Non-metals
- insulators
- brittle (for the solids)

Metalloids
- semiconductors
- behave more like nonmetals than metals

CHAPTER 2 : Compounds & Chemical Reactions

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

Formulas
some elements occur naturally as diatomics H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

compounds have a fixed composition
ex rust = iron oxide = Fe_2O_3 two atoms of iron combine with three atoms of oxygen to form a molecule of Fe_2O_3

urea = $CO(NH_2)_2$
brackets used to indicate structure

Hydrates are solids that contain water that can be removed

blue $CuSO_4 \cdot 5H_2O \xrightarrow{heat/dry} CuSO_4 + 5H_2O$ white

· denotes a hydrate

anhydrous means no water attached to the compound.

You must be able to count atoms in a formula

ex $Co(NO_3)_2 \cdot 6H_2O$

Chemical equations describe a chemical reaction

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$$

stochiometric coefficients 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

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

i 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 $= T = \frac{2}{3k_B} \frac{1}{N} \sum_{i=1}^{N} \frac{1}{2} m_i v_i^2$

$3k_B$: constant; $\frac{1}{N} \sum_{i=1}^{N} \frac{1}{2} m_i v_i^2$: 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 electrical 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   these are organic compounds from petroleum, natural gas, ...
- simplest is methane = CH_4

In general, the simplest series is the alkanes, C_nH_{2n+2}

methane	CH_4	gases at room temperature and atmospheric pressure
ethane	C_2H_6	
propane	C_3H_8	
butane	C_4H_{10}	
pentane	C_5H_{12}	liquids "
hexane	C_6H_{14}	

alcohols - replacing H with OH gives an alcohol

CH_4 to CH_3OH methanol
C_2H_6 to C_2H_5OH 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 usually omitted)

exception H_n-nonmetal: name doesn't indicate the # of H's (n) because its 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 e^-

$$\underbrace{2Na(s) + Cl_2(g)}_{neutral} \longrightarrow \underbrace{2NaCl(s)}_{neutral}$$

But really $Na + Cl \longrightarrow Na^+ + Cl^-$ (e^- transferred from Na to 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 Na_2Cl_2.

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

ex Iron Fe^{2+} or Fe^{3+} ex Copper Cu^{+} or Cu^{2+}

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

Rules

- use English name of 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

name does not include the # 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_4^+ use the name from Table 2.5

Transition metals can form more than one ion.

ex Iron Fe^{2+} or Fe^{3+} ex Copper Cu^{+} or 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

$Al(s)$ aluminum metal melting point 660 °C
Al_2O_3 aluminum oxide melting point 2050 °C

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

Chapter 3 : Measurement

UNITS

measurements in science (ex temperature) usually involve units (but not always : pH)

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

Measurement	Base unit	Symbol
length		
mass		
time		
temperature		