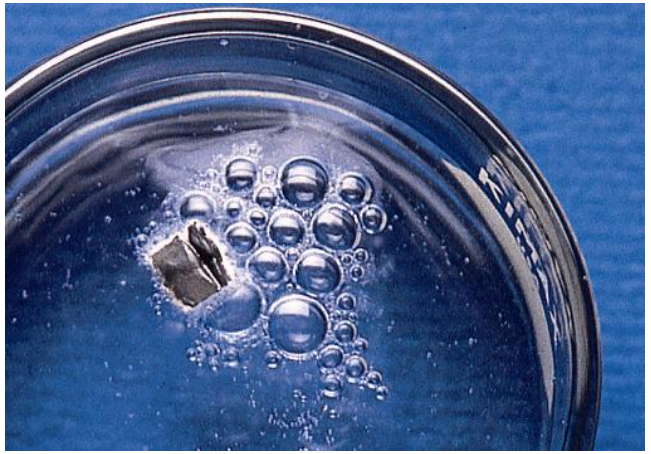
Mass Relationships in Chemical Reactions

Chapter 3



Micro World
atoms & molecules

Macro World
grams

Atomic mass is the mass of an atom in atomic mass units (amu)

By definition:
1 atom ^{12}C "weighs" 12 amu

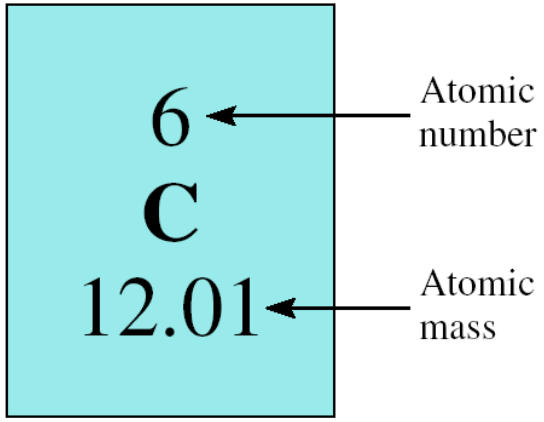
atomic mass = molar mass

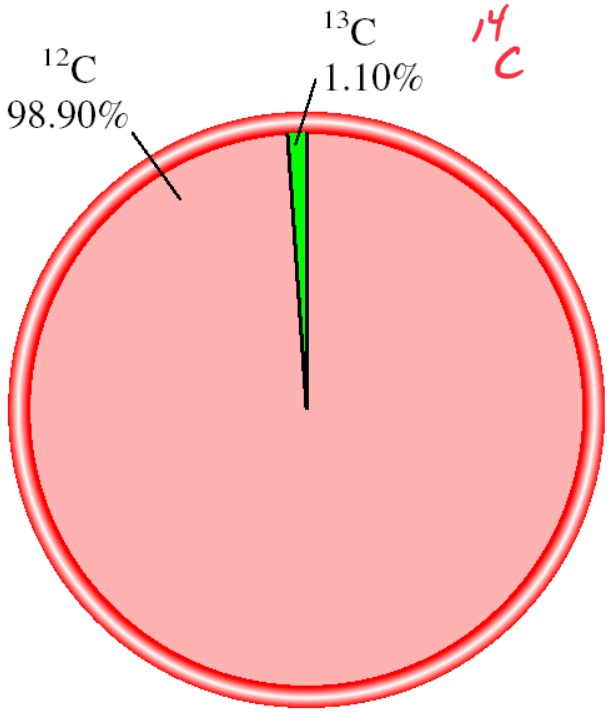
On this scale

^{1}H = 1.008 amu

^{16}O = 16.00 amu

The ***average atomic mass*** is the weighted average of all of the naturally occurring isotopes of the element.





