Chapters 2 Atoms, Molecules and Ions

History

John Daltons Atomic Theory:

1) all matter is composed of small indivisible particles called atoms
2) all atoms in an element are same but different elements have different atoms
3) compounds are formed when different atoms combine in fixed proportion
4) in a chemical reaction atoms are rearranged, no new atoms are created and none are destroyed.

History of Discovery of the Atom: Classical View

1895	Wilhelm Roentgen	Discovers X-rays
1896	Henri Becquerel	Discovers radioactivity
1897	J.J. Thomson	Measured deflection of cathode rays in magnetic and electric fields. Shows that deflections were same regardless of gas in cathode tube. Hence: Rays were not atoms but charged particle found in all matter. Measured the mass to charge ratio: found it to be -5.686×10^{-12} kg/Coulomb, thus smaller than a hydrogen ion (as known previously)
1909	Robert Milliken	Oil-drop experiment to determine the charge on electron. -1.602×10^{-19} C
Early 1900s	Ernest Rutherford	Develops the basic atomic model, establishing that there is a positive center (protons) to the atom which is surrounded by negative charge (electrons).
1932	James Chadwick	Discovers neutrons (have no charge and have same mass as protons).

Basic Structure

Central nucleus surrounded by electrons. Nucleus has protons and neutrons,

Particle	Found in	Charge	Mass
Neutron (n)	Nucleus	None	1 amu
Proton (p)	Nucleus	+	1 amu
Electron (e)	Shells outside nucleus	-	0.000545 amu 9.109×10^{-28} g

Every neutral atom has same number of electrons and protons.

Mass number (M) = n + p

Atomic number (Z) = p (or e)

Isotopes: different mass number but same atomic number.

Allotropes: two or more forms of the same element.

History of the Periodic Table (PT)

1830 – 55 elements were known.
1869 – Dimitri Medeleev, constructed the first what is now called Periodic Table
Initially PT was arranged by mass number. Most elements that came in a column had similar properties, however some did not. He moved those elements out of sequence to fit the trend.
Then PT was arranged according to atomic number.
Modern PT – Glenn Seaborg improved the old PT after he discovered majority of the lanthanide elements.

Molecules and Ionic Compounds
Empirical formula – lowest ratio of elements in a compound.
Molecular formula – actual ratio of elements in a compound.
Binary compound – has two different elements in a compound.
Atomic ions – atoms that have lost or gained electrons
Polyatomic ions – are also compounds that are electrically positive or negative.
Ionic compounds – have anions (-) and cations (+)

Naming
Molecules:
1) Name first element first followed by second element and end the second element name with "ide:
e.g. HCl - hydrogen chloride
NO – nitrogen oxide
For polyatomic molecules:
N_2O_4 – dinitrogen tetraoxide
2) Most common non-metal "ides" – carbide, nitride, oxide, phosphide, sulfide, fluoride, chloride, bromide, iodide.
3) Prefixes –
1 –mono; 2- di; 3- tri; 4- tetra; 5- penta; 6- hexa; 7- hepta; 8- octa; 9- nona; 10 – deca.
4) Always write the number of atoms in a molecule as subscripts.

Ionic Compounds:
Made from cations and anions.
<u>Cations</u> – positively charged, formed from metals.
Transition metals can have more than one kind of cations. Have to write 2+ as roman numerals (II) or 3+ as (III) i.e. use roman numerals to show the charge of transition metals. Roman numerals have to be in parenthesis. This is ONLY for transition metals.
<u>Anions</u> – negatively charged, formed from non-metals.

Name metal as is and then the non-metal as "ide" (as in molecules above). Main difference here is – you CANNOT use mono, di, tri etc…as for molecules.
NaCl – sodium chloride
$MgCl_2$ – magnesium chloride (not magnesium dichloride!)

Polyatomic Ions:
Polyatomic Ions: two or more non metals combine to form an ion.

Positive Polyatomic Cations

H_3O^+ hydronium ion (exists only in acidic solutions)
NH_4^+ ammonium ion (formed from NH_3 – ammonia)

Simple Polyatomic Anions

OH^- hydroxide
CN^- cyanide

Oxygen Containing Polyatomic Ions (all end in "ate" or "ite")

Formula	Name
CO_3^{2-}	Carbonate
HCO_3^-	Hydrogen carbonate
SO_4^{2-}	Sulfate
HSO_4-	Hydrogen sulfate
SO_3^{2-}	Sulfite
HSO_3^-	Hydrogen sulfite
NO_3^-	Nitrate
NO_2-	Nitrite
PO_4^{3-}	Phosphate
HPO_4^{2-}	Hydrogen phosphate
H_2PO_4-	Dihydrogen phosphate
$C_2H_3O_2^-$ CH_3COO-	Acetate

Formula	Name
CrO_4^{2-}	Chromate
$Cr_2O_7^{2-}$	Dichromate
MnO_4^-	Permanganate
SCN^-	Thiocyanate
$S_2O_3^{2-}$	Thiosulfate
ClO^-	Hypochlorite
ClO_2^-	Chlorite
ClO_3^-	Chlorate
ClO_4^-	Hypochlorate

Acids:
Acids: produce hydrogen ions and usually end in "ic" in their names. (**Web List**)
Hydrates: association of ionic compounds with water molecules. Use mono, di, tri etc to indicate number of water molecules.

