Mass Relationships in Chemical Reactions

Chapter 3

Chang & Goldsby

Modified by Dr. Juliet Hahn

© Derek Croucher/Alamy

Atomic Mass

Micro World → Macro World

atoms & molecules → grams

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

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

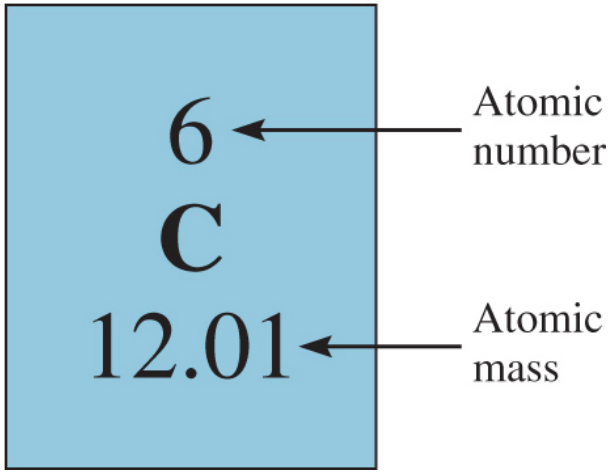
On this scale

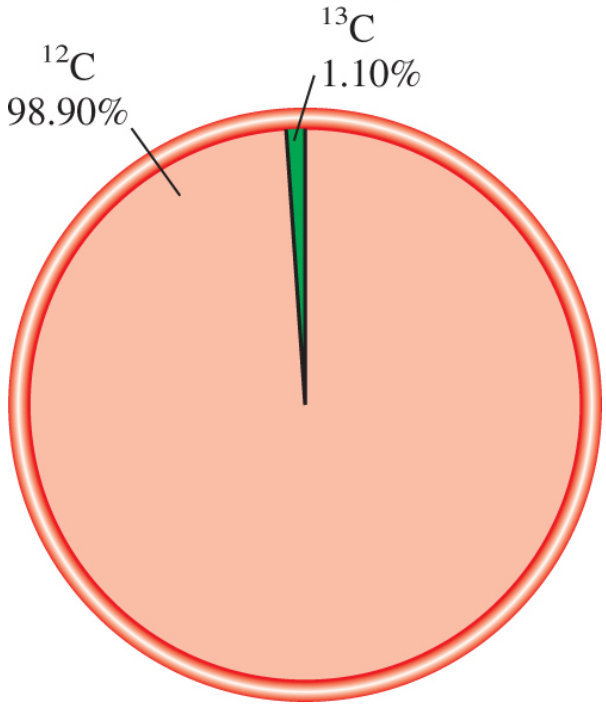
$$1H = 1.008 \text{ amu}$$

$$16O = 16.00 \text{ amu}$$

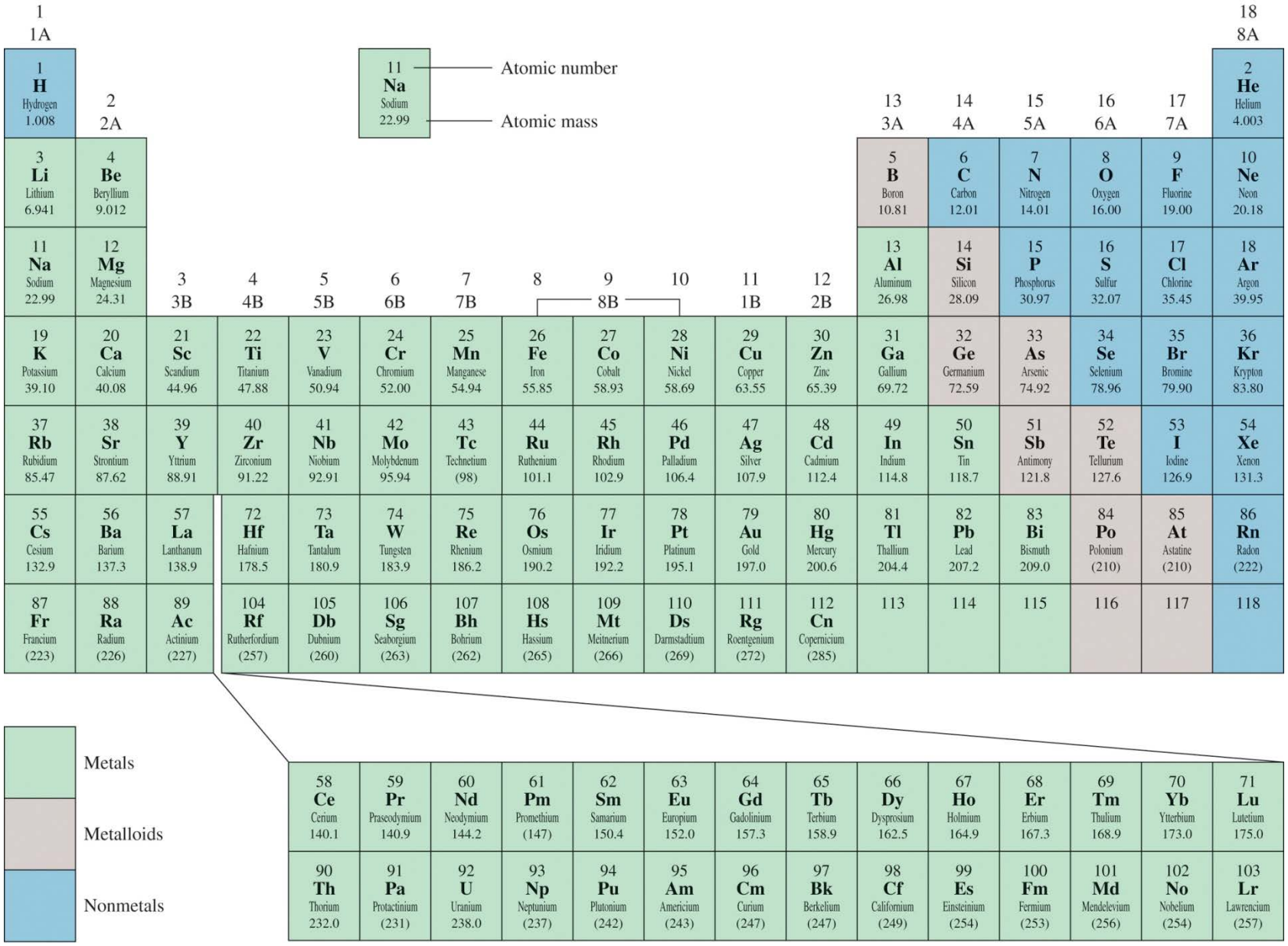
Atomic Mass (1)

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





Atomic Mass on the Periodic Table



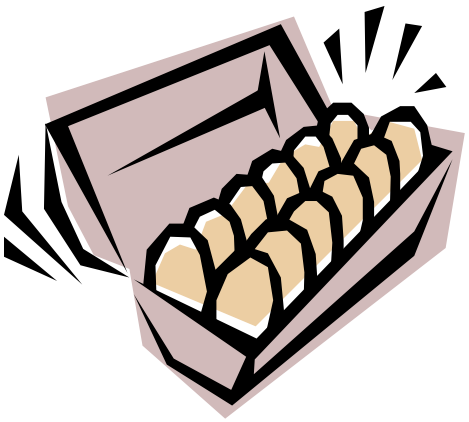
1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H Hydrogen 1.008												5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesium 24.31											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 Cn Copernicium (285)	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)

The Mole

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

Dozen = 12



Pair = 2

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

$$1\,mol = N_A = 6.0221415 \times 10^{23}$$

Avogadro's number (N_A)

