AP Chemistry

Chapter 2 Outline

a) The Atomic Theory of Matter
   i) **Democritus** (460-370 BC), other Greek philosophers postulated that matter was made up of tiny indivisible particles *atomos* = indivisible or uncuttable
   ii) Plato, Aristotle: notion that there can be no ultimately indivisible particles
   iii) **Antoine Lavoisier**: Law of conservation of mass
   iv) John Dalton
      (1) Each element is made of extremely small particles (atoms).
      (2) All atoms of a given element are identical to one another in mass and other properties, but the atoms of one element are different from the atoms of other elements.
      (3) Atoms of an element are not changed into atoms of a different element by chemical reactions; atoms are neither created nor destroyed in chemical reactions.
      (4) Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of particle.
      (5) Law of multiple proportions: atoms may combine in more than one ratio to form different substances eActivity & animation

b) The Discovery of Atomic Structure
   i) **J. J. Thomson** and cathode rays
      (1) Cathode rays = negatively charged electrons
   ii) **Robert Millikan**
      (1) Oil drop experiment to determine the charge of the electron
   iii) Becquerel, Marie & Pierre Curie
      (1) Radioactivity= spontaneous emission of radiation
   iv) **Rutherford**
      (1) Alpha particles = nucleus of helium atom (2 protons, 2 neutrons)
      (2) Beta particles = high speed electrons = radioactive equivalent of cathode rays
      (3) Gamma particles = high energy radiation similar to x-rays
   v) The Nuclear Atom
      (1) Thomson Model: "plum pudding" model
      (2) Rutherford gold foil experiment
         (a) nucleus: protons and (later) neutrons
         (b) Electrons outside; most of atom is empty space

c) Modern View of Atomic Structure
   i) The charges of atomic and subatomic particles are expressed as multiples of the electronic charge, 1.602×10^{-19} C.
      (1) Proton +1, electron -1, neutrons are uncharged
   ii) Atoms have extremely small masses and diameters.
      (1) Atomic mass unit (amu) = 1.66054×10^{-24} g
      (2) Angstrom = 10^{-10} m = 100 pm = 0.1 nm; most atomic diameters are on the order of 1-5 angstroms
   iii) The tiny nucleus contains most of the mass and is extremely dense!

(1) Nucleus = protons + neutrons
(2) Electrons found in "cloud" surrounding nucleus
(a) Comprise most of the volume of the atom
(b) Electrons have major role in chemical reactions

iv) Atomic number = number of protons in nucleus = number of electrons in neutral atom

v) Mass number = total number of protons plus neutrons in nucleus

vi) ${}^{A}_{Z}X$ where X = chemical symbol, Z = atomic number, A = mass number
(1) alternate notation: chemical name-A

vii) Isotopes = atoms with identical numbers of protons (i.e, same atomic number) but different numbers of neutrons (i.e., different mass number)

d) Atomic Weights

i) Atomic mass scale based on assigning 12 amu to an atom of carbon-12
(1) 1 g = 6.02214 x 10^{23} amu

ii) Average atomic mass (aka atomic weight) = weighted average of atomic masses for all isotopes, based on fractional abundance of each isotope and the mass of each isotope

iii) $atomic\ weight = \sum (relative\ abundance) x (isotope\ mass)$

iv) Mass spectrometer = most direct and accurate means for determining atomic and molecular weights
(1) Mass spectrum
(2) Relative abundance

e) The Periodic Table

i) Giant mnemonic device

ii) Period = horizontal row

iii) Family = vertical column of elements with similar properties
(1) Three common conventions for labeling the groups;
(a) Dr. V likes numbering them simply 1-18 (the IUPAC recommendation)
(b) This text uses Arabic numerals to number the columns, using the letter A to signify the main block elements, and the letter B to distinguish the transition elements; the numbers give information on valences

iv) Metals—left side of table; generally solids, exhibit luster and conductivity

v) Nonmetals—upper right side of table, range of properties

vi) "Stairway to heaven" separates metals from nonmetals; elements along this are called metalloids

f) Molecules and Molecular Compounds

i) Molecule = assembly of two or more atoms tightly bound together
(1) Diatomic molecule: 2 atoms of the same element
(a) The "special 7"
(i) "Horses need oats for clear brown eyes."
(ii) Count Hofbrincl

ii) Allotropes = different forms of the same element
(a) O_2 (diatomic oxygen) vs. O_3 (ozone)

iii) Molecular compounds: contain more than one type of atom

(1) Composition given by chemical formula
(2) Most molecular substances contain only nonmetals

iv) Molecular formula = actual numbers and types of atoms in a molecule

v) Empirical formula = lowest whole number ratios of each type of atom in a molecule
(1) Certain types of analysis lead only to empirical formulas.

vi) Structural formulas show attachments between atoms in the molecule.
(1) Perspective drawing, ball-and-stick models, space filling models

g) Ions and Ionic Compounds

i) Ion = formed when an electron is gained or lost from an atom
(1) Cation = positively charged ion (electron is lost)—typically formed by metals
(2) Anion = negatively charged ion (electron is gained)—typically formed by nonmetals
(3) Net charge of ion represented by superscript
(4) Charges of some common ions

Group Number	Common Charge
1 (1A)	1+
2 (2A)	2+
13 (3A)	3+
16 (6A)	2-
17 (7A)	1-

Nitrogen can form a 3- ion.

(5) Polyatomic ions—Memorize the common ions!

ii) Ionic compounds: three dimensional arrays of alternating anions and cations
(1) Typically formed between a metal and a nonmetal
(2) Only empirical formulas can be written for most ionic substances

h) Naming Inorganic Compounds

i) General Rule: Cation name, then anion name

ii) Stock notation: For metals that can form multiple cations, the ion charge becomes part of the cation name, written in Roman numerals
(1) Older naming system: suffix –ous to lower charged ion, suffix –ic to higher charged ion ("stick to the ceiling")

iii) Oxyanions: -ate vs. –ite; per vs. hypo

iv) Hydrogen-containing polyatomics: add the word hydrogen
(1) Older naming system: use the prefix bi-

v) Further reading on acid nomenclature is available at this link

vi) Naming binary molecular compounds
(1) The name of the element farther to the left in the periodic table is usually written first. Oxygen is always written last, unless combined with fluorine.
(2) If both elements are in the same group, the element with the higher atomic number is named first.
(3) The name of the second element is given the –ide ending.

(4) Greek prefixes are used to indicate the number of atoms of each element. The prefix *mono-* is never used with the first element.

Prefix	Meaning
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

i) Some Simple Organic Compounds
  i) Organic chemistry: the student of compounds of carbon
  ii) Organic compounds: compounds that contain carbon and hydrogen, often in combination with oxygen, nitrogen, or other elements
  iii) Hydrocarbons: compounds that contain only carbon and hydrogen 3D models
    (1) Alkanes names end in "ane"; contain only single bonds
    (2) Prefix indicates the number of carbon atoms in longest continuous chain
      (a) "Mother eats prunes, but prunes hate her. Oh no! Diarrhea!"
  iv) Functional Groups—specific groups of atoms which confer particular patterns of behavior
    (1) Alcohol = -OH group
      (a) Name of alcohol derived from alkane name by adding an –ol ending
        (i) Number is used to indicate position of alcohol group