

Atomic Mass

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

On this scale:

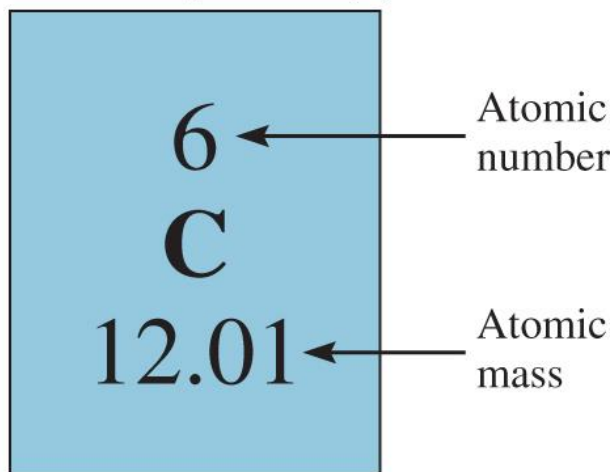
$${}^1\text{H} = 1.008 \text{ amu}$$

$${}^{16}\text{O} = 15.99 \text{ amu}$$

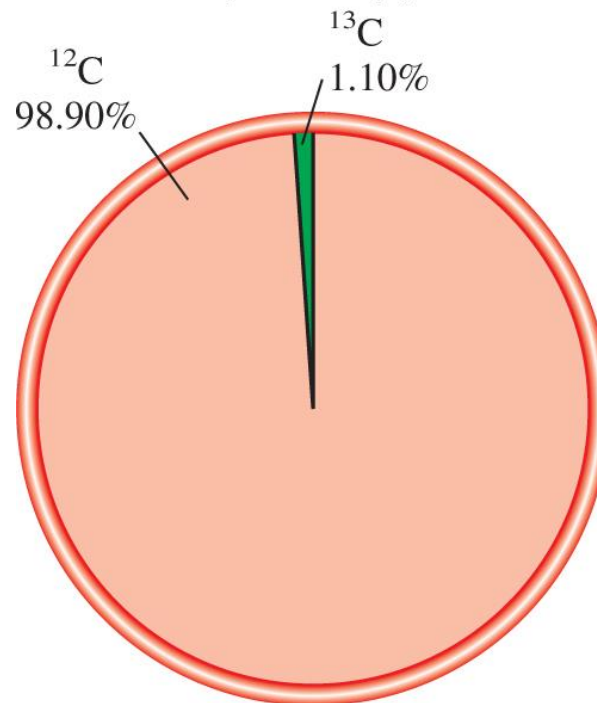
Atomic Mass (1)

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

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Example 3.1

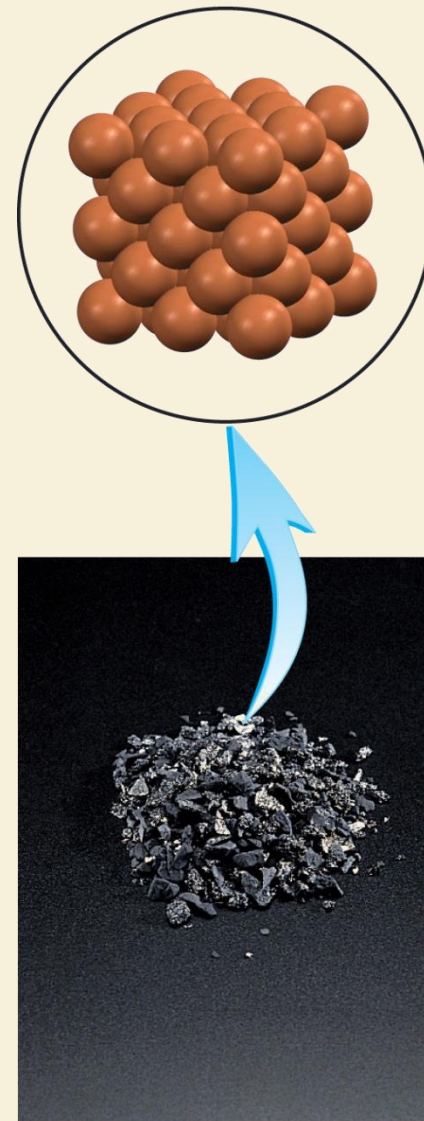
Copper, a metal known since ancient times, is used in electrical cables and pennies, among other things.

The atomic masses of its two stable isotopes, ${}^{63}_{29}\text{Cu}$ (69.09 percent) and ${}^{65}_{29}\text{Cu}$ (30.91 percent), are 62.93 amu and 64.9278 amu, respectively.