Molar Mass

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

$$1\text{mole } {}^{12}\text{C atoms} = 6.022 \times 10^{23} \text{ atoms} = 12.00\text{g}$$

conversion factor

$$1 \ {}^{12}\text{C atom} = 12.00 \text{ amu}$$

$$1\text{mole } {}^{12}C \text{ atoms} = 12.00 \text{ g } {}^{12}C$$

$$1 \text{ mole lithium atoms} = 6.941 \text{ of Li}$$

For any element

$$\text{atomic mass(amu)} = \text{molar mass(gram)}$$

Molar Mass

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

1 mole of atoms = 6.022×10^{23} atoms = atomic mass(in grams)

conversion factor for ANY element

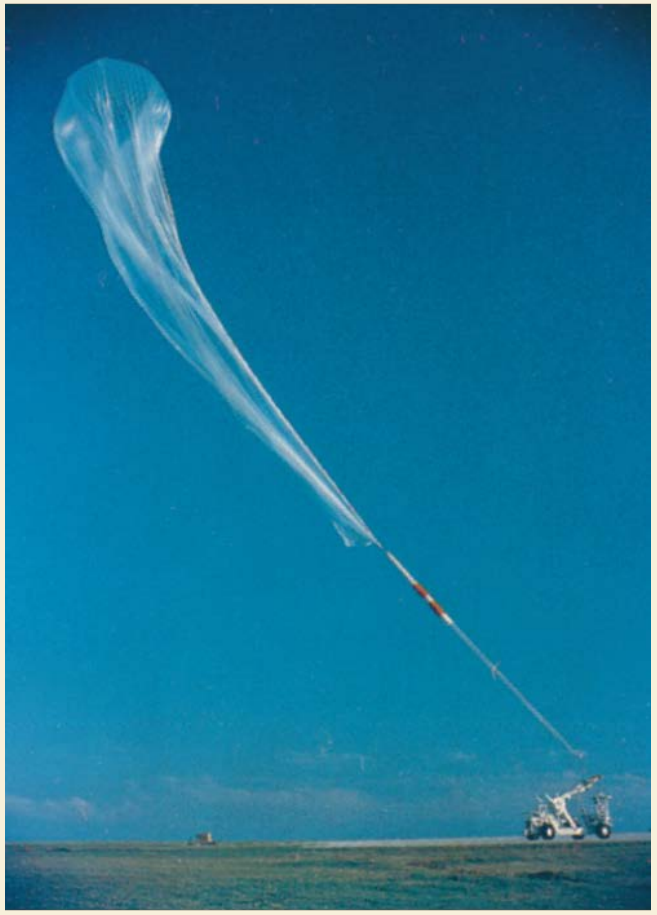
For any element

$$\text{atomic mass(amu)} = \text{molar mass(gram)}$$

Example 3.2

Helium (He) is a valuable gas used in industry, low-temperature research, deep-sea diving tanks, and balloons.

How many moles of He atoms are in 6.46 g of He?



A scientific research helium balloon.

Example 3.2 (1)

Strategy

We are given grams of helium and asked to solve for moles of helium.

What conversion factor do we need to convert between grams and moles?

Arrange the appropriate conversion factor so that grams cancel and the unit moles is obtained for your answer.

Example 3.2 (2)

Solution

The conversion factor needed to convert between grams and moles is the molar mass. In the periodic table (see inside front cover) we see that the molar mass of He is 4.003 g. This can be expressed as

$$1\ \text{mol He} = 4.003\ \text{g He}$$

From this equality, we can write two conversion factors

$$\frac{1\ \text{mol He}}{4.003\ \text{g He}} \text{ and } \frac{4.003\ \text{g He}}{1\ \text{mol He}}$$

The conversion factor on the left is the correct one.

Example 3.2 (3)

Grams will cancel, leaving the unit mol for the answer, that is,

$$6.46 \ \cancel{\text{g He}} \times \frac{1 \text{ mol He}}{4.003 \ \cancel{\text{g He}}} = 1.61 \text{ mol He}$$

Thus, there are 1.61 moles of He atoms in 6.46 g of He.

Check

Because the given mass (6.46 g) is larger than the molar mass of He, we expect to have more than 1 mole of He.

Example 3.3

Zinc (Zn) is a silvery metal that is used in making brass (with copper) and in plating iron to prevent corrosion.

How many grams of Zn are in 0.356 mole of Zn?

End 8/23 9 am class
End 8/23 10 am class

Zinc