High School Chemistry Essentials

A comprehensive cheat sheet designed for high school chemistry students, simplifying core concepts for exams and lab work. It covers essential topics from the periodic table and bonding to reactions, states of matter, acids/bases, and stoichiometry, with key formulas, definitions, and practical examples.

Foundations: Elements & Bonding

PERIODIC TABLE BASICS

Periods (Rows)	Horizontal rows (1-7). Indicate the number of electron shells an atom has.
Groups (Columns)	Vertical columns (1-18). Indicate the number of valence electrons (for main group elements) and similar chemical properties.
Metals	Left and center (Groups 1-12, parts of 13-16). Tend to lose electrons to form positive ions (cations). Shiny, malleable, ductile, good conductors.
Nonmetals	Upper right. Tend to gain electrons to form negative ions (anions) or share electrons. Dull, brittle, poor conductors.
Metalloids	Along the 'staircase' line (B, Si, Ge, As, Sb, Te). Exhibit properties of both metals and nonmetals.
Common Group Charges	• Group 1 (Alkali Metals): +1 (e.g., Na^+) • Group 2 (Alkaline Earth Metals): +2 (e.g., Mg^{2+}) • Group 17 (Halogens): -1 (e.g., Cl^-) • Group 18 (Noble Gases): 0 (stable)
Memory Tip	Periods are like ROWS in a play, they go across. Groups are like COLUMNS supporting a roof, they go up and down.

CHEMICAL BONDING

Ionic Bonds	Between a **metal and a nonmetal**. Involves the **transfer** of electrons from metal to nonmetal, forming ions (cations and anions) which are attracted electrostatically. **Example:** `NaCl` (Na loses 1e⁻ to Cl)
Covalent Bonds	Between two **nonmetals**. Involves the **sharing** of electrons to achieve a stable electron configuration (usually an octet). **Example:** H_2O (O shares electrons with 2 H atoms)
Metallic Bonds	Between **metal atoms**. Valence electrons are delocalized and form a 'sea of electrons' that can move freely, explaining metal properties like conductivity.
Octet Rule	Atoms tend to gain, lose, or share electrons to achieve a stable configuration of **eight valence electrons** (like noble gases). Hydrogen follows the 'duet rule' (2 electrons).
Lewis Dot Structures	Diagrams that show the valence electrons of atoms as dots around the element symbol. Used to illustrate bonding and non-bonding electron pairs.
Common Mistake	Confusing electron *transfer* (ionic) with electron *sharing* (covalent). Remember, 'ionic' sounds like 'ions' which are formed by transfer!
Polar vs. Nonpolar Covalent	• **Nonpolar:** Equal sharing of electrons (e.g., O_2, Cl_2). • **Polar:** Unequal sharing of electrons, creating partial charges (e.g., H_2O - Oxygen pulls electrons stronger).

Reactions, Matter & Gases

CHEMICAL REACTIONS

1. Synthesis (Combination)
Two or more reactants combine to form a single, more complex product.
$A + B \rightarrow AB$
Example: $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$

2. Decomposition
A single compound breaks down into two or more simpler substances.
$AB \rightarrow A + B$
Example: $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

3. Single Replacement (Displacement)
One element replaces another element in a compound.
$A + BC \rightarrow AC + B$
Example: $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

4. Double Replacement (Displacement)
The positive ions (cations) of two ionic compounds swap places, forming two new compounds (often one is a precipitate, gas, or water).
$AB + CD \rightarrow AD + CB$
Example: $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

5. Combustion
A rapid reaction with oxygen, usually producing heat and light. For hydrocarbons, products are always carbon dioxide and water.
$\text{Hydrocarbon} + O_2 \rightarrow CO_2 + H_2O$
Example: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Balancing Chemical Equations

- **Law of Conservation of Mass:** Atoms are neither created nor destroyed.
- **Steps:**
  1. Count atoms of each element on both sides.
  2. Balance metals first, then nonmetals (excluding H & O).
  3. Balance Oxygen (O).
  4. Balance Hydrogen (H).
  5. Check all elements. Coefficients must be lowest whole numbers.
     Example: `_C₂H₆ + _O₂ → _CO₂ + _H₂O` becomes `2C₂H₆ + 7O₂ → 4CO₂ + 6H₂O`

Memory Tip:
'Subscripts STAY, Coefficients CHANGE!' You change the number of molecules (coefficients), not the formula of the molecules (subscripts).