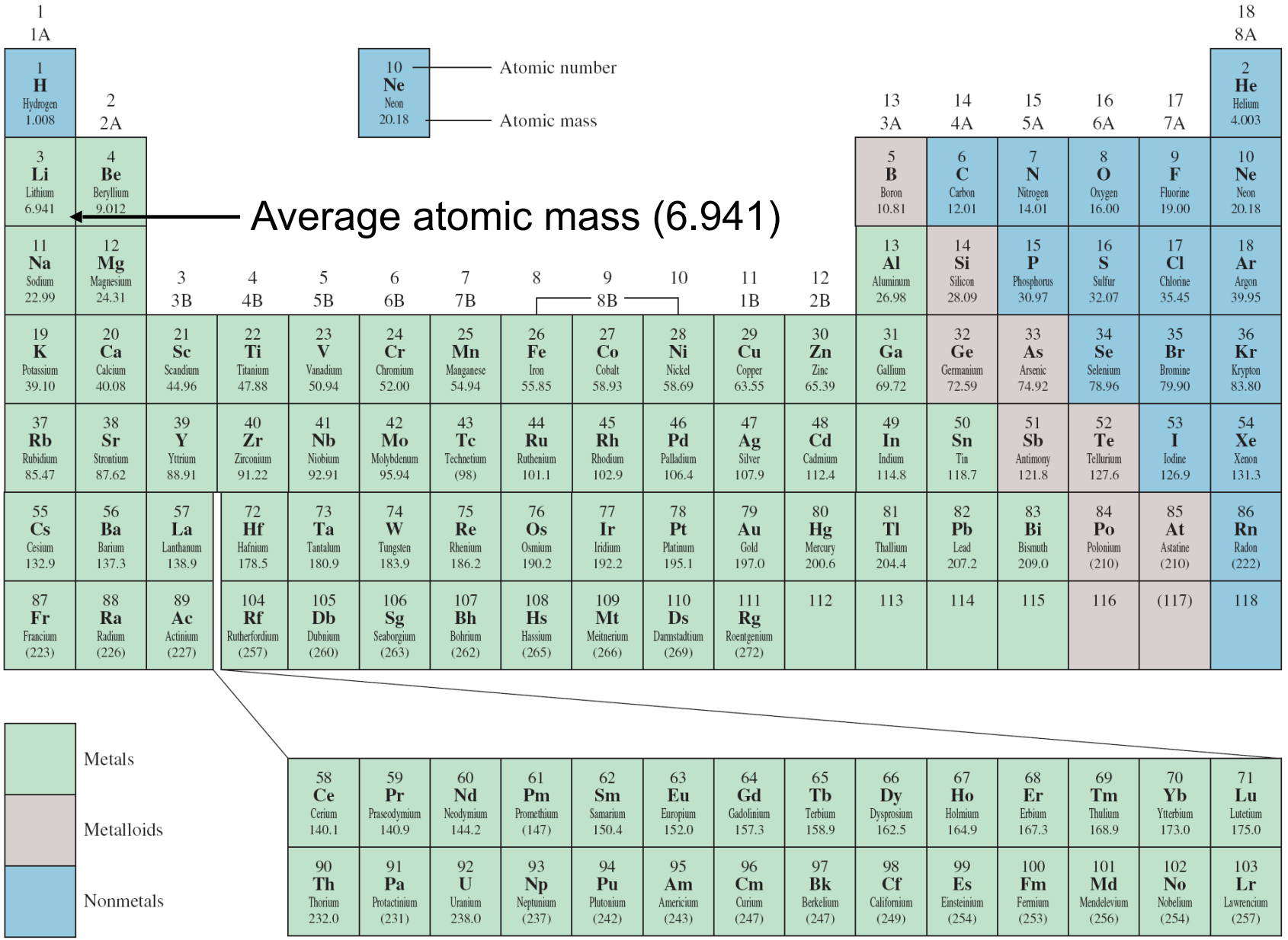
Naturally occurring lithium is:

7.42% ^{6}Li (6.015 amu)

92.58% ^{7}Li (7.016 amu)

