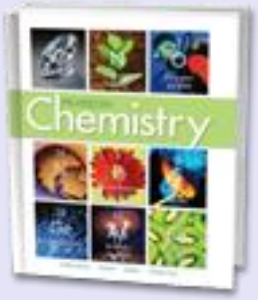
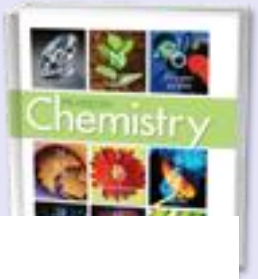


Chapter 10
Chemical Quantities

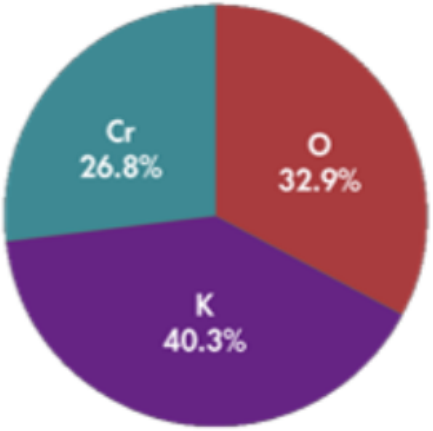
The Mole: A Measurement of Matter

Mole-Mass and Mole-Volume Relationships

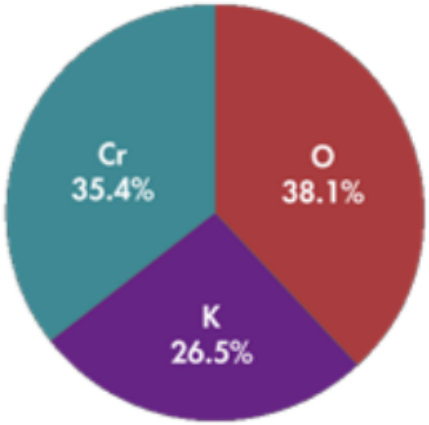
Percent Composition and Chemical Formulas



Molar Quantities Chapter 10B



Potassium chromate, K_2CrO_4



Potassium dichromate, $K_2Cr_2O_7$

Topics:

1. Molar Quantities

Objectives:

1. Calculate Percent Composition (Percent by Mass of elements in a compound) using mass, formulas, and percentages.
2. Determine mole ratios of elements within a formula.
3. Understand and calculate Empirical Formulas using mass, percentages, and moles.
4. Determine Molecular Formula from Empirical Formulas.
5. Understand and utilize the mole in mathematical computations according to the mole concept (Avogadro's Number).
6. Calculate Molar Mass of Elements and Compounds. Interconvert moles and mass.
7. Calculate Molar Volume at STP. Interconvert moles and liters, molar mass and density.

Review Molar Quantities

Use the periodic table to find the molar mass of each of the following elements.

Sodium (Na):

Oxygen (O):

Carbon (C):

Consider sodium oxide, Na_2O. What do the subscripts represent?

What is the molar mass of sodium oxide?

