11. A bottle of Cabernet Sauvignon is labeled as having an alcohol content of 12.5% by volume.

    a. Write the percentage of the alcohol in the wine as a conversion factor.

12.5 mL alcohol = 100 mL wine

$$\frac{12.5\ \text{mL alcohol}}{100\ \text{mL wine}}$$

    b. If an individual were to consume 320. mL of the wine, how many fluid ounces of pure alcohol would the individual have ingested? (1 pint = 16 ounces; 8 pints = 1 gal)

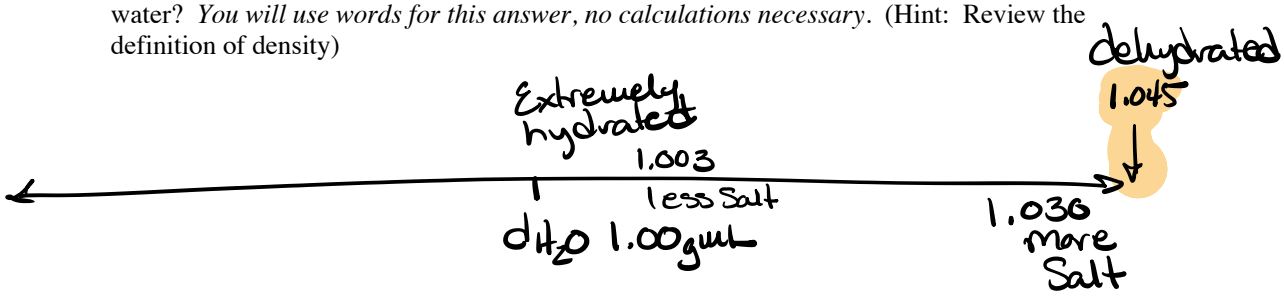
12. Urine is a water-based solution containing a variety of dissolved solids. The specific gravity of a urine sample of a young wrestler is 1.045, which is outside the normal range of 1.003 – 1.030. (The specific gravity of a substance is its density divided by the density of water at 4°C, at which the assumption stated below is accurate.)

    a. What is the density (d) of the urine sample? (Assume that d(H_2O) = 1.00 g/mL)

$$SpG = \frac{d_{obj}}{d_{H_2O}}$$

$$1.045 \times 1.00\ \text{g/mL} = \boxed{1.045\ \text{g/mL}}$$

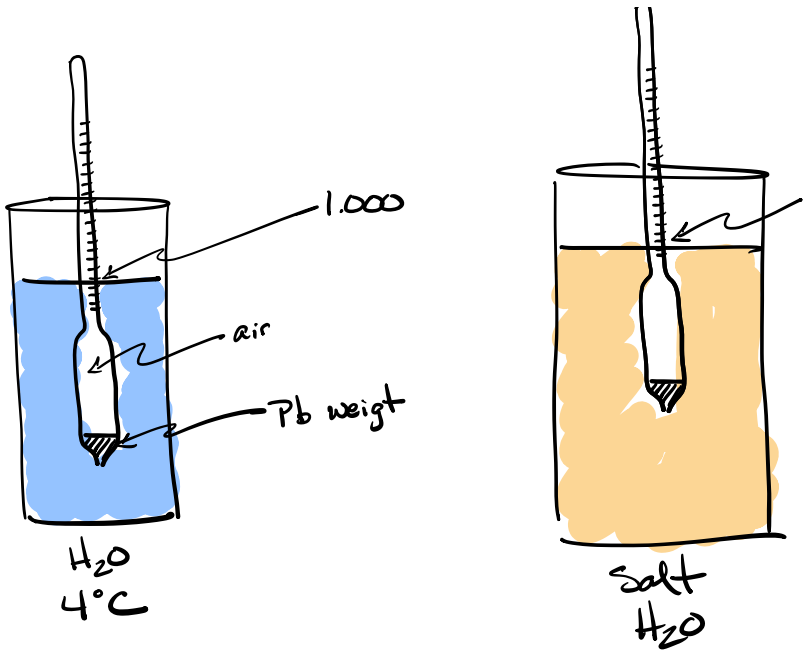
    b. Is it more likely that the wrestler is dehydrated or that he recently drank a large amount of water? *You will use words for this answer, no calculations necessary*. (Hint: Review the definition of density)