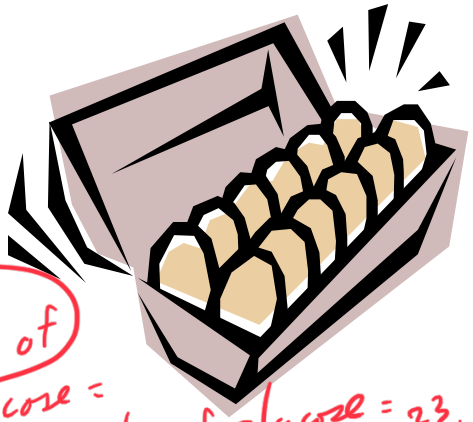
Average atomic mass of lithium:

$$\frac{7.42 \times 6.015 + 92.58 \times 7.016}{100} = 6.941 \text{ amu}$$


1 1A
18 8A
10 Ne Neon 20.18
Atomic number
Atomic mass
Average atomic mass (6.941)
1 H Hydrogen 1.008
2 2A
13 3A
14 4A
15 5A
16 6A
17 7A
2 He Helium 4.003
3 Li Lithium 6.941
4 Be Beryllium 9.012
5 B Boron 10.81
6 C Carbon 12.01
7 N Nitrogen 14.01
8 O Oxygen 16.00
9 F Fluorine 19.00
10 Ne Neon 20.18
11 Na Sodium 22.99
12 Mg Magnesium 24.31
3 3B
4 4B
5 5B
6 6B
7 7B
8
9
10
8B
11 1B
12 2B
13 Al Aluminum 26.98
14 Si Silicon 28.09
15 P Phosphorus 30.97
16 S Sulfur 32.07
17 Cl Chlorine 35.45
18 Ar Argon 39.95
19 K Potassium 39.10
20 Ca Calcium 40.08
21 Sc Scandium 44.96
22 Ti Titanium 47.88
23 V Vanadium 50.94
24 Cr Chromium 52.00
25 Mn Manganese 54.94
26 Fe Iron 55.85
27 Co Cobalt 58.93
28 Ni Nickel 58.69
29 Cu Copper 63.55
30 Zn Zinc 65.39
31 Ga Gallium 69.72
32 Ge Germanium 72.59
33 As Arsenic 74.92
34 Se Selenium 78.96
35 Br Bromine 79.90
36 Kr Krypton 83.80
37 Rb Rubidium 85.47
38 Sr Strontium 87.62
39 Y Yttrium 88.91
40 Zr Zirconium 91.22
41 Nb Niobium 92.91
42 Mo Molybdenum 95.94
43 Tc Technetium (98)
44 Ru Ruthenium 101.1
45 Rh Rhodium 102.9
46 Pd Palladium 106.4
47 Ag Silver 107.9
48 Cd Cadmium 112.4
49 In Indium 114.8
50 Sn Tin 118.7
51 Sb Antimony 121.8
52 Te Tellurium 127.6
53 I Iodine 126.9
54 Xe Xenon 131.3
55 Cs Cesium 132.9
56 Ba Barium 137.3
57 La Lanthanum 138.9
72 Hf Hafnium 178.5
73 Ta Tantalum 180.9
74 W Tungsten 183.9
75 Re Rhenium 186.2
76 Os Osmium 190.2
77 Ir Iridium 192.2
78 Pt Platinum 195.1
79 Au Gold 197.0
80 Hg Mercury 200.6
81 Tl Thallium 204.4
82 Pb Lead 207.2
83 Bi Bismuth 209.0
84 Po Polonium (210)
85 At Astatine (210)
86 Rn Radon (222)
87 Fr Francium (223)
88 Ra Radium (226)
89 Ac Actinium (227)
104 Rf Rutherfordium (257)
105 Db Dubnium (260)
106 Sg Seaborgium (263)
107 Bh Bohrium (262)
108 Hs Hassium (265)
109 Mt Meitnerium (266)
110 Ds Darmstadtium (269)
111 Rg Roentgenium (272)
112
113
114
115
116
(117)
118
58 Ce Cerium 140.1
59 Pr Praseodymium 140.9
60 Nd Neodymium 144.2
61 Pm Promethium (147)
62 Sm Samarium 150.4
63 Eu Europium 152.0
64 Gd Gadolinium 157.3
65 Tb Terbium 158.9
66 Dy Dysprosium 162.5
67 Ho Holmium 164.9
68 Er Erbium 167.3
69 Tm Thulium 168.9
70 Yb Ytterbium 173.0
71 Lu Lutetium 175.0
90 Th Thorium 232.0
91 Pa Protactinium (231)
92 U Uranium 238.0
93 Np Neptunium (237)
94 Pu Plutonium (242)
95 Am Americium (243)
96 Cm Curium (247)
97 Bk Berkelium (247)
98 Cf Californium (249)
99 Es Einsteinium (254)
100 Fm Fermium (253)
101 Md Mendelevium (256)
102 No Nobelium (254)
103 Lr Lawrencium (257)
Metals
Metalloids
Nonmetals

