CHAPTER 2: Compounds & Chemical Reactions

Elements combine to form compounds whose properties are, in general, completely different from those of the elements.

Some elements occur naturally as diatomics: H₂, N₂, O₂, F₂, Cl₂, Br₂, I₂.

Compounds have a fixed composition.

Rust = iron oxide = Fe₂O₃. Two atoms of iron combine with three atoms of oxygen to form a molecule of Fe₂O₃.

Urea = CO(NH₂)₂. Brackets used to indicate structure.

Hydrates are solids that contain water that can be removed.

Blue CuSO₄·5H₂O → white CuSO₄ + 5H₂O. Anhydrous means no water attached to the compound.
Chemical equations describe a chemical reaction

\[ 2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O} \]

Stoichiometric coefficients are used to balance the reaction. (Mass conservation law enforced)

Energy, heat, and temperature

Chemical reactions either emit or absorb energy. However, energy is conserved overall (cannot be created or destroyed)

\[ E = K + U \]

Total energy = kinetic energy + potential energy

\[ K = \sum_{i=1}^{N} \frac{1}{2} m_i v_i^2 \]

\( K \) counts atoms \((N\) total\)

Ex: if we heat a beaker of water, the molecules start moving faster \((v\) increases\) and eventually they can escape into the air as vapor.

\( U \): can be thought of as stored energy

Ex: energy is stored in a chemical bond
Temperature \( T = \frac{2}{3k_b} \frac{1}{N} \sum_{i=1}^{N} \frac{1}{2} m_i v_i^2 \),

constant average kinetic energy of the atoms

heat: defined as energy transferred between two objects due to a temperature difference between them.

molecule - collection of atoms attached to each other by chemical bonds, electrically neutral.

chemical bond - attaches atoms together - atoms share their electrons, bond is thus electrically in nature.

Look at some molecules formed by non-metals (most of organic chemistry and biochemistry)

- **Hydrides** = \( H + \) non-metal; formulas are predictable from the periodic table

- **Hydrocarbons** - \( C \) and \( H \); there are organic compounds from petroleum, natural gas, ...
  - simplest is methane = \( CH_4 \)

In general, the simplest series is the alkanes, \( C_n H_{2n+2} \)

- methane \( \text{CH}_4 \)
- ethane \( \text{C}_2\text{H}_6 \)
- propane \( \text{C}_3\text{H}_8 \)
- butane \( \text{C}_4\text{H}_{10} \)
- pentane \( \text{C}_5\text{H}_{12} \)
- hexane \( \text{C}_6\text{H}_{14} \)
Chemistry

Alcohols - replacing H with OH gives an alcohol:

CH₄ → CH₃OH methanol
C₂H₆ → C₂H₅OH ethanol

Nomenclature → inorganic

Chemists need a systematic method for assigning names to compounds because there are so many compounds known and new compounds are made all the time.

Binary compounds of 2 non-metals
- use # of atoms of each element as a prefix (Greek, mono, di, tri...) usually omitted

Exception H₂ - non-metal: name doesn't indicate the # of H's (n) because it's clear (see pg. 51 of text)

Common names - a few compounds have common (non-systematic) names used by chemists

Ionic compounds → metal reacted with nonmetal
  → formed by a transfer of electrons

\[
2\text{Na}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s)
\]

Neutral \[\text{neutral} \quad \text{neutral}\]

But really, \[\text{Na}^+ + \text{Cl}^-\] and then these charged particles (called ions) pack together into a crystal structure to maximize the electrostatic forces.
In the NaCl(s) crystal structure, each ion is surrounded by six of the other kind. NaCl(s) does not consist of molecules which can be identified. Rather, many ions pack together.

By writing NaCl(s) we are simply indicating that the ratio of Na and Cl is 1:1. We use the smallest ratio, so we do not write Na₂Cl₂.

We call NaCl a "formula unit."

Cation → +ve ion (metal)
Anion → -ve ion (non-metal)

Table 2.3 elements in the same group tend to gain or lose the same # of e⁻; namely the # required to reach a noble gas.

Rules for Nomenclature:
1. Cation written first
2. Formula unit is electrically neutral
3. Use smallest integer ratio
Transition metals can form more than one ion. For example, iron forms Fe\(^{2+}\) and Fe\(^{3+}\), and copper forms Cu\(^+\) and Cu\(^{2+}\).

Stock system — use a roman numeral in brackets to indicate the charge, after the English name.

**Rules**

- Use the English name of the metal, with a roman numeral only if the metal can form multiple ions.
- If the anion is composed of a single element, use "-ide" ending. The name does not include the number of atoms involved because you can figure it out from the periodic table.

- If the anion is polyatomic (composed of > 1 element) or the cation is NH\(^+\), use the name from Table 2.5.
Transition metals can form more than one ion.

- Iron: \( Fe^{2+} \) and \( Fe^{3+} \)
- Copper: \( Cu^{+} \) and \( Cu^{2+} \)

**Stock system** - use Roman numeral:

- \( Fe^{2+} \) iron(II)
- \( Fe^{3+} \) iron(III)

**Old (Latin) system**

- **ous** for lower charge
- **ic** for higher charge

- \( Fe^{2+} \) ferrous
- \( Fe^{3+} \) ferric
- \( Cu^{+} \) cuprous
- \( Cu^{2+} \) cupric

Must memorize the box on page 66.

(+ the tables in Ch. 2)
Properties of Ionic Solids

- Hard and brittle
- Crystalline structure that does not deform (falls apart instead)
- Electrostatic interactions result in high melting points

$\text{Al} (s)$ aluminum metal melting point 660$^\circ$C
$\text{Al}_2\text{O}_3$ aluminum oxide melting point 2050$^\circ$C

- Not conductive (no mobile charge carriers)
- But conductive when melted or dissolved in water (charge carriers can move)

Chapter 3: Measurement

Measurements in science (e.g., temperature) usually involve units (but not always: pH)

Science uses the SI system of units. A partial list: (Table 3.1)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Base unit</th>
<th>Symbol</th>
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<tr>
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