$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{\text{grams}}{\text{milliliter}} = \frac{\text{g}}{\text{mL}} \text{ or } \text{g/mL}$$

$$\text{Specific gravity} = \frac{\text{density of object g/mL}}{\text{density of } H_2O \text{ @ } 4^\circ C = 1.000\ \text{g/mL}}$$

$$= \text{unitless value}$$

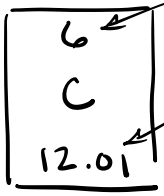

1.000
air
Pb weight
H_2O
4°C
salt
H_2O

1 1A																	18 8A
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 24.30	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 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.84	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.41	31 Ga Gallium 69.72	32 Ge Germanium 72.64	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		72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	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 (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)		104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (289)	117 Ts Tennessine	118 Og Oganesson
Lanthanides			57 La Lanthanum 138.9	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 152.0	64 Gd Gadolinium 157.2	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
Actinides			89 Ac Actinium (227)	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

6 ← atomic #
C
Carbon
12.01 ← Average atomic mass

# of protons in atom

Pure Appl.Chem., Vol.85, pp.1047–1078, 2013.
Values rounded to four significant figures



atomic # = # protons in nucleus

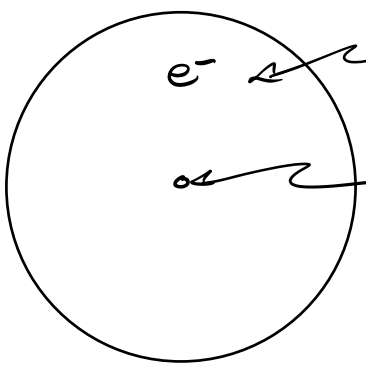
Average mass

Average mass of single C atom in atomic mass units (amu)

