{23}

Worked Examples

Molar mass: CO_2 = 12.01 + 2(16.00) = 44.01 g/mol.

Mass → particles: 22.0 g CO_2 ÷ 44.01 g/mol = 0.500 mol × N_A = 3.01×10^{23} molecules.

Compare samples: equal masses → lighter molar mass has MORE moles & particles.
Mass of 1 particle = molar mass ÷ N_A: 1 H_2O = 18.02 ÷ 6.022×10^{23} = 2.99×10^{-23} g.
Ionic compounds: count formula units, not molecules (NaCl has no molecules).

⚠ Molecules ≠ atoms. 1 mol H_2O has 3 mol atoms (2 mol H + 1 mol O). Read the Q.

✓ FRQ: show the setup w/ units; a bare number earns no calculation point, even if right.

1.2 Mass Spectra of Elements

Reading a Mass Spectrum

x-axis: mass (amu) → each peak = 1 isotope. **y-axis**: relative abundance (how common).
Isotopes: same # protons, different # neutrons → different mass, same chemistry.
# of peaks = # of naturally occurring isotopes; tallest peak = most common isotope.

Average Atomic Mass

Weighted average: Σ(isotope mass × fractional abundance), added over every isotope.

Isotope	Mass (amu)	Abundance
^{35}Cl	34.97	75.78%
^{37}Cl	36.97	24.22%

Example: (34.97)(0.7578) + (36.97)(0.2422) = 35.45 amu → matches periodic table.
Estimate first: the avg mass sits closest to the most abundant isotope's mass.
Br: ^{79}Br & ^{81}Br ≈ 50/50 → avg ≈ 80.

Working Backward

Find abundance: let x = fraction of isotope 1, (1 − x) = isotope 2 → solve avg = $m_1x + m_2(1-x)$.
Identify element: compute the avg mass → match it to the periodic table's atomic mass.

⚠ No element has an atom w/ the average mass. Cl atoms are 35 or 37, never 35.45.

✓ Only single-element spectra are tested. Convert % to decimals before multiplying.

1.3 Elemental Composition

Pure Substances

Molecules (H_2O) vs. **formula units** (ionic, NaCl).
Law of definite proportions: a compound's mass ratio of elements is always the same (H_2O is always 11.2% H by mass, any sample).
Mass % = (mass of element in 1 mol ÷ molar mass) × 100. H in H_2O: 2.016/18.02 = 11.2%.

Empirical Formula Steps

Step	Action
1. Assume 100 g	% → grams
2. Grams → moles	÷ molar mass
3. Divide by smallest	Get mole ratio
4. Make whole #s	× 2, 3... if .5, .33

Example: 40.0% C, 6.7% H, 53.3% O → 3.33 : 6.65 : 3.33 mol → ÷ 3.33 → 1 : 2 : 1 → **CH_2O**, the empirical formula (lowest ratio).
Empirical formula: lowest whole-# ratio.
Molecular formula = (empirical) × n.
n = molar mass ÷ empirical mass. CH_2O (30.03) & M = 180.2 → n = 6 → $C_6H_{12}O_6$.

Ratio Traps

1.5 → × 2; **1.33 or 1.67** → × 3; **1.25** → × 4. Don't round 1.5 to 2; multiply all instead.

⚠ Mass ratio ≠ mole ratio. Convert grams to moles BEFORE comparing any amounts.

✓ Mass % alone gives only the empirical formula; you need molar mass for the molecular one.

1.4 Composition of Mixtures

Pure Substance vs. Mixture

	Pure	Mixture
Particle types	1	2+
Composition	Fixed	Varies
Mass %	Constant	Varies

Elemental Analysis

Elemental analysis: measure an element's mass in a sample → find relative # of atoms or purity.
Purity % = (mass of pure compound ÷ mass of sample) × 100. Pure = 100%; real < 100%.
Compare to theory: measured % ≠ pure compound's % → sample is impure.

Worked Example

Sample: 10.0 g impure NaCl contains 3.50 g Cl.
Step 1: Cl in pure NaCl = 35.45/58.44 = 60.7%.
Step 2: mass NaCl = 3.50 g ÷ 0.607 = 5.77 g.
Step 3: purity = 5.77 g ÷ 10.0 g × 100 = 57.7% (the impurity has no Cl in it at all, by assumption).

Reasoning w/ Impurities

Impurity w/ HIGHER % of element → measured % ↑; **lower %** (or none) → measured % ↓.
Wet sample (not fully dried): extra water mass → the calculated % of solute ↓ (too low).

⚠ A mixture can't have one formula. Only pure substances follow definite proportions.

✓ Error questions: say which direction the % shifts and WHY (extra or missing mass).

1.5 Atomic Structure & Electron Config

Atom & Coulomb's Law

Nucleus: protons (+) & neutrons (0); **electrons** (−) move around it, far outside the nucleus.
Coulomb's law: $F \propto q_1q_2/r^2$. ↑ nuclear charge or ↓ distance → stronger hold on e^- → harder to remove (higher ionization energy).
Core e^- (inner) shield valence e^- from the nucleus.

