General Chemistry I topics

Periodic table, ions and ionic compounds, stoichiometry, concentration, formula weights, interconverting masses and moles, thermochemistry, enthalpy, wave behavior of matter, quantum mechanics and atomic orbitals, representations of orbitals (s,p,d,f), electron spin and Pauli exclusion principle, electron configurations, effective nuclear charge, sizes of atoms and ions (trends), electron affinity, electronegativity, group trends, Lewis symbols, ionic bonding and energetics, covalent bonding, molecular geometry and bonding theories, VSEPR, covalent bonding and orbital overlap, molecular orbitals for simple diatomic molecules, gas laws.

Expected knowledge after completing General Chemistry I

Italicized red items may be supplemental information.

Elements

All main group elements, the first row transition metals, and a few other elements: Ag, Au, Hg, and U. Chapters 20 and later we'll also encounter *Tc, Pd, Cd, Pt, Ac, Th, Pa, Np, Pu, Am, and Cm*.

Subatomic particles

Electrons, e^-, -1 charge. Protons, p^+, +1 charge. Neutrons, n^0, no charge. α particles are positively charged. β particles are negatively charges. γ particles have no charge. Know how to write atomic notation, e.g., ${}^{17}_{8}O$ where 17 is the mass number and 8 is the atomic number.

Group/family names

1A or 1	alkali metals	4d, 5d, 6d elements	transition metals
2A or 2	alkaline earth metals	4f and 5f elements	f-block elements
5A or 15	*pnictogens*	4f elements	lanthanides
6A or 16	*chalcogens*	5f elements	actinides
7A or 17	halogens	*elements after U*	*transuranium elements*
8A or 18	noble, inert, or rare gases	*elements after Lr (#103)*	*postactinide elements*
1, 2, 13 to 18	main group or representative elements	1, 2	s-block elements
13 to 18	p-block elements	3 to 12	d-block elements

Some periodic facts

Know the trends for effective nuclear charge, ionization energy, electron affinity, electronegativity, metallicity, atomic radii, ionic radii, and lattice energies.

Metals are solids at room temperature (except Hg), conduct electricity and heat well, shiny, ductile and malleable, and tend to lose electrons to form cations. Nonmetals come in all phases at room temperature, do not conduct electricity (except graphite) or heat well, are typically dull or brittle, and tend to gain electrons to form anions. One definition of semi-metals (or metalloids) is that they have physical properties of metals and chemical properties of nonmetals; this book lists B, Si, Ge, As, Sb, Te, and At as semi-metals.

Commonly taught allotropes are ozone (O_3), dioxygen (O_2), diamond (C), graphite (C), cyclooctasulfur (S_8).

Alkali metals: chemical reactivity increases going down the group; Na and below form peroxides (e.g., Na_2O_2); K and below form superoxides (e.g. KO_2). Alkaline earth metals: chemical reactivity increases going down the group. Halogens: chemical reactivity decreases going down the group.

There are seven homonuclear diatomic elements: H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2

IUPAC nomenclature (see pp 60 – 68 of volume 1) *We'll learn more nomenclature in chapter 24.*

An ionic compound is named based on the cation and anion. The "ion" name is dropped. If the metal has only one common charge (e.g., Al, Zn, Ag, Ba, Li), then the charge is not written.

cation (charge) + anion "ide", e.g., iron (III) oxide for Fe_2O_3

A binary molecular compound (not an acid) is named as follows. Typically the least electronegative atom is named first. Prefixes (mono-, di-, tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-) are used except that mono- is not use with the first named element. Also, prefix endings of "a" and "o" are dropped if the element is oxygen. An "ide" ending is given to the second element.

In general, acids will have a leading H in the formula (although this will not be true later in the course) and in aqueous solution, an acid is named as follows:

root anion has "ide" ending	hydro____ic acid
root anion has "ate" ending	____ic acid
root anion has "ite" ending	____ous acid

Strong acids and bases

There are seven strong acids: chloric acid, hydrobromic acid, hydrochloric acid, hydroiodic acid, nitric acid, perchloric acid, and sulfuric acid. The first proton ionizes completely from these strong acids. The strong bases consist of the hydroxides of the alkali metals and heavy alkaline earth metals (Ca, Sr, Ba).