Calculate the average atomic mass of copper. The relative abundances are given in parentheses.

63.55 amu

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Atomic Mass on the Periodic Table

1 1A H Hydrogen 1.008	2 2A											13 3A	14 4A	15 5A	16 6A	17 7A	18 8A 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 8B	9 8B	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 Cn Copernicium (285)	113	114	115	116	117	118

11
Na
Sodium
22.99

Atomic number

Atomic mass

Metals

Metalloids

Nonmetals

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

$$1 \text{ mol} = N_A = 6.0221413 \times 10^{23}$$

Avogadro's number (N_A)

Molar Mass

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

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

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

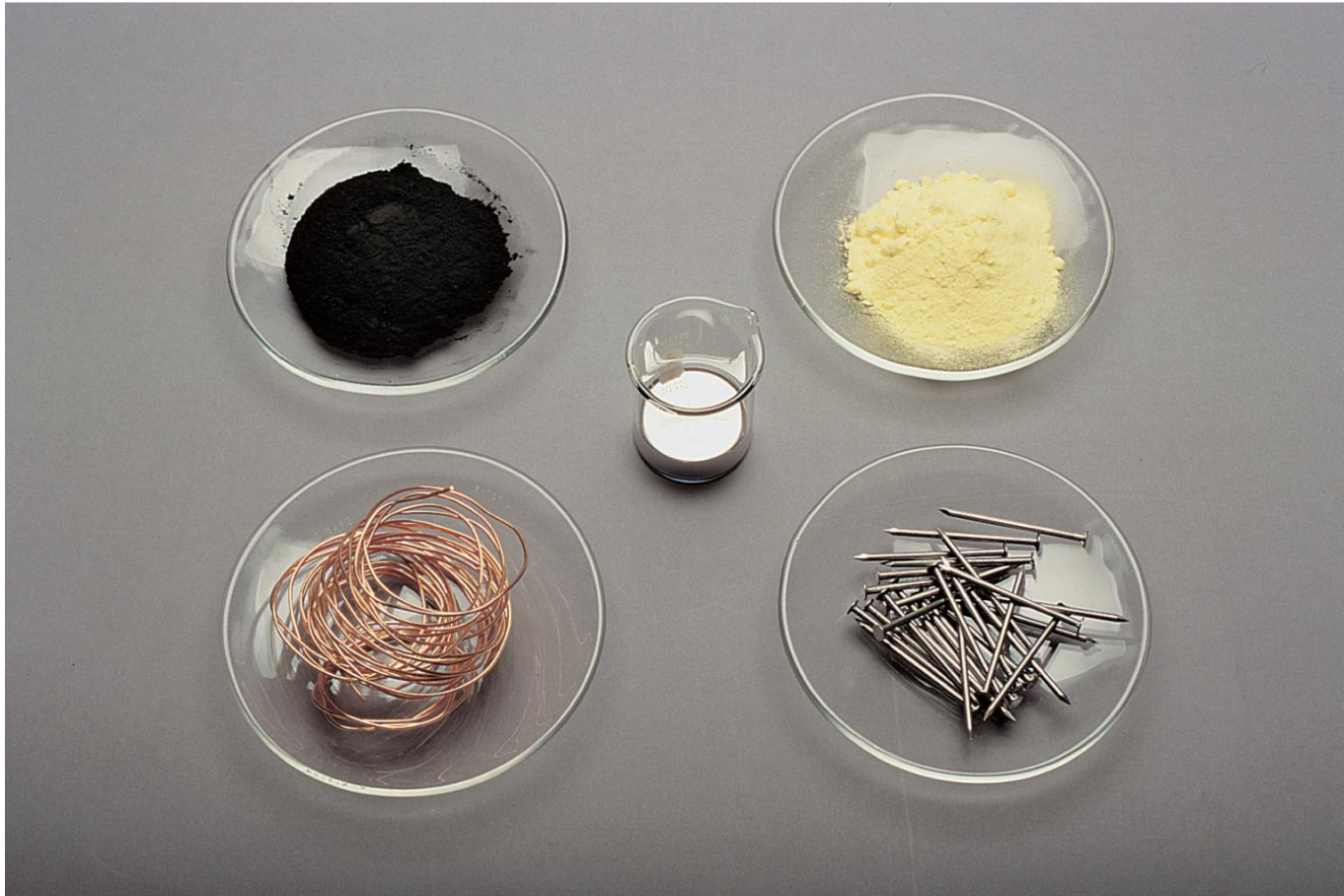
$$1 \text{ mole } ^{12}\text{C atoms} = 12.00 \text{ g } ^{12}\text{C}$$