Aufbau Order (Fill Low → High)

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p. Capacity: s holds 2 e^-, p holds 6 e^-, d holds 10 e^-.

Atom/Ion	Configuration
O (8 e^-)	$1s^22s^22p^4$
Na	$[Ne]3s^1$
Fe	$[Ar]4s^23d^6$
Fe^{3+}	$[Ar]3d^5$
Cl^-	$[Ne]3s^23p^6 = [Ar]$

Shorthand: [noble gas] + the rest. S = $[Ne]3s^23p^4$; Ca = $[Ar]4s^2$. Count e^- to check.

Ions

Anions: add e^- to the next open subshell. **Cations**: remove from the highest n first.
Transition metals: lose 4s before 3d (Fe → Fe^{2+} = $[Ar]3d^6$, not $[Ar]4s^23d^4$). Fe^{3+} = $[Ar]3d^5$.

⚠ 4s fills before 3d but EMPTIES first when forming cations (transition metals).

✓ Explain w/ Coulomb's law: name the charge (protons) AND the distance (shell).

1.6 Photoelectron Spectroscopy (PES)

Reading a PES Spectrum

x-axis: binding energy (MJ/mol) = energy to remove an e^- from that subshell. Usually drawn HIGH → LOW, left to right (reversed axis).
Each peak = 1 subshell. **Peak height** ∝ # of e^- in it (up to 2 for an s peak, up to 6 for a p peak).
Farthest-left peak (highest energy) = 1s core; lowest-energy peak = valence e^-.

Example: Sodium

Subshell	# e^-	Energy
1s	2	Highest
2s	2	High
2p	6	Medium
3s	1	Lowest

Read config from peaks: heights 2, 2, 6, 1 → $1s^22s^22p^63s^1$ = 11 e^- = sodium (Na).

Comparing Spectra

Next element (more protons): the same subshells shift to HIGHER binding energy b/c ↑ nuclear charge pulls each e^- harder (Coulomb).
Valence peak energy ≈ 1st ionization energy (Na: 0.50 MJ/mol ≈ 496 kJ/mol, lowest peak).
Big gap between peaks = a new shell: Na's 2p → 3s jump in energy shows n = 2 → n = 3.

⚠ Check axis direction: binding energy usually INCREASES to the left on AP PES graphs.

✓ Shifted peaks → explain w/ Coulomb's law: more protons, same shell → stronger attraction.

1.7 Periodic Trends

Trend Table

Property	Across →	Down ↓
Atomic radius	↓	↑
1st IE	↑	↓
Electronegativity	↑	↓
Electron affinity	↑	↓

Why (Coulomb's Law)

Across a period: +1 proton, same shell, little added shielding → ↑ Z_{eff} → e^- pulled closer, held tighter → smaller atom, higher IE & EN.
Down a group: new shell → valence e^- farther & more shielded → weaker attraction.

Exceptions & Ions

Be → B: IE ↓ b/c B's 2p e^- is higher energy than 2s. **N → O**: IE ↓ b/c O's paired 2p e^- repel.
Successive IE: big jump when removing a core e^-. Mg: 738, 1451, **7733** kJ/mol → 2 valence e^-.
Cations smaller than parent atom (lose shell/↓ repulsion); **anions** larger (↑ repulsion).
Isoelectronic radii: more protons → smaller. O^{2-} > F^- > Na^+ > Mg^{2+} (all have 10 e^-).

⚠ "More shells" alone isn't enough on an FRQ: tie it to distance & attraction (Coulomb's law).

✓ Trend FRQ: compare protons (or Z_{eff}), shells/distance, then attraction → property.

⚠ Exceptions: IE drops Be → B and N → O; know both reasons (2p energy, paired-e^- repulsion).

1.8 Valence Electrons & Ionic Compounds

Valence Electrons Drive Bonding

Metals (low IE) lose e^-; **nonmetals** (high EA, EN) gain e^- → ions → ionic compounds.

Typical Ion Charges

Group	Valence e^-	Ion
1	1	+1
2	2	+2
13	3	+3
15	5	−3
16	6	−2
17	7	−1

Goal: noble-gas config. Na → Na^+ [Ne]; Cl → Cl^- [Ar]; Mg → Mg^{2+} [Ne]; O → O^{2-} [Ne].

Same Column, Same Formula

Analogous compounds: same column → same formula. NaCl → KBr; MgO → CaS; Na_2O → K_2S.
Predict formulas: balance charges. $Al^{3+} + O^{2-}$ → Al_2O_3; $Ca^{2+} + N^{3-}$ → Ca_3N_2 (total charge 0).
Unknown element: forms XCl_2 → likely group 2 (X^{2+}) → its oxide is XO, its nitride X_3N_2.
Metal + nonmetal → ionic compound.
Same column, same chemistry: equal valence e^- → similar reactions (Na & K both react w/ water).

⚠ Ionic formulas are formula units (lowest ratio): MgO, not Mg_2O_2; reduce the ratio.

✓ MCQ: unfamiliar element? Use its column to predict its ion charge & compounds.