Common names of some compounds

NH_3	ammonia	*C_3H_8*	*propane*
H_2O	water	*CH_3OH*	*methanol*
CH_4	methane	*C_2H_5OH*	*ethanol*
C_2H_6	ethane	*C_3H_7OH*	*propanol* (organic classes will number it)

Ions

Hg_2^{2+}	*mercury (I) ion*	NH_4^+	ammonium ion
CN^-	*cyanide ion*	$CH_3CO_2^-$ and $C_2H_3O_2^-$	acetate ion
CO_3^{2-}	carbonate ion	HCO_3^-	hydrogen carbonate or bicarbonate ion
BrO_3^-	*bromate ion*	*BrO^-*	*hypobromite ion*
BrO_4^-	*perbromate ion*	*BrO_2^-*	*bromite ion*
ClO_3^-	chlorate ion	ClO^-	hypochlorite ion
ClO_4^-	perchlorate ion	ClO_2^-	chlorite ion
IO_3^-	*iodate ion*	*IO^-*	*hypoiodite ion*
IO_4^-	*periodate ion*	*IO_2^-*	*iodite ion*
OH^-	hydroxide ion		
NO_3^-	nitrate ion	NO_2^-	nitrite ion
PO_4^{3-}	phosphate ion	*PO_3^{3-}*	*phosphite ion*
$H_2PO_4^-$	dihydrogen phosphate ion	*$H_2PO_3^-$*	*dihydrogen phosphite ion*
HPO_4^{2-}	hydrogen phosphate ion	*HPO_3^{2-}*	*hydrogen phosphite ion*
SO_4^{2-}	sulfate ion	SO_3^{2-}	sulfite ion
HSO_4^-	hydrogen sulfate or *bisulfate ion*	HSO_3^-	hydrogen sulfite or *bisulfite ion*
CrO_4^{2-}	*chromate ion*	*$C_2O_4^{2-}$*	*oxalate ion*
$Cr_2O_7^{2-}$	*dichromate ion*	*MnO_4^-*	*permanganate ion*

Types of reactions

Combustion: heating a substance with oxygen produces oxides of each element.
Combination: two or more reactants produce a single product.
Decomposition: one reactant (with or without heating) produces two or more products.
- Metal hydrogen carbonates, upon some heating, will produce metal carbonates, water, and carbon dioxide.
- Metal carbonates, upon heating, will produce metal oxides and carbon dioxide.

Single-replacement: AX + B → A + BX
Redox (oxidation-reduction): electrons are transferred between reactants.
Metathesis (or exchange or double-replacement): AX + BY → AY + BX
- The reaction proceeds if a precipitate forms, a weak/non-electrolyte (e.g., water) forms or a gas forms.

Precipitation: a metathesis reaction where an insoluble product forms.
Neutralization: an acid and a base produce a salt and water.
Gas formation reactions:
- carbonate or hydrogen carbonate compound + acid → salt + water + carbon dioxide gas
- sulfite or hydrogen sulfite compound + acid → salt + water + sulfur dioxide gas
- sulfide compound + acid → salt + hydrogen sulfide gas
- *ammonium compound + strong base → salt + water + ammonia gas*

Writing molecular equations, complete ionic equations, and net ionic equations. Identifying spectator ions.

Solubility table: Ionic compounds containing

- acetates, nitrates, alkali metals and/or ammonium are always soluble.
- chlorides, bromides, and iodides are soluble except with silver, mercury (I) and lead (II).
- sulfates are soluble except with mercury (I), lead (II), strontium and barium.
- sulfides and hydroxides are insoluble except with calcium, strontium, barium, alkali metals and ammonium.
- carbonates and phosphates are insoluble except with alkali metals and ammonium.