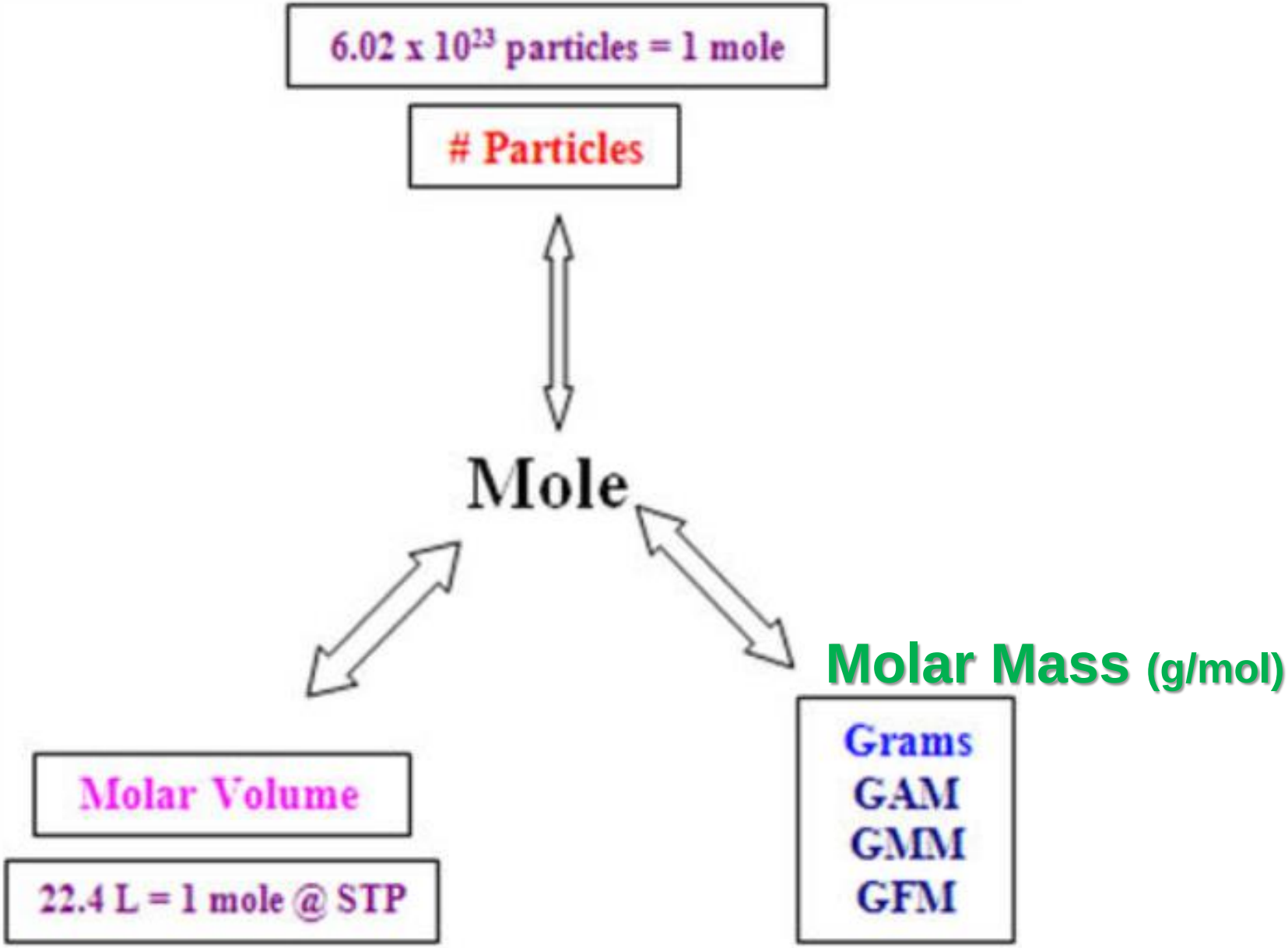
Consider calcium nitrate, $Ca(NO_3)_2$. What do the subscripts represent? How many atoms of each element are there?

What is the molar mass of calcium nitrate?

If a sample contains 21.2 g N_2, how many moles of N_2 does it contain?

How many liters of N_2 gas is this?

How many molecules of N_2 gas is this?


6.02 x 10^23 particles = 1 mole
Particles
Mole
Molar Mass (g/mol)
Grams
GAM
GMM
GFM
Molar Volume
22.4 L = 1 mole @ STP

Review Molar Quantities

WARM-UP

Use the periodic table to find the molar mass of each of the following elements.

Sodium (Na): 22.99 g/mol

Oxygen (O): 16.00 g/mol

Carbon (C): 12.01 g/mol

Consider sodium oxide, Na_2O. What do the subscripts represent?

There are two atoms of sodium and one atom of oxygen.

What is the molar mass of sodium oxide?

Na 2 x 23.0 g/mol = 46.0 g/mol
O 1 x 16.0 g/mol = 16.0 g/mol
= 62.0 g/mol

Consider calcium nitrate, $Ca(NO_3)_2$. What do the subscripts represent? How many atoms of each element are there?

There are two nitrate ions.
1 Ca, 2 N, 6 O

What is the molar mass of calcium nitrate?

Ca 1 x 40.1 g/mol = 40.1 g/mol
N 2 x 14.0 g/mol = 28.0 g/mol
O 6 x 16.0 g/mol = 96.0 g/mol
= 164 g/mol

If a sample contains 21.2 g N_2, how many moles of N_2 does it contain?

21.2 g x 1 mol/28.0 g = 0.757 mol

How many liters of N_2 gas is this?

