Atoms and Atomic Theory

Reference:

General Chemistry
Principles and Modern Applications TENTH EDITION,
Pearson Canada
Toronto

Law of Conservation of Mass

- The process of burning is so familiar it is hard to realize what a difficult riddle this posed for early scientists.
- In 1774, Antoine Lavoisier performed an experiment in which he heated a sealded glass vessel containing a sample of tin and some air. He found that the mass before heating (glass vessel+tin+air) and after heating (glass vessel+tin calx+remaining air) were the same.

- The total mass of substances present after a chemical reaction is the same as the total mass of substances before the reaction.
- Stated another way, this law says that matter can neither be created nor destroyed in a chemical reaction.

Law of Constant Composition

- In 1799, Joseph Proust reported one hundred ponds of copper dissolved in sulfuric or nitric acids and precipitated by carbonates of soda, invariably gives 10 pounds of green carbonate.
- All samples of a compound have the same composition-the same proportions by mass of the constituent elements.

Daltons Atomic Theory

Describes the basis of atomic theory with three assumptions:

1) Each element is composed of small particles called atoms. Atoms are neither created nor destroyed in chemical reactions.

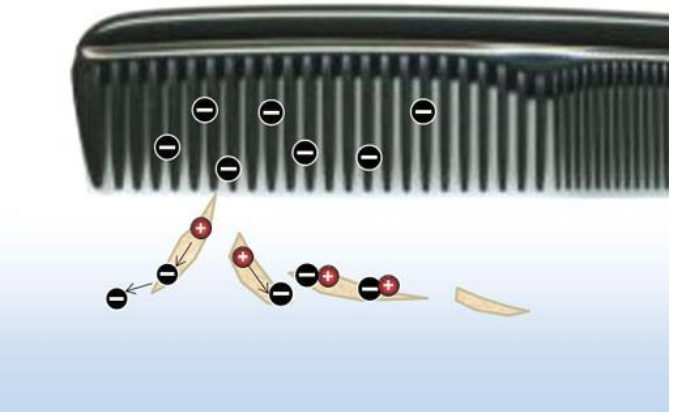
2) All atoms of a given element are identical but atoms of one element are different from those off all other elements.

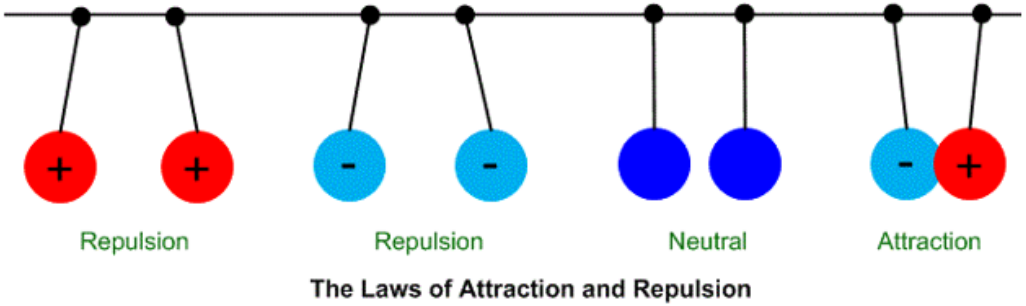
3) Compounds are formed when the atoms of more than one element combine in mol numerical ratios.

Electrons and Other discoveries in Atomic Physics

- Electricity snd magnetism were used in the experiments so that led to the current theory of atomic structure
- Certain objects display properties called electric charge, which can be either positive (+) or negative (-)
- An object having equal numver of (+) or (-) charged particles carries no net charge and is electrically neutral
- If the number or (+) charge exceed the number of (-) charge, the object has a net positive charge.
- If the number of (-) charge exceed the number of (+) charge, the object has a negative charge.

- (+) and (-) charges attract each other, while two (+) and two (-) charges reperl each other.





The Laws of Attraction and Repulsion

- (a)Electrostatically charged comb. If you comb your hair the static charge develop on the comb and causes bits of paper to be attracted to the comb.
- (b) Both object on the left carry negative charge repel each other.

The objects in the center lack any electrical charge and exert no force on each other.

The objects on the right carry opposite charges and attract each other.

X-Rays and Radioactivity

✓X-ray is form of high energy electromagnetic radiation

✓Radioactivity is the spontaneous emission of radiation from a substance

- ➢Two types of radiation form from radioactive material were identified by Ernest Rutherford
- ➢Alpha (α): α-particles carry two fundamental units of positive charge and the same mass as helium atoms. This particle are identical to He^{2+} ions
- ➢Beta (β): β-particles are negatively charged and have the same properties as electrons

✓Gamma (γ) rays: is not effected by electric or magnetic field. It is not made of particles. It is electromagnetic radiation of extremely high penetrating power.