or

Average mass in grams of 1 mole of carbon atoms

1 mole = 6.022×10^{23} atoms



electron cloud = volume of atom

e^- = 1/2000 of an amu

nucleus

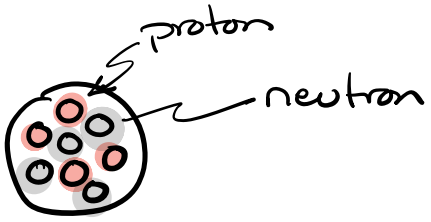
mass of atom

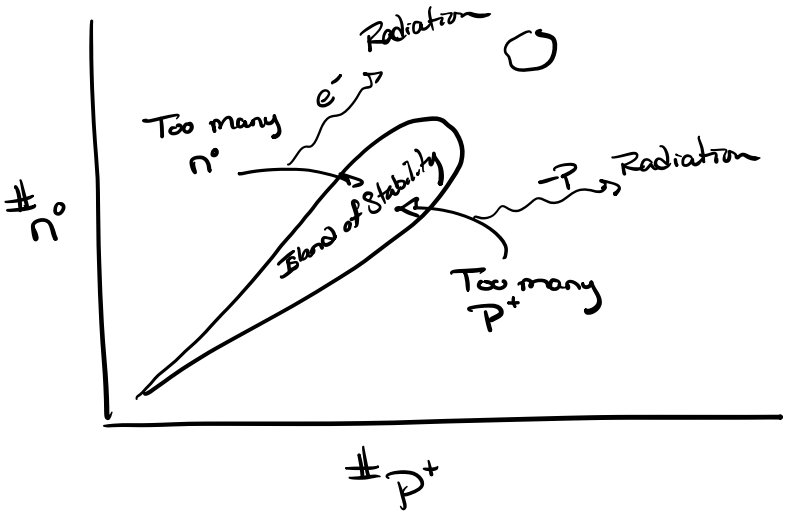
proton 1 amu

neutron 1 amu

Isotopes - family of elements w/ same # of p but different neutrons

	C	C	C
# p^+	6	6	6
# n°	6	7	8
# e^-	6	6	6
amu	12 amu	13 amu	14 amu





Nuclid Symbol

mass # / atomic # X Charge

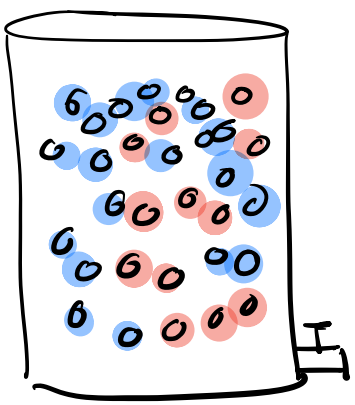
mass # = $p^+ + n^\circ$

	$^{12}_{6}C$	$^{13}_{6}C$	$^{14}_{6}C$
# p^+	6	6	6
# n°	6	7	8
# e^-	6	6	6

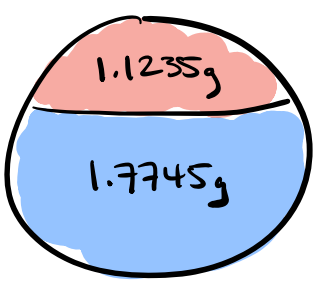
mass # → $^{12}_{6}C$ ← mass #

Carbon-12

^{12}C	^{13}C	^{14}C
12 amu	13 amu	14 amu
98.9%	1.10%	0.00%



100 marbles per bag



Ave marble

35% @ 3.21g × $\frac{35 \text{ Red}}{100 \text{ marbles}}$ = 1.1235 g

65% @ 2.73g × $\frac{65 \text{ Blue}}{100 \text{ marbles}}$ = 1.7745 g

2.8980

= 2.9 g / ave marble

Oxygen example

$^{16}_{8}O$	$^{17}_{8}O$	$^{18}_{8}O$
16 amu	17 amu	18 amu
99.762%	0.0380%	0.2000%

Calculate average amu for oxygen

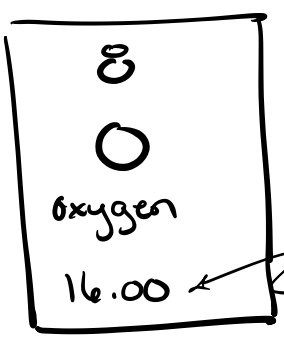
Contribution ^{16}O: $16 \text{ amu} \times \frac{99.762 \text{ } ^{16}O \text{ atoms}}{100 \text{ atoms}} = 15.96192 \text{ amu}$

^{17}O: $17 \text{ amu} \times \frac{0.0380}{100} = 0.00646 \text{ amu}$

^{18}O: $18 \text{ amu} \times \frac{0.2000}{100} = 0.036 \text{ amu}$

$+$

16.00438 amu



Average mass = 16 amu

Average amu based on the relative % abundance

Mole

The mole is a number like a dozen

1 dozen = 12

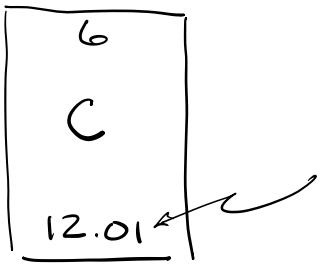
1 mole = ~~The~~ old # of atoms in 12 g of ^{12}C

New

$6.02214076 \times 10^{23}$ entities exactly

now a definition

How does the # on the bottom of element Symbol on PT have two different units?



Ave. amu per atom
&
Ave mass in grams of 1 mole of atoms

$$1\ \text{amu} = 1.660\,54 \times 10^{-24}\ \text{grams}$$

What is the mass of 1 mole of C atoms in grams?

mole C atom ⟶ C atom ⟶ amu ⟶ grams

$$\text{Exact}\quad 1\ \text{mole C atom} \times \frac{6.022\,140\,76 \times 10^{23}\ \text{atom}}{1\ \text{mole C atom}} \times \frac{12.01\ \text{amu}}{1\ \text{C atom}} \times \frac{1.660\,54 \times 10^{-24}\ \text{g}}{1\ \text{amu}} =$$

def, 4, 6, -24

$$12.010\,006\,746\,0\ \text{g}$$

$$= 12.01\ \text{g} / 1\ \text{mole C atom}$$

$$\frac{1}{6.022\,140\,76 \times 10^{23}} = 1.660\,54 \times 10^{-24}$$

How many atoms are in a sample of given mass?