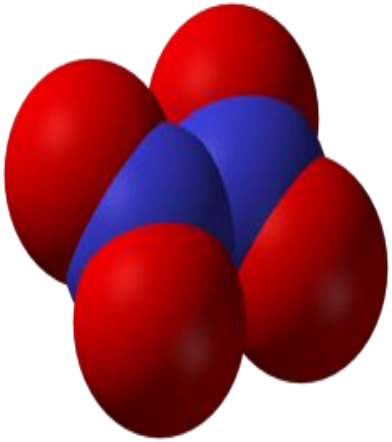
0.757 mol x 22.4 L/1 mol = 17.0 L

How many molecules of N_2 gas is this?

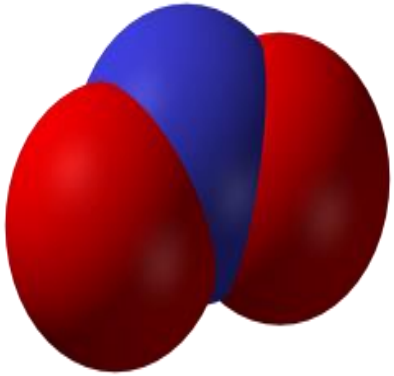
$0.757 \text{ mol} \times 6.02 \times 10^{23} \text{ molecules}/1 \text{ mol}$
$= 4.56 \times 10^{23} \text{ molecules}$

LESSON QUESTION

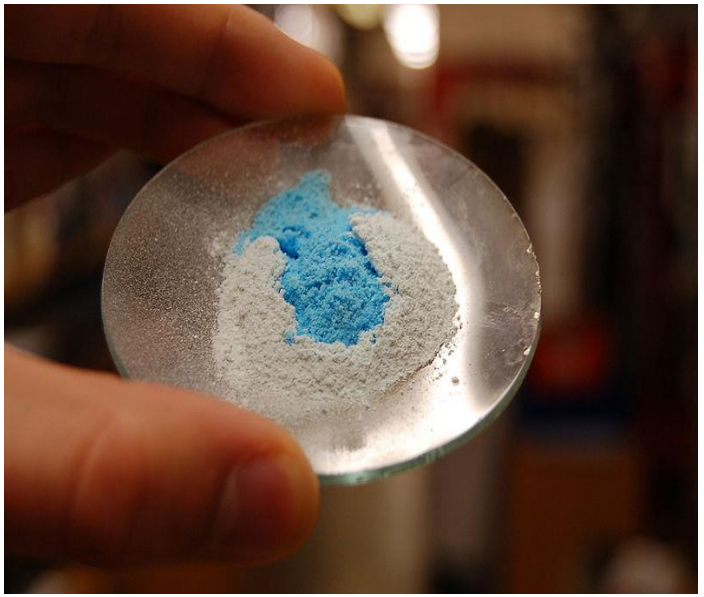
How Do Scientists Calculate the Composition of Elements in a Compound?



N_2O_4



NO_2



$CuSO_4$ hydrate

Percent composition of a compound

The basis for accurate **quantitative** analysis is the proportion by weight or mass of elements in a formula.

If we added the individual masses of each atom in a formula, we will obtain the total mass for the compound or molecule:

Total % of all elements in a formula = 100 %

It follows that the proportion of any ONE element in a sample is equal to the mass of the sample divided by the total mass, therefore:

% element = mass of the element / total mass x 100 %

STRATEGY

Percent composition of a compound

The relative amounts of the elements in a compound are expressed as the percent composition or the **percent by mass** of each element in the compound.

Determine the percent composition of potassium chromate, K_2CrO_4:

K = ? %
Cr = ? %
O = ? %
100.0 %

Percent composition of a compound

The relative amounts of the elements in a compound are expressed as the percent composition or the percent by mass of each element in the compound.