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

For any element
atomic mass(amu) = molar mass(gram)

Examples of One Mole

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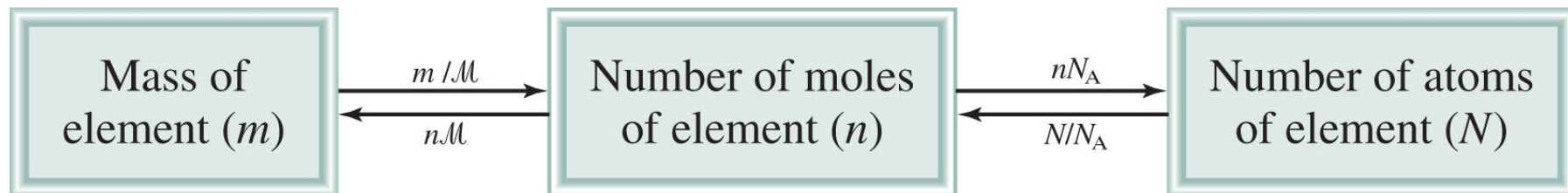
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Converting Between Mass and Atoms

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

$$1 \text{ amu} = 1.66 \times 10^{-24} \text{ g} \text{ or } 1 \text{ g} = 6.022 \times 10^{23} \text{ amu}$$

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M = molar mass in g/mol

N_A = Avogadro's number

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?

1.61 mol He

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Courtesy National Scientific Balloon Facility/Palestine, Texas

A scientific research helium balloon.

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?

23.3 g Zn

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Zinc

Example 3.4

Sulfur (S) is a nonmetallic element that is present in coal.

When coal is burned, sulfur is converted to sulfur dioxide and eventually to sulfuric acid that gives rise to the acid rain phenomenon.

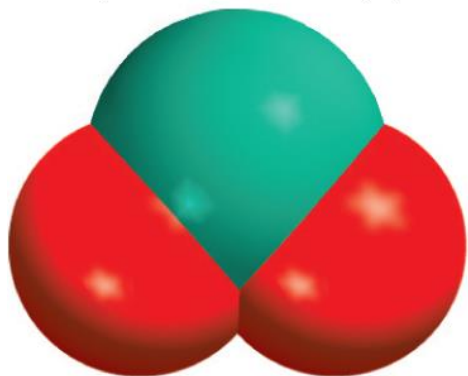
How many atoms are in 16.3 g of S?

3.06×10^{23} atoms of S

Molecular Mass

Molecular mass (or molecular weight) is the sum of the atomic masses (in amu) in a molecule.

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SO₂

1S	32.07 amu
2O	<u>+2 × 16.00 amu</u>
SO ₂	64.07 amu

For any molecule

molecular mass (amu) = molar mass (grams) (numerically)

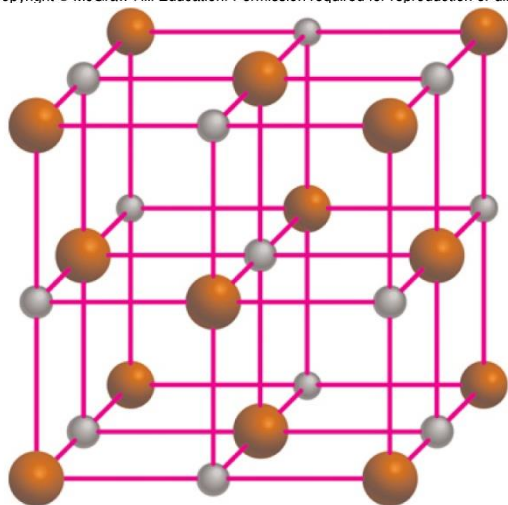
$$1 \text{ molecule SO}_2 = 64.07 \text{ amu}$$

$$1 \text{ mole SO}_2 = 64.07 \text{ g SO}_2$$

Formula Mass

Formula mass is the sum of the atomic masses (in amu) in a formula unit of an ionic compound.

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NaCl

1Na	22.99 amu
1Cl	<u>+ 35.45 amu</u>
NaCl	58.44 amu

For any ionic compound

formula mass (amu) = molar mass (grams) (numerically)

1 formula unit NaCl = 58.44 amu

1 mole NaCl = 58.44 g NaCl