Properties of Protons, neutrons and Electrons

✓Protons: positively charged fundamental particles of the matter in the nuclei of atoms

✓Neutrons: penetrating radiation consisted of beam of neutral particles

✓The number of protons in a given atom is called the **atomic number, or the proton number, Z**

✓The number of electrons in the atom is equal to Z because the atom is electrically neutral

✓The total number of proton and neutrons in an atom is called the **mass number, A**

✓**The number of neutron is A-Z** and electrically neutral.

Chemical Elements

- ✓Each element has a name and distinctive symbol
  - ➢Exp: carbon:C, oxygen:O, neon:Ne, iron:Fe

✱To represent a particular atom we use symbolism

number p + number n
number p
$\rightarrow {}^{A}_{Z}E \leftarrow$ Symbol of element

A= mass number Z = atomic number

$^{27}_{13}Al$

- ✓Has 13 protons and 14 neutrons in its nucleus and 13 electron outside the nucleus (recall that an atom has the same number of electrons as protons)

Isotopes

✓atoms that have the **same** atomic number (Z) but different masss number (A) are called isotopes.

➢Exp: all neon atoms have 10 protons in their nuclei, and most have 10 neutron as well. A very few neon atoms have 11 neutrons and some have 12

$^{20}_{10}Ne$ $^{21}_{10}Ne$ $^{22}_{10}Ne$

Ions

✓When atoms lose or gain electrons the species formed are called ions and carry net charges.

✓Removing electrons result in positively charged ion

✓The number of proton does not change when an atom becomes an ion.

✓Exp: $^{20}_{10}Ne^{+}$ 10 protons 10 neutrons and 9 electrons

$^{22}_{10}Ne^{2+}$ 10 protons 12 neutrons and 8 electrons

$^{16}_{8}O^{2-}$ 8 protons 8 neutrons and 10 electrons

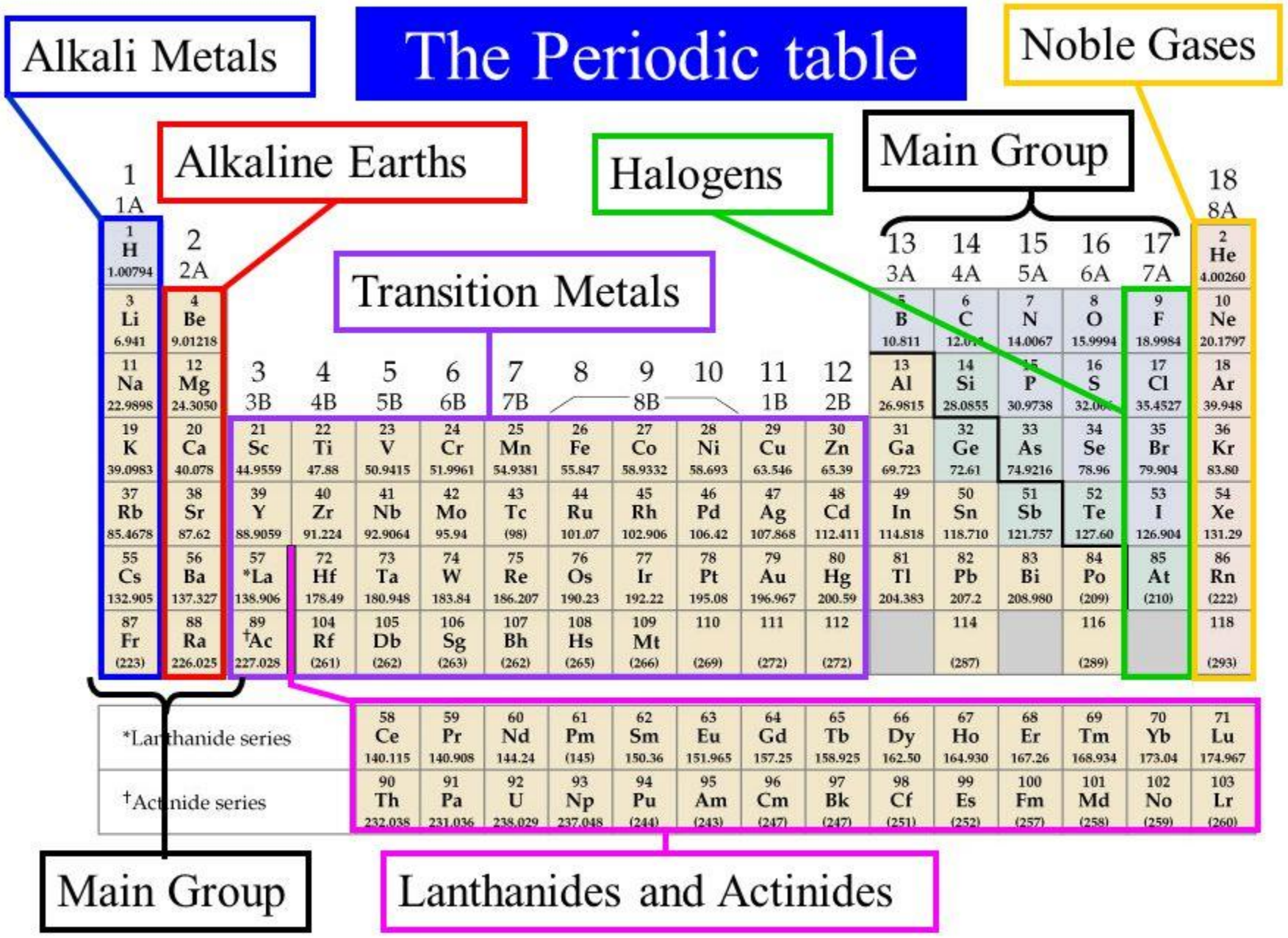
number p + number n → $^{A}_{Z}E^{\pm ?}$ ← number p − number e