Determine the percent composition of potassium chromate, K_2CrO_4:

% element = mass of the element / total mass x 100 %

K = 2 x 39.1 g/mol = 78.2 g/mol

Cr = 1 x 52.0 g/mol = 52.0 g/mol

O = 4 x 16.0 g/mol = 64.0 g/mol

Molar Mass = 194.2 g/mol

K = 78.2/194.2 x 100% = 40.3%

Cr = 52.0/194.2 x 100% = 26.8%

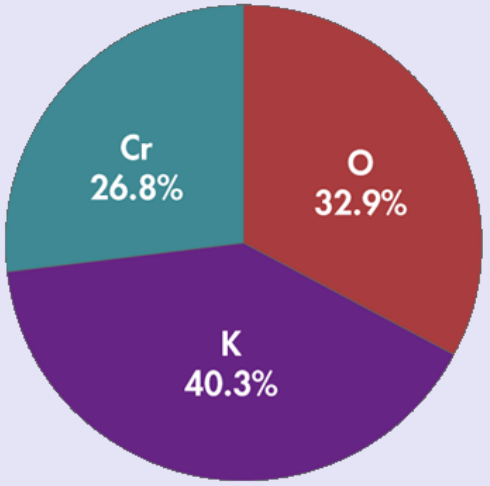
O = 64.0/194.2 x 100% = 32.9%

Percent composition of a compound

Percentages must total 100%. The percent composition of any compound is always the same (law of definite proportions.)

The percent composition of potassium chromate, K_2CrO_4, is:

K = 40.3%
Cr = 26.8%
O = 32.9%
100.0 %



Potassium chromate, K_2CrO_4

Note: 100% = 1

The percentages can be set equal to "1" as follows:

$$0.403 + 0.268 + 0.329 = 1$$

TRY IT

$$\% \text{ by mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

A sample of a compound containing carbon and oxygen had a mass of 88 grams. Experimental procedures determined that 24 grams of the sample was carbon and 64 grams was oxygen. Find the % composition of each element.

TRY IT

$$\% \text{ by mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

A sample of a compound containing carbon and oxygen had a mass of 88 grams. Experimental procedures determined that 24 grams of the sample was carbon and 64 grams was oxygen. Find the % composition (*of each element*) of the compound.

% C = mass of C / Total Mass x 100% → 24 g / 88 g x 100 % = 27% Carbon

% O = mass of O / Total Mass x 100% → 64 g / 88 g x 100 % = 73% Oxygen

Note: The percentages can be set equal to "1" as follows:

STRATEGY

0.27 g + 0.73 g = 1 g

… **for every 1 g of sample, there is 0.27 g C & 0.73 g O**

Calculating Percent Composition from Mass Data

A compound is formed when 9.03 g Mg combines completely with 3.48 g N. What is the percent composition of this compound?

Calculating Percent Composition from Mass Data

A compound is formed when 9.03 g Mg combines completely with 3.48 g N. What is the percent composition of this compound?

1. Find total mass 9.03 g Mg + 3.48g N = 12.51 g of compound

2. Find % by mass

% Mg = mass of Mg / Total Mass x 100% → 9.03 g / 12.51 g x 100 % = 72.2% Mg

% N = mass of N / Total Mass x 100% → 3.48 g / 12.51 g x 100 % = 27.8% N

Show the percentages of the elements adding up to 100% and 1.

Calculating Percent Composition from Mass Data

A compound is formed when 9.03 g Mg combines completely with 3.48 g N. What is the percent composition of this compound?

1. Find total mass 9.03 g Mg + 3.48g N = 12.51 g of compound

2. Find % by mass

% Mg = mass of Mg / Total Mass x 100% → 9.03 g / 12.51 g x 100 % = 72.2% Mg

% N = mass of N / Total Mass x 100% → 3.48 g / 12.51 g x 100 % = 27.8% N

NOTE: the percentages of the elements add up to 100% or 1.

72.2% + 27.8% = 100%

0.722 + 0.278 = 1

Calculating Percent Composition from a Formula

Determine the % composition of Sulfuric Acid

What is the formula?

Find GFM or GMM

Find percent composition

STRATEGY

Calculating Percent Composition from a Formula

Determine the % composition of Sulfuric Acid ($H_2SO_{4\ aq}$)

Find GFM or GMM

H	2 x 1.00 g/mol	= 2.00 g/mol
S	1 x 32.1 g/mol	= 32.1 g/mol
O	4 x 16.0 g/mol	= 64.0 g/mol
		= 98.1 g/mol

Find percent composition

% H GAM/Total Mass → 2.00 g / 98.1 g/mol = 0.0204 = 2 %

% S GAM/Total Mass → 32.1 g / 98.1 g/mol = 0.327 = 33 %

% O GAM/Total Mass → 64.0 g / 98.1 g/mol = 0.652 = 65 %

$$\%\ \text{by mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

Calculating Percent Composition from a Formula

Calculate the percent composition of ethane (C_2H_6).

