Module 4: Describing Chemical and Physical Changes

Chemical and Physical Changes

Fundamentals of Chemistry Open Course

Learning Objectives | Module 4

1. Distinguish between chemical and physical changes, particularly in equations containing chemical formulas.

2. Interpret chemical equations to visualize chemical reactions or physical changes.

3. Determine whether a given chemical equation is balanced or not; balance chemical equations.

4. Apply chemical equations to determine the outcome of a chemical reaction on the submicroscopic level.

5. Convert a submicroscopic image of a chemical reaction or physical change into a chemical equation.

Review. Physical and Chemical Changes

- **Physical changes** alter the state or appearance of matter but do not affect its chemical composition.

Melting wax (a) and condensing water (b) are physical changes.

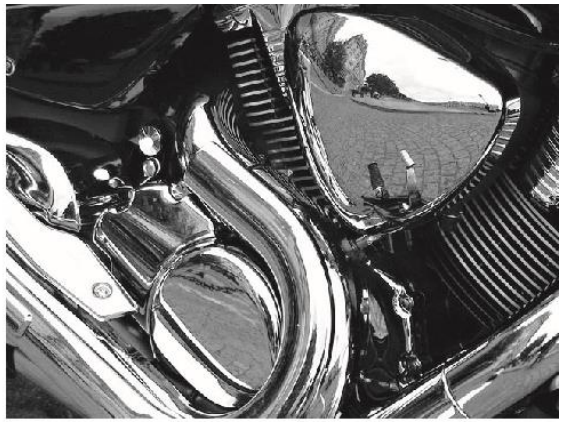
(a)

(b)

- **Chemical changes (chemical reactions)** alter the chemical structure of a substance by breaking and/or forming chemical bonds.

Reaction of iron with oxygen (a) is a chemical change; chromium does not react with oxygen (b).

(a)



(b)

Chemical Equations

- **Chemical equations** contain chemical formulas and (usually) phase designators to represent the state of a chemical system before and after some change.

[initial state] → [final state]

- The change may be chemical or physical! Physical changes involve *only* a change in phase designator—chemical formulas do not change.

- Numbers before each chemical formula (**stoichiometric coefficients**) represent the number of formula units involved in the change.

- Coefficients reflect the number ratios in which formula units combine in a chemical reaction.

- Like a recipe, chemical equations can be scaled. In scaling an equation, we multiply all coefficients by the same scaling factor. Chemical formulas remain unchanged!

Chemical Equations

Example. Evaporation of water, a physical change, can be represented as follows.

$$H_2O(\ell) \rightarrow H_2O(g)$$

Example. Combustion of butane (C_4H_{10}) is a chemical change.

$$C_4H_{10}(g) + 6.5\ O_2(g) \rightarrow 4\ CO_2(g) + 5\ H_2O(g)$$

This equation can be scaled to any level desired…

$$2\ C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8\ CO_2(g) + 10\ H_2O(g)$$

$$1\ \text{mol}\ C_4H_{10}(g) + 6.5\ \text{mol}\ O_2(g) \rightarrow 4\ \text{mol}\ CO_2(g) + 5\ \text{mol}\ H_2O(g)$$

$$2\ \text{mol}\ C_4H_{10}(g) + 13\ \text{mol}\ O_2(g) \rightarrow 8\ \text{mol}\ CO_2(g) + 10\ \text{mol}\ H_2O(g)$$

Lingering Questions

- Some chemical substances can react with one another in more than one way. How can we predict the outcome when substances are mixed?

- What makes a chemical equation physically plausible? What natural laws must chemical reactions follow?