The Mole (mol): A unit to count numbers of particles

Dozen = 12



Pair = 2

180 g of glucose = 1 mole of glucose = $6.022 * 10^{23}$ molecules

12.011 g of carbon → 1 mol of carbon → $6.022 * 10^{23}$ atoms of carbon

The ***mole (mol)*** is the amount of a substance that contains as many elementary entities as there are atoms in exactly 12.00 grams of ^{12}C

1 mol = N_A = 6.02211367 x 10^{23}

Avogadro's number (N_A) = $6.022 * 10^{23}$ atoms

Molar mass is the mass of 1 mole of eggs / shoes / marbles / atoms in grams

1 mole ^{12}C atoms = 6.022×10^{23} atoms = 12.00 g

1 ^{12}C atom = 12.00 amu

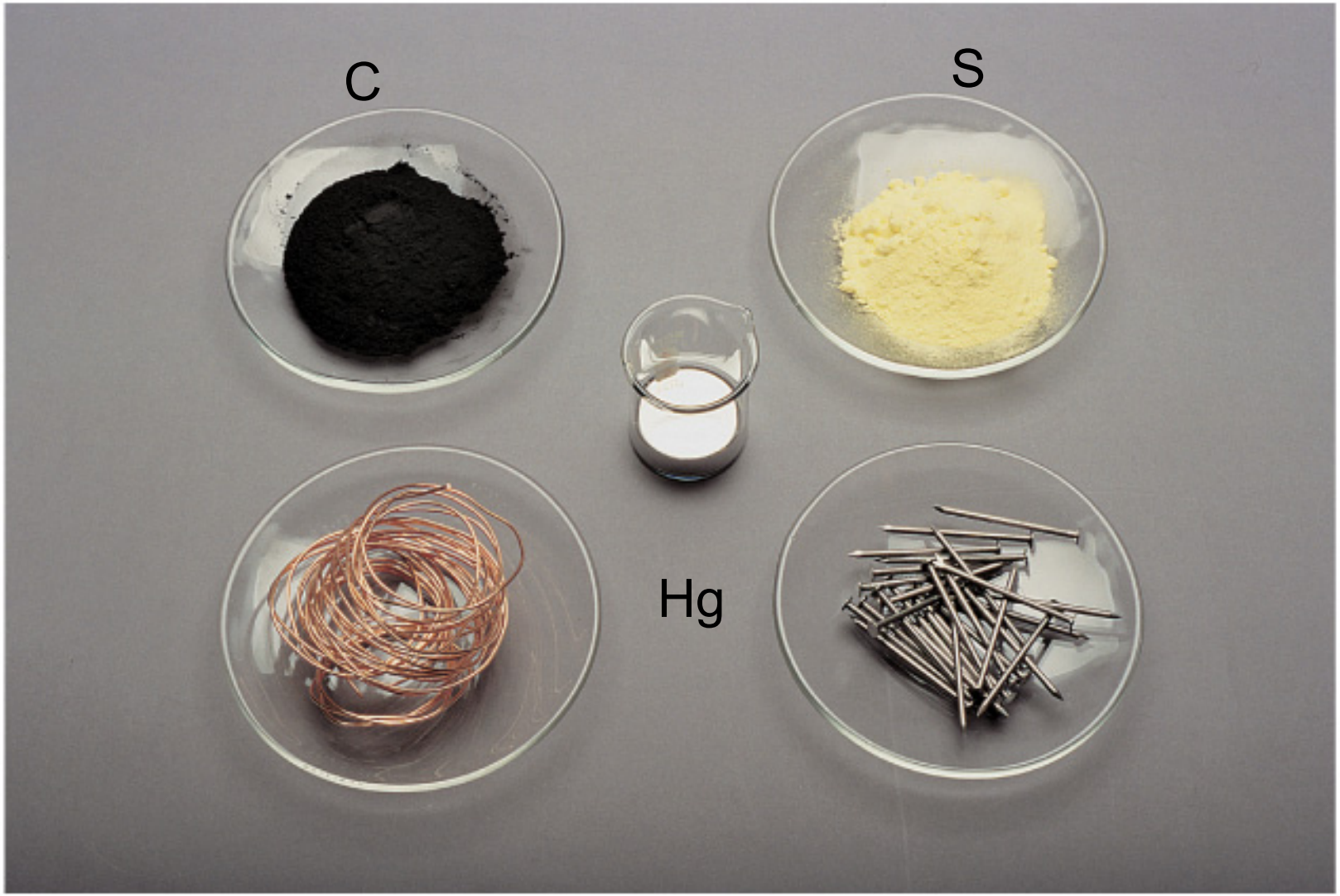
1 mole ^{12}C atoms = 12.00 g ^{12}C

1 mole lithium atoms = 6.941 g of Li

For any element