Calculating Percent Composition from a Formula

Calculate the percent composition of ethane (C_2H_6).

Find the molar mass of ethane (C_2H_6)

mass of C in 1 mol C_2H_6 = 2 mol × 12.0 g/mol = 24.0 g
mass of H in 1 mol C_2H_6 = 6 mol × 1.00 g/mol = 6.00 g

molar mass of C_2H_6 = 24.0 g/mol + 6.00 g/mol = 30.0 g/mol

Find percent composition

% C GAM/Total Mass → 24.0 g / 30.0 g/mol = 0.80 = 80 %
% H GAM/Total Mass → 6.00 g / 30.0 g/mol = 0.20 = 20 %

$$\%\ \text{by mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

Calculating Mass from Percent Composition

Calculate the mass of the elements in 350 g of ethane (C_2H_6).

Calculating a Formula from Percent Composition

Calculate the mass of the elements in 350 g of ethane (C_2H_6).

Rearrange % mass equation

% mass = mass of element / total mass

Mass of element = (% mass)(total mass)

Find percent composition

% C GAM/Total Mass → 24.0 g / 30.0 g/mol = 0.80 = 80 %

% H GAM/Total Mass → 6.00 g / 30.0 g/mol = 0.20 = 20 %

Find the mass of each element in 350 g of ethane (C_2H_6)

mass of C = 350 g x 80 % = 280 g

mass of H = 350 g x 20 % = 70 g

Mole Ratios (Divide "moles" by "moles")

- $CaCl_2$

  Ratio of subscripts = __:__

  Mole ratio of Ca:Cl = __:__

- $Ca_3(PO_4)_2$

  Ratio of subscripts = __:__:__

  Mole ratio of Ca:P:O = __:__:__

- $C_6H_{12}O_6$

  Ratio of subscripts = __:__:__

  Mole ratio C:H:O = __:__:__

- NO_2

  Ratio of subscripts = __:__

  Mole ratio of N:O = __:__

- N_2O_4

  Ratio of subscripts = _:_

  Mole ratio of N:O = 2:4 = __:__

EMPIRICAL → smallest whole number ratio

Mole Ratios (Divide "moles" by "moles")

- $CaCl_2$
  - Ratio of subscripts = 1:2
  - Mole ratio of Ca:Cl = 1:2
- $Ca_3(PO_4)_2$
  - Ratio of subscripts = 3:2:8
  - Mole ratio of Ca:P:O = 3:2:8
- $C_6H_{12}O_6$
  - Ratio of subscripts = 6:12:6
  - Mole ratio C:H:O = 1:2:1
- NO_2
  - Ratio of subscripts = 1:2
  - Mole ratio of N:O = 1:2
- N_2O_4
  - Ratio of subscripts = 2:4 = 1:2
  - Mole ratio of N:O = 2:4 = 1:2
  - *Both molecules are nitrous oxide*

EMPIRICAL → smallest whole number ratio

Calculating a Formula from Percent Composition

A compound contains 11% hydrogen and 89 % oxygen. What is its formula?

Calculating a Formula from Percent Composition

A compound contains 11% hydrogen and 89 % oxygen. What is its formula?

Remember that percentage can be made into decimals equaling 1 g:

11 % + 89 % = 100 % → 0.11 g + 0.89 g = 1.0 g

Find Moles using the grams:

H 0.11 g x 1 mol/1.00 g = 0.110 mol H

O 0.89 g x 1 mol/16.0 g = 0.0556 mol O

Find the Mole Ratio (divide moles by moles): law of definite proportions

0.110 mol / 0.0556 mol = 2:1

Since the mole ratio = 2:1, the formula is H_2O (water)

Calculating a Formula from Percent Composition

Done WITHOUT Decimals

A compound contains 11% hydrogen and 89 % oxygen. What is its formula?

