A Brief History of Atomic Theory

The “modern” atomic picture has evolved over many centuries

Often fraught with religious and philosophical overtones

John Dalton – Early 1800’s

Developed first fairly refined atomic picture in response to two “laws”. Developed using mass measurements!

Law of Conservation of Matter: (Lavosier 1780’s)

Law of Definite Proportions: (Proust ~1800)

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Dalton’s Atomic Theory

4 main components

1. All matter is made of Atoms
2. All atoms of a given element are identical
3. Compounds are the result of a combination of two or more different kinds of atoms
4. Chemical reactions involve the combination, separation or rearrangement of atoms

Dalton’s theory leads to the Law of Multiple Proportions:

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Modern Atomic Picture

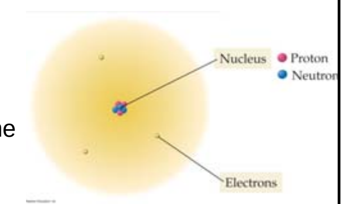
(With thanks to Thompson, Millikan, Rutherford…[Read these sections])

Components of Atoms:

Name	Charge	Symbol	Location	Mass (kg)
electron	-1	${}^{0}_{-1}\mathrm{e}$ or e^-	outside of nucleus	9.11×10^{-31}
proton	+1	${}^{1}_{1}\mathrm{p}$	in nucleus	1.67×10^{-27}
neutron	0	${}^{1}_{0}\mathrm{n}$	in nucleus	1.67×10^{-27}

Characteristics:

- Atoms are small (30 - 150 pm)
- Most of the atom is empty space
- Nucleus is extremely small and massive
  - ~99.9% of the mass ion << 0.1% of volume
  - A pea in Busch stadium
- e^- occupy the region around the nucleus
- Atoms are electrically neutral



<u>Key to Chemical Behavior: *electrons* determine chemical behavior</u>

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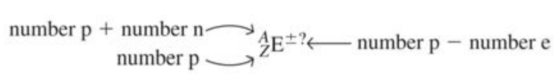
Identifying Atoms

<u>Atomic Number</u>: number of protons in an atom (if atom is neutral, then it also measures the number of electrons).

<u>Mass Number</u>: allows a measure of the total number of protons and neutrons in an atom.

<u>Atomic Mass (Weight)</u>: represents the mass of an average atom of the element. Atomic mass is the weighted average factoring in all naturally occurring **isotopes** and their abundance.

Isotope:



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Calculating Atomic Masses

The **Atomic Mass Unit (amu):** 1/12 of the atomic mass of a carbon atom with 6 protons and 6 neutrons. Allows quantitation of mass ratios.

1 amu = 1.661×10^{-24}g

Actual masses:

Particle	Mass (g)	Mass (amu)
Electron	9.11×10^{-28}	0.0005486
Proton	1.6726×10^{-24}	1.0073
Neutron	1.67×10^{-24}	1.0087

Mass Number allows estimation of mass of an isotope (in amu)

Even given all this, adding up the masses of p, n, and e- ≠ experimentally determined mass!! Why?

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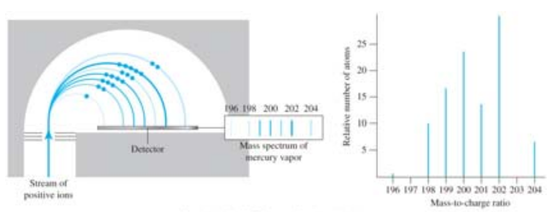
More Isotopes

How do we know what isotopes exist?



Revisiting Isotope Abundance:

Example: Bromine exists as two isotopes, ^{79}Br and ^{81}Br. If the atomic mass of Bromine is 79.904 amu, what are the relative abundances of the two isotopes?

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Periodic Table:
(with kudos to Mr. Mendeleev)

Categorizes the information about the elements

Contained on the Table:

- Symbol, Atomic number, Atomic Mass (at least)
- Elemental Symbols for ~111 elements. (learn the 1st 36 for now, will want knowledge of the remainder except the lanthanides and actinides within the next few weeks)
  - Allows prediction of metal, non-metal, or semi-metal behavior by position.
  - Can also make predictions of ionic charge of elements and chemical behavior by knowledge of the element's **group. (periodicity)** Position in periods also can allow some predictability of atomic properties too.

Items of note

- Some elements exist as diatomic ***molecules***
- Many nonmetals have ***allotropes***

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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 (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide 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
†Actinide series	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 (262)

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