R  Reactions and Equations

General equation; reaction → products
(you want to see how many atoms are created or destroyed)

Ex: \( \text{PCl}_5 (s) + \text{H}_2\text{O} (l) \rightarrow \text{H}_3\text{PO}_4 (aq) + \text{HCl} (aq) \)

\[
\begin{array}{cccc}
P & Cl & H & O \\ 1 & 5 & 2 & 1
\end{array}
\rightarrow
\begin{array}{cccc}
P & Cl & H & O \\ 1 & 5 & 8 & 4
\end{array}
\]
unbalanced equation

balanced formula
\( \text{PCl}_5 (s) + 4\text{H}_2\text{O} (l) \rightarrow \text{H}_3\text{PO}_4 (aq) + 5\text{HCl} (aq) \)

step 1: place a 1 in front of the formula with the largest number of atoms
(if it is a tie, select the one with the most elements)

step 2: balance the elements in the compounds;
   a) elements in starting formula that are in only one other compound
   b) all other elements in starting formula
   c) all other elements in all compound

step 3: balanced uncombined element

ex: \( \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \)

\[
\begin{array}{cccc}
\text{H} & \text{O} & \text{C} & \text{H} & \text{O} \\
3 & 8 & 2 & 1 & 3
\end{array}
\]
unbalanced

\[
\begin{array}{cccc}
\text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} \\
3 & 8 & 10 & 3 & 8 & 10
\end{array}
\]
balanced

1. R.5 Combination Reactions
A + X → AX (a reaction in which two or more substances combine to form a single product)

Reaction between sodium and chlorine to form sodium chloride is a combination reaction:
\( 2\text{Na} (s) + \text{Cl}_2 (g) \rightarrow 2\text{NaCl} (s) \)
\( \text{Na} (s) + \text{O}_2 (g) \rightarrow \text{Na}_2\text{O}_2 (s) \) - solid sodium peroxide

2. R.6 Decomposition
A → A + X

Opposite of a combination reaction, in that a compound breaks down into simpler substances

Discovery of oxygen by heating mercury(II) oxide is a typical decomposition reaction:
2HgO(s) → 2Hg(l) + O₂(g)
water: H₂O → H₂(g) + O₂(g)

3. R.7 Burning Reaction
organic molecules; C, H, O, combustion – need oxygen for fire
(as a rule, these equations are most easily balanced if you take the elements C,H,O in that order)
CₓHᵧOₑ + O₂ → CO₂ + H₂O
Ex: ethane: 2C₂H₆ + 7O₂ → 4CO₂(g) + 6H₂O(l)

4. R.9 Double-Replacement Precipitation Reactions
When solutions of two compounds are mixed, a positive ion from one compound may combine
with the negative ion from the other compound to form a solid compound that settles to the
bottom. The solid is a precipitate; the reaction is a precipitate reaction
AX + BY → AY + BX
Ex: calcium chloride and sodium fluoride; CaCl₂(aq) + 2NaF(aq) → CaF₂(s) + 2NaCl(aq)
Ex: BaCl₂ + Na₂SO₄ → (Ba²⁺ + 2Cl⁻) + (2Na⁺ + SO₄²⁻) → BaSO₄(s) + NaCl(aq)

5. R.10 Neutralization
(Ionic bonds – salts)
acid + base → water + salt ; HX + YOH → H₂O + YX
ex: HX(aq) + MOH(aq) → H₂O(l) + MX(aq)
(acid) (base) (water) (salt)
ex: nitric acid: HNO₃(aq) + NaOH(aq) → H₂O(l) + NaNO₃(aq)

6. R.8 Single Replacement (oxidation-reduction)
many elements are capable of replacing ions of other elements from aqueous solution. This is
oxidation-reduction or “redox” reaction. The equation for such an element looks as if one element
is replacing another in a compound.
A + BX → AX + B  more positive oxidation – loss of e⁻  more negative oxidation – gain of e⁻
Ex: Ca(s) + 2HCl(aq) → CaCl₂ + H₂(g)
• Ca (0 charge) → Ca²⁺ + 2e⁻ → oxidized
• 2H → H₂ reduced