Percentage can be made into numbers equaling 100 g:

11 % + 89 % = 100 % → 11 g + 89 g = 100 g

Find Moles using the grams:

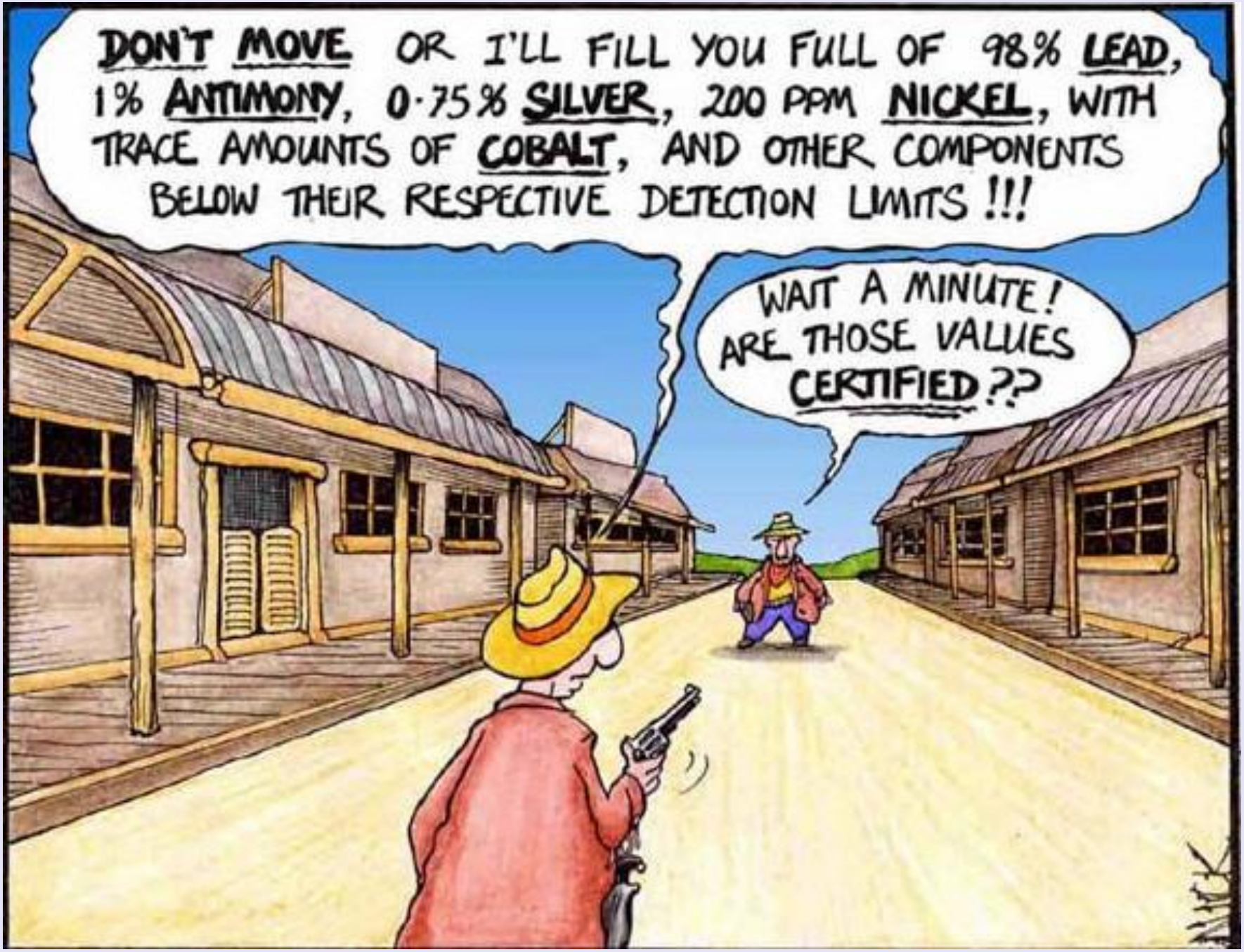
H 11 g x 1 mol/1.00 g = 11.0 mol H

O 89 g x 1 mol/16.0 g = 5.56 mol O

Find the Mole Ratio (divide moles by moles): law of definite proportions

11.0 mol / 5.56 mol = 2:1

Since the mole ratio = 2:1, the formula is H_2O (water)


DON'T MOVE OR I'LL FILL YOU FULL OF 98% LEAD, 1% ANTIMONY, 0·75% SILVER, 200 PPM NICKEL, WITH TRACE AMOUNTS OF COBALT, AND OTHER COMPONENTS BELOW THEIR RESPECTIVE DETECTION LIMITS !!!
WAIT A MINUTE! ARE THOSE VALUES CERTIFIED??

Empirical Formulas

The empirical formula of a compound gives the lowest whole-number ratio of the atoms or moles of the elements in a compound.

An empirical formula may or may not be the same as a molecular formula.

For carbon dioxide, the empirical and molecular formulas are the same: CO_2, both having mole ratios of 1:2.