Thermochemistry terminology

energy (E), work (w), heat (q), surroundings, system, universe, internal energy, enthalpy ($\Delta H = q_p$), state function exothermic, endothermic, 1st law of thermodynamics, constant pressure calorimetry and bomb calorimetry (constant volume), heat capacity (J/°C), molar heat capacity(J/mol·°C), specific heat capacity (J/g·°C), Hess' law, enthalpy of formation, standard state, bond enthalpies (D)

The electronic structure of atoms

Dalton's atomic model: mainly identical, indivisible and indestructible atoms
Thomson's atomic model (plum pudding) – after his cathode ray tube experiment
Rutherford's atomic model – after his gold foil experiment
Bohr's atomic model – used to explain (only) hydrogen emission spectra (the Balmer series)
Quantum mechanic atomic model – based on quantum mechanics
Other: $c = \lambda \nu$, $E = h \nu$ wave-particle duality, photoelectric effect, photons, Heisenberg's uncertainty principle.
Schrödinger's wave equation: $H\Psi = E\Psi$ that gives a statistical method of locating an electron.
Four quantum numbers: principle quantum number, $\boldsymbol{n}$ = 1, 2, 3...
azimuthal or angular mometum quantum number, $\boldsymbol{l}$ = 0, 1, ... *n-1*
magnetic quantum number, $\boldsymbol{m_l}$ = -*l*, -*l*+1, ... 0, ... +*l*-1, +*l*
(electron) spin magnetic quantum number, $\boldsymbol{m_s}$ = +½, -½
Pauli exclusion principle: the four quantum number may not be the same for any two electrons (which results in the fact that no more than two electrons are allowed per orbital).
Aufbau principle: electrons are placed in the lowest energetic available orbital.
Hund's rule: the lowest energy is attained with the number of electrons with the same spin is maximized (i.e., degenerate orbitals will fill up singly before any pairing begins).

Electron configurations and condensed (or noble gas or core) notation configurations.
Core vs valence electrons. Lewis symbols.
Paramagnetic (unpaired electrons) vs diamagnetic (paired electrons).

Chemical bonding concepts

Ionic vs covalent vs metallic bonding.
Lewis structures: octet rule, resonance. Exceptions to the octet rule:
odd number, less than 8 (primarily Be and B), and more than 8 (with a 3rd row or lower element, such as P).
Bond lengths and bond dissociate energies (or bond enthalpies).
Bond polarity, dipole moments, and molecular polarity.
Valence shell electron-pair repulsion (VSEPR) theory.
Electron-domain geometry, molecular geometry, and bond angles.
linear, trigonal planar (angular/bent), tetrahedral (trigonal pyramidal, angular/bent), trigonal bipyramidal (seesaw, T-shaped, linear), octahedral (square pyramidal, square planar).
Valence-bond theory: σ and π bonding, hybrid orbitals, *sp, sp*^{2}*, sp*^{3}*, sp*^{3}*d, sp*^{3}*d*^{2}
Delocalized π bonding.
Molecular orbital (MO) theory: bonding and antibonding molecular orbitals. molecular orbital diagram, bond order, decreasing 2s-2p interaction across the 2nd period (so σ_{2p} is above π_{2p}* for O_2, F_2, Ne_2).

Other concepts

The scientific method: observations, experiments, hypotheses, theories, and scientific laws.
Matter has three states: gas, liquid and solid. Matter can be classified into pure substances (compounds, elements), solutions/homogeneous mixtures or heterogeneous mixtures.
The base SI units are *kg*, *m*, *s*, *K*, *mol*, *A*, and *cd*. Know the prefixes: *centi-*, *milli-*, *nano-*, *kilo-*, etc.
The uncertainties in measurements require the usage of significant figures.
Understand the difference between precision (repetition) and accuracy (correctness).

Dimensional analysis is a very important tool. Master it.

Density is mass per volume.
Empirical formulae can be found from mass percentages or combustion data.
Atomic weights can be found using isotope abundances and weights (and vice versa).
Molarity is moles of solute per liter of solution.

Stoichiometry, limiting reactant, and percent yield concepts.