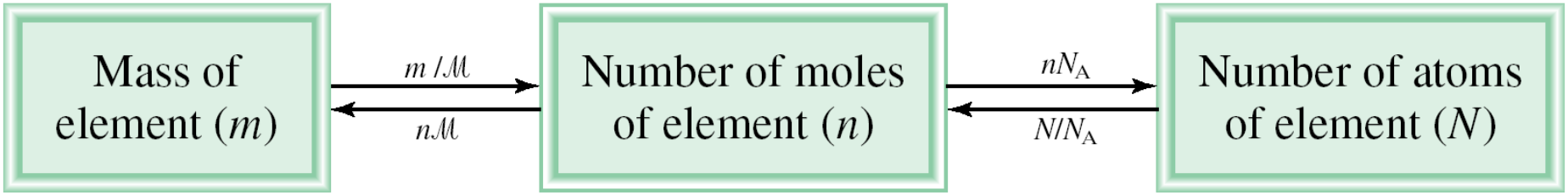
atomic mass (amu) = molar mass (grams)

One Mole of:



$$\frac{1\ {}^{12}\text{C atom}}{12.00\ \text{amu}} \times \frac{12.00\ \text{g}}{6.022 \times 10^{23}\ {}^{12}\text{C atoms}} = \frac{1.66 \times 10^{-24}\ \text{g}}{1\ \text{amu}}$$

1 amu = 1.66×10^{-24} g or 1 g = 6.022×10^{23} amu



$\mathcal{M}$ = molar mass in g/mol

N_A = Avogadro's number

How many atoms are in 0.551 g of potassium (K) ?

$$1 \text{ mol K} = 39.10 \text{ g K}$$

$$1 \text{ mol K} = 6.022 \times 10^{23} \text{ atoms K}$$

$$0.551 \text{ g K} \times \frac{1 \text{ mol K}}{39.10 \text{ g K}} \times \frac{6.022 \times 10^{23} \text{ atoms K}}{1 \text{ mol K}} =$$

$$8.49 \times 10^{21} \text{ atoms K}$$