How much mass will a given number of atoms weigh?

Count atoms ⟷ g/mole ⟷ weight mass

Stoichiometry

How many Copper atoms are in a Cylinder of Copper weighing **263.7 g**?

29
Cu
63.55

① molar mass of Cu (mass per 1 mole) 63.55 g/mole 63.55 g = 1 mole Cu atoms

② Value of mole 6.022×10^{23}

Road Map

g Cu —(molar mass)→ mole Cu atoms —(def mole)→ Cu atoms

mass Count

$$263.7 \text{ g Cu} \times \frac{1 \text{ mole Cu}}{63.55 \text{ g Cu}} \times \frac{6.022 \times 10^{23} \text{ Cu atoms}}{1 \text{ mole Cu}} = 2.498822 \times 10^{24} \text{ Cu atoms}$$

$$2.499 \times 10^{24} \text{ Cu atoms}$$

1 1A																	18 8A
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 24.30	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 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.84	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.41	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80
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87 Fr Francium (223)	88 Ra Radium (226)		104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (266)	107 Bh Bohrium (264)	108 Hs Hassium (277)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113 Nh Nihonium (284)	114 Fl Flerovium (289)	115 Mc Moscovium (288)	116 Lv Livermorium (289)	117 Ts Tennessine	118 Og Oganesson
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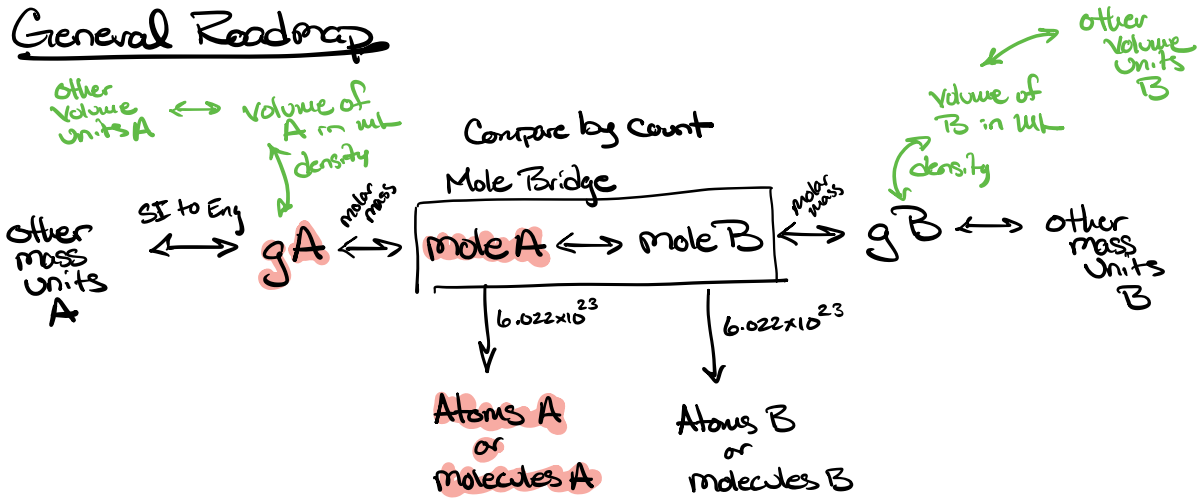
Values rounded to four significant figures

Stoichiometry

Starting point

g A ⟶ mole A ⟶ atoms A

General Roadmap



g A ⟶ (molar mass) mole A ⟶ (6.022x10^23) Atoms or Molecules A

Singular

Atom	molecule
Cu	H_2
C	O_2
O	CO_2
	$C_6H_{12}O_6$

What is the molar mass of water H_2O?

