

CHM 101

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 sealed 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 pounds 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.

Dalton's Atomic Theory

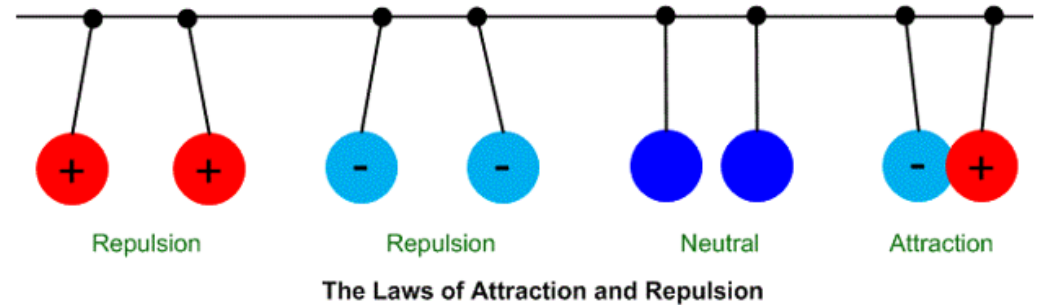
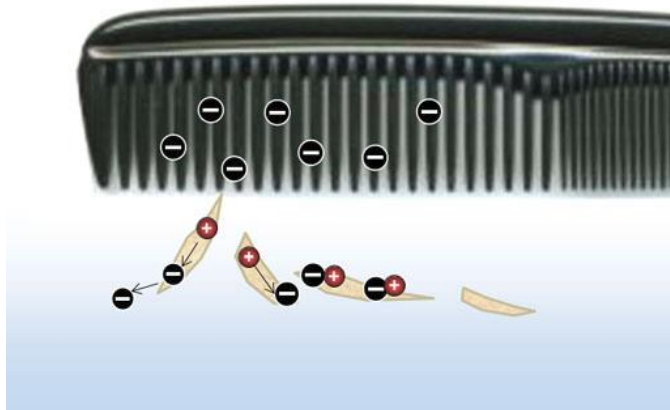
Describes the basis of atomic theory with three assumptions:

- 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 of 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 and 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 number of (+) or (-) charged particles carries no net charge and is electrically neutral
- If the number of (+) 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 repel each other.



- (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

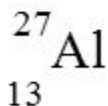
- ✓ Each element has a name and distinctive symbol
 - Exp: carbon:C, oxygen:O, neon:Ne, iron:Fe

***To represent a particular atom we use symbolism**



A = mass number Z = atomic number

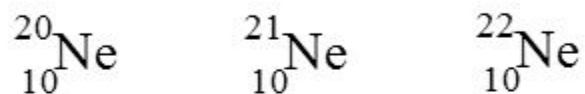
- ✓ Has 13 protons and 14 neutrons in its nucleus and 13 electron outside the nucleus (recall that an atom has the same number of electrons as protons)



Isotopes

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

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



Ions

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

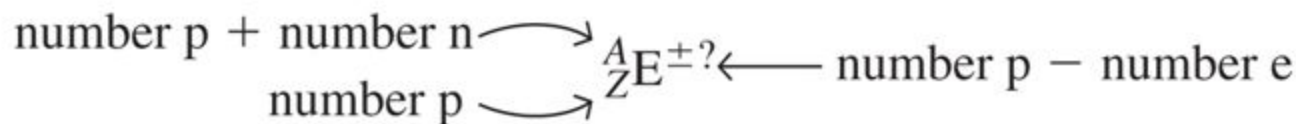
✓ Removing electrons result in positively charged ion

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

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

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

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



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	Transition Metals										Main Group					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 32.06	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 227.025	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		<table border="1"> <tr> <td>58 Ce 140.115</td> <td>59 Pr 140.908</td> <td>60 Nd 144.24</td> <td>61 Pm (145)</td> <td>62 Sm 150.36</td> <td>63 Eu 151.965</td> <td>64 Gd 157.25</td> <td>65 Tb 158.925</td> <td>66 Dy 162.50</td> <td>67 Ho 164.930</td> <td>68 Er 167.26</td> <td>69 Tm 168.934</td> <td>70 Yb 173.04</td> <td>71 Lu 174.967</td> </tr> <tr> <td>90 Th 232.038</td> <td>91 Pa 231.036</td> <td>92 U 238.029</td> <td>93 Np 237.048</td> <td>94 Pu (244)</td> <td>95 Am (243)</td> <td>96 Cm (247)</td> <td>97 Bk (247)</td> <td>98 Cf (251)</td> <td>99 Es (252)</td> <td>100 Fm (257)</td> <td>101 Md (258)</td> <td>102 No (259)</td> <td>103 Lr (260)</td> </tr> </table>																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)
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)																																
†Actinide series																																													

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

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

- ✓ Exp:
 - 1 mol ^{12}C = $6.02214179 \times 10^{23}$ ^{12}C atoms = 12 g
 - 1 mol ^{16}O = $6.02214179 \times 10^{23}$ ^{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