Outcome of a chemical reaction

Note: The combustion of propane (C_3H_8) will be used as the basis for this lesson, with an initial system consisting of 6 moles of propane and 20 moles of oxygen.
One of the reactants is therefore necessarily oxygen, and the products are water and carbon dioxide.

Definition of a chemical reaction

A chemical transformation is one in which reactants react with each other to produce **new** products.

$$\overbrace{C_3H_{8(g)} + 5O_{2(g)}}^{\text{reactant}} \text{ "gives" } \longrightarrow \overbrace{4H_2O_{(l)} + 3CO_{2(g)}}^{\text{products}}$$

1, 5, 4, 3 : stoichiometric coefficients

Evolution of the chemical reaction

In moles	$C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 4H_2O_{(l)} + 3CO_{2(g)}$					
Initial state:	6	20	0	0	x = 0	t = 0
Final state:	$6 - x_f$	$20 - 5x_f$	$4x_f$	$3x_f$	$x = x_f$	t_f

- **RATE X OF THE CHEMICAL REACTION**

x is the **rate of chemical transformation**. It is a quantity of matter (mol).
x can be used to monitor changes in the composition of a system during a chemical transformation.

- **FINAL STATE OF THE SYSTEM**

The final state of the system is reached when the system doesn't evolve anymore.

Note: If the chemical reaction is total, one of the reactants has then been entirely consumed. It is the limiting reactant: $x_f = x_{max}$

Determination of the theoretical yield x_{max} and the limiting reactant:
2 hypotheses must be considered:
Hyp 1: C_3H_8 is the limiting reactant: $n_{C_3H_{8\,f}} = 0 \Rightarrow 6 - x_{max,1} = 0 \Rightarrow x_{max,1} = 6 \text{ mol}$
Hyp 2: O_2 is the limiting reactant: $n_{O_{2\,f}} = 0 \Rightarrow 20 - 5x_{max,2} = 0 \Rightarrow x_{max,2} = \frac{20}{5} = 4 \text{ mol}$
$x_{max,2} < x_{max,1} \Rightarrow x_{max} = x_{f,2} = 4\,mol.$
Oxygen gas is the limiting reactant: $n_{O_2} = 0$.
At the final state of the system, we therefore have:
$n_{C_3H_8} = 2$ mol, $n_{O_2} = 20$ mol, $n_{H_2O} = 16$ mol, $n_{C_3H_8} = 12$ mol.

Stoichiometric mixture

A mixture is said to be **stoichiometric** if the initial quantities of the component reactants are in the proportions of the stoichiometric coefficients of these reactants in the reaction equation.
The quantities of all the reactants then cancel out for the same value of x_{max}. At the end of the reaction, all the reactants are fully consumed.

Ex:	$C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 4H_2O_{(l)} + 3CO_{2(g)}$	**en mol**
EI	3	15
EF	0	0