H	1.008 g/mole (4)	× 2 (Counted)	=	2.016
O	16.00 g/mole (4)	× 1 (Subscript)	= +	16.00
				18.016

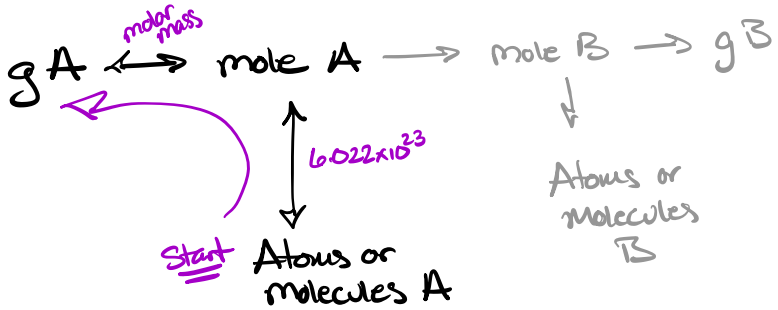
18.02 g/mole H_2O

$C_6H_{12}O_6$ (glucose)

C	12.01 g/mole (4)	× 6 (Exact)	=	72.06
H	1.008 g/mole (4)	× 12	=	12.096
O	16.00 g/mole (4)	× 6	= +	96.00
				180.156 g/mole $C_6H_{12}O_6$

= 180.16 g/mole $C_6H_{12}O_6$

How many grams would 9.23×10^{16} molecules of $C_6H_{12}O_6$ weigh?



3 5

$$9.23 \times 10^{16} \text{ molecules } C_6H_{12}O_6 \times \frac{1 \text{ mole } C_6H_{12}O_6}{6.022 \times 10^{23} \text{ molecules } C_6H_{12}O_6} \times \frac{180.16 \text{ g } C_6H_{12}O_6}{1 \text{ mole } C_6H_{12}O_6}$$

4

= 9.23 EE 16 ÷ 6.022 EE 23 x 180.16 = 2.761336×10^{-5} g

(EE = 10^x)

$$= 2.76 \times 10^{-5} \text{ g}$$

Elements	Atoms
C	C
Cu	Cu
O	O
N	N

Singular

Compounds	molecules
$C_6H_{12}O_6$	
CO_2	
H_2O	
NH_3	

How many atoms of Oxygen are in 5.27 g of Carbon dioxide (CO_2) ?

g A $\xrightarrow{\text{molar mass } CO_2}$ mole A $\xrightarrow{1 \text{ mole } CO_2 = 2 \text{ mole O}}$ mole B $\longrightarrow$ g B

A = CO_2

$\downarrow 6.022 \times 10^{23}$

atoms B

B = O

CO_2 1 molecule CO_2 = 2 atoms O

How many oxygen atoms in CO_2?

How many moles of oxygen in 1 mole CO_2?

1 mole molecules CO_2 = 2 moles atoms O

CO_2 CO_2 CO_2

CO_2 ... 6.022×10^{23}

#C	#O
6.022×10	$2 \times 6.022 \times 10^{23}$

$X_l Y_m Z_n$

Atom ratio = Molar Ratios !

① molar mass CO_2

C 12.01 g/mole × 1 = 12.01

O 16.00 g/mole × 2 = + 32.00

44.01 g/mole CO_2

② Road map

g CO_2 $\xrightarrow{44.01\ g/mole}$ mole CO_2 $\xrightarrow{1\ mole\ CO_2 = 2\ mole\ O}$ mole O $\xrightarrow{6.022 \times 10^{23}}$ atoms O

$$5.27\ g\ CO_2 \times \frac{1\ mole\ CO_2}{44.01\ g\ CO_2} \times \frac{2\ mole\ O}{1\ mole\ CO_2} \times \frac{6.022 \times 10^{23}\ atom\ O}{1\ mole\ O} = 1.442214 \times 10^{23}\ atoms\ O$$

(5.27 g CO_2: 3 sig figs; 44.01 g CO_2: 4 sig figs; 2 mole O: exact; 6.022×10^{23}: 4 sig figs)

$$= 1.44 \times 10^{23}\ atoms\ O$$