number p →

Introduction to The Periodic Table

- ✓ The classification system we need known as the periodic table of the elements

- ✓ Read atomic masses
- ✓ Read the ions formed by main group elements
- ✓ Read the electron configuration
- ✓ Learn trends in physical and chemical properties


Alkali Metals
The Periodic table
Noble Gases
Alkaline Earths
Halogens
Main Group
Transition Metals
1 1A
2 2A
3 3B
4 4B
5 5B
6 6B
7 7B
8
9 8B
10
11 1B
12 2B
13 3A
14 4A
15 5A
16 6A
17 7A
18 8A
1 H 1.00794
2 He 4.00260
3 Li 6.941
4 Be 9.01218
5 B 10.811
6 C 12.011
7 N 14.0067
8 O 15.9994
9 F 18.9984
10 Ne 20.1797
11 Na 22.9898
12 Mg 24.3050
13 Al 26.9815
14 Si 28.0855
15 P 30.9738
16 S 32.066
17 Cl 35.4527
18 Ar 39.948
19 K 39.0983
20 Ca 40.078
21 Sc 44.9559
22 Ti 47.88
23 V 50.9415
24 Cr 51.9961
25 Mn 54.9381
26 Fe 55.847
27 Co 58.9332
28 Ni 58.693
29 Cu 63.546
30 Zn 65.39
31 Ga 69.723
32 Ge 72.61
33 As 74.9216
34 Se 78.96
35 Br 79.904
36 Kr 83.80
37 Rb 85.4678
38 Sr 87.62
39 Y 88.9059
40 Zr 91.224
41 Nb 92.9064
42 Mo 95.94
43 Tc (98)
44 Ru 101.07
45 Rh 102.906
46 Pd 106.42
47 Ag 107.868
48 Cd 112.411
49 In 114.818
50 Sn 118.710
51 Sb 121.757
52 Te 127.60
53 I 126.904
54 Xe 131.29
55 Cs 132.905
56 Ba 137.327
57 *La 138.906
72 Hf 178.49
73 Ta 180.948
74 W 183.84
75 Re 186.207
76 Os 190.23
77 Ir 192.22
78 Pt 195.08
79 Au 196.967
80 Hg 200.59
81 Tl 204.383
82 Pb 207.2
83 Bi 208.980
84 Po (209)
85 At (210)
86 Rn (222)
87 Fr (223)
88 Ra 226.025
89 †Ac 227.028
104 Rf (261)
105 Db (262)
106 Sg (263)
107 Bh (262)
108 Hs (265)
109 Mt (266)
110 (269)
111 (272)
112 (272)
114 (287)
116 (289)
118 (293)
*Lanthanide series
†Actinide series
58 Ce 140.115
59 Pr 140.908
60 Nd 144.24
61 Pm (145)
62 Sm 150.36
63 Eu 151.965
64 Gd 157.25
65 Tb 158.925
66 Dy 162.50
67 Ho 164.930
68 Er 167.26
69 Tm 168.934
70 Yb 173.04
71 Lu 174.967
90 Th 232.038
91 Pa 231.036
92 U 238.029
93 Np 237.048
94 Pu (244)
95 Am (243)
96 Cm (247)
97 Bk (247)
98 Cf (251)
99 Es (252)
100 Fm (257)
101 Md (258)
102 No (259)
103 Lr (260)
Main Group
Lanthanides and Actinides

The Concept of the Mole and the Avogadro Constant

- ✓ A mole: is the amount of the substance that contains the same number of elementary entities (atoms, molecules and so on)
- ✓ Avogadro constant or Avogadro number, N_A: The amount of elementary entities in a mole

$$N_A = 6.02214179 \times 10^{23}\ mol^{-1}$$

- ✓ Exp:
  - ➢ 1 mol ^{12}C = 6.02214179 x 10^{23} ^{12}C atoms = 12 g
  - ➢ 1 mol ^{16}O = 6.02214179 x 10^{23} ^{16}O atoms = 15.9949 g (and so on)

✓Molar mass, M: the mass of one mole of substance , from a table of atomic masses

✓Exp: the molar mass of lithium is 6.941 g/mol Li