STATES OF MATTER & GAS LAWS

Solids	$Fixedshapeandvolume. Particlesaretightlypackedandvibrateinfixedpositions. Strongintermolecularforces.$
Liquids	$Fixedvolume, variableshape(takesshapeofcontainer). Particlesareclosebutcanslidepasteachother. Moderateintermolecularforces.$
Gases	$Variableshapeandvolume(fillscontainer). Particlesarefarapartandmoverandomlyandrapidly. Negligibleintermolecularforces.$
Boyle's Law (P vs. V)	$P_1V_1 = P_2V_2$
At constant temperature and moles, pressure and volume are **inversely proportional**. If pressure increases, volume decreases.	$P_1V_1 = P_2V_2$
Charles's Law (V vs. T)	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
At constant pressure and moles, volume and temperature (in Kelvin) are **directly proportional**. If temperature increases, volume increases.	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Ideal Gas Law	$PV = nRT$
Relates Pressure (P), Volume (V), moles (n), and Temperature (T). R = Ideal Gas Constant ($0.0821\,\frac{\mathrm{L \cdot atm}}{\mathrm{mol \cdot K}}$). **Units are crucial!** P in atm, V in L, T in K.	$PV = nRT$
Common Mistake:	$Forgettingtoconvert**temperaturetoKelvin**forallgaslawcalculations!\backslash K = ^\circ C + 273.15\backslash$

Acids, Moles & Calculations

ACIDS, BASES & pH

pH Scale	Measures the acidity or basicity of a solution, from 0 to 14. • **0-6.9:** Acidic • **7.0:** Neutral • **7.1-14:** Basic (Alkaline)

pH Calculation	`pH = -log[H⁺]`
	`pOH = -log[OH⁻]`
	`pH + pOH = 14`

Acid Indicators	Substances that change color depending on the pH of the solution. • **Litmus Paper:** Red in acid, blue in base. • **Phenolphthalein:** Colorless in acid, pink in base.
Arrhenius Definition	• **Acid:** Produces H^+ ions when dissolved in water (e.g., $HCl \rightarrow H^+ + Cl^-$) • **Base:** Produces OH^- ions when dissolved in water (e.g., $NaOH \rightarrow Na^+ + OH^-$)
Brønsted-Lowry Definition	• **Acid:** A proton (H^+) **donor** (e.g., HCl in $HCl + H_2O \rightarrow H_3O^+ + Cl^-$) • **Base:** A proton ($H^+$) **acceptor** (e.g., NH_3 in $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$)
Conjugate Acid-Base Pairs	When a Brønsted-Lowry acid donates a proton, it forms its conjugate base. When a Brønsted-Lowry base accepts a proton, it forms its conjugate acid. **Example:** HCl (acid) + H_2O (base) $\rightleftharpoons$ Cl^- (conjugate base) + H_3O^+ (conjugate acid)
Memory Tip:	Brønsted-Lowry is broader. Think of it like a `give and take` (donor/acceptor) of protons, rather than just what they *produce* in water.

MOLES & STOICHIOMETRY

The Mole (mol)	The SI unit for amount of substance. A mole of any substance contains Avogadro's number of particles.
Avogadro's Number	6.022×10^{23} This is the number of particles (atoms, molecules, ions, formula units) in exactly one mole of a substance.
Molar Mass (g/mol)	The mass of one mole of a substance. Numerically equal to the atomic mass (for elements) or formula/molecular mass (for compounds) in grams. **Example:** Molar mass of H_2O = $(2 \times 1.008) + 16.00 = 18.016$ g/mol

Mole-to-Mass Conversion	`Moles x Molar Mass = Grams`
	`Grams / Molar Mass = Moles`
	Example: How many grams are in 0.5 mol of H_2O?
	`0.5 mol x 18.016 g/mol = 9.008 g`

Mole-to-Particle Conversion	`Moles x Avogadro's Number = Particles`
	`Particles / Avogadro's Number = Moles`
	Example: How many molecules in 2 mol of CO_2?
	2 mol $\times 6.022 \times 10^{23}$ molecules/mol $= 1.2044 \times 10^{24}$ molecules

Mole-to-Mole Conversion (Stoichiometry)	Uses the **mole ratio** from a **balanced chemical equation** to convert between moles of different substances. **Example:** $2H_2 + O_2 \rightarrow 2H_2O$ If you have 4 moles of H_2, how many moles of H_2O are produced? 4 mol $H_2 \times (2$ mol H_2O / 2 mol $H_2) = 4$ mol H_2O
Common Mistake:	Forgetting to **balance the chemical equation** *before* doing any mole-to-mole (stoichiometry) calculations. The coefficients are the key!