Summary of naming:

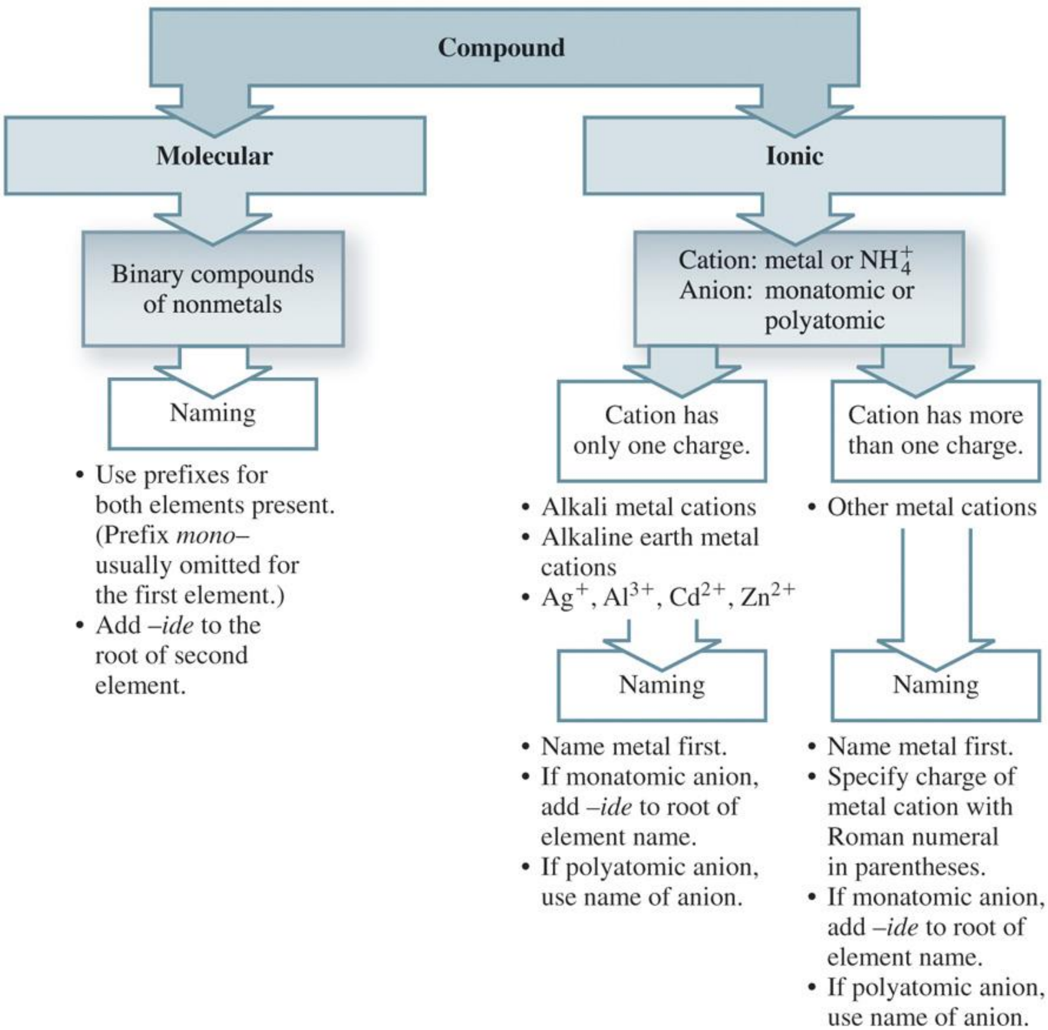

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TABLE 2.8 Names and Formulas of Some Common Monatomic Ions

Name	Formula
Cations	
Aluminum	Al^{3+}
Barium	Ba^{2+}
Cadmium	Cd^{2+}
Calcium	Ca^{2+}
Cesium	Cs^{+}
Chromium(III)	Cr^{3+}
Cobalt(II)	Co^{2+}
Copper(I)	Cu^{+}
Copper(II)	Cu^{2+}
Hydrogen	H^{+}
Iron(II)	Fe^{2+}
Iron(III)	Fe^{3+}
Lead(II)	Pb^{2+}
Lithium	Li^{+}
Magnesium	Mg^{2+}
Manganese(II)	Mn^{2+}
Mercury(II)	Hg^{2+}
Potassium	K^{+}
Silver	Ag^{+}
Sodium	Na^{+}
Strontium	Sr^{2+}
Tin(II)	Sn^{2+}
Zinc	Zn^{2+}
Anions	
Bromide	Br^{-}
Chloride	Cl^{-}
Fluoride	F^{-}
Hydride	H^{-}
Iodide	I^{-}
Nitride	N^{3-}
Oxide	O^{2-}
Sulfide	S^{2-}