CO_2 molecule

composed of

1 carbon atom
and
2 oxygen atoms

composed of

6.02×10^{23} carbon atoms
(1 mol C atoms)
and
$2 \times (6.02 \times 10^{23})$ oxygen atoms
(2 mol O atoms)

For calcium sulfide the molecular formula is Ca_2S_2, so the mole ratio is 2:2. The empirical formula of calcium sulfide is CaS since the simplest whole number mole ratio is 1:1.

Empirical Formulas

The figure below shows two compounds of carbon and hydrogen having the same empirical formula $(CH)_x$ but different molecular formulas.

Ethyne (C_2H_2), also called acetylene, is a gas used in welders' torches.

Styrene (C_8H_8) is used in making polystyrene.

Empirical Formulas

Empirical formula $(CH)_x$ can be included in a molecular formula to distinguish molecules:

$(CH)_2$

Ethyne (C_2H_2)

$(CH)_8$

Styrene (C_8H_8)

$(HO)_2$

Peroxide (H_2O_2)

STRATEGY

Determining Empirical Formulas

… the simplest mole ratio of elements in a compound

Step 1 → find the number of moles of each element in the compound

Step 2 → divide the # moles by the **smallest** # moles (from step 1)

Step 3 → determine a whole # mole ratio

Ethanoic acid, methanal, and glucose all have the same empirical formula — CH_2O.

A compound composed of Nickel and fluorine contains 9.11 g Ni and 5.89 g F. What is the empirical formula of this compound?

Step 1 → find the number of moles of each element in the compound

Step 2 → divide the # moles by the **smallest** # moles (from step 1)

Step 3 → determine a whole # mole ratio

A compound composed of Nickel and fluorine contains 9.11 g Ni and 5.89 g F. What is the empirical formula of this compound?

Step 1 → find the number of moles of each element in the compound

9.11 g x 1 mol / 58.7 g Ni = 0.155 mol Ni

5.89 g x 1 mol / 19.0 g F = 0.310 mol F

Step 2 → divide the # moles by the **smallest** # moles (from step 1)

0.155 mol / 0.155 mol = 1

0.310 mol / 0.155 mol = 2.01

Step 3 → determine a whole # mole ratio … law of definite proportions

1:2 NiF_2

Note: remember, the metal comes first in a formula while the non-metal is listed last

1,6 diaminohexane is used to make nylon. What is the empirical formula of this compound if its percent composition is 62.1 % C, 13.8 % H, and 24.1 % N?

1,6 diaminohexane is used to make nylon. What is the empirical formula of this compound if its percent composition is 62.1 % C, 13.8 % H, and 24.1 % N?

DONE WITH DECIMALS

Change % into grams: 62.1 % = .621 g C, 13.8% = 13.8 g H, etc.

Find the number of moles of each element in the compound

0.621 g x 1 mol / 12.0 g C = 0.0518 mol C

0.138 g x 1 mol / 1.00 g H = 0.138 mol H

0.241 g x 1 mol / 14.0 g N = 0.0172 mol N

Divide the # moles by the **smallest** # moles

0.0518 mol / 0.0172 mol = 3.01 C

0.138 mol / 0.0172 mol = 8.02 H

0.0172 mol / 0.0172 mol = 1.00 N

Determine a whole # mole ratio … law of definite proportions

C:H:N 3:8:1 C_3H_8N

TRY IT

1,6 diaminohexane is used to make nylon. What is the empirical formula of this compound if its percent composition is 62.1 % C, 13.8 % H, and 24.1 % N?

DONE WITHOUT DECIMALS

Change % into grams: 62.1% = 62.1 g C, 13.8% = 13.8 g H, etc.

Find the number of moles of each element in the compound

62.1 g x 1 mol / 12.0 g C = 5.18 mol C

13.8 g x 1 mol / 1.00 g H = 13.8 mol H

24.1 g x 1 mol / 14.0 g N = 1.72 mol N

Divide the # moles by the **smallest** # moles

5.18 mol / 1.72 mol = 3.01 C

13.8 mol / 1.72 mol = 8.02 H

1.72 mol / 1.72 mol = 1.00 N

Determine a whole # mole ratio … law of definite proportions

C:H:N 3:8:1 C_3H_8N

STRATEGY

Determining Molecular Formulas

The molecular formula of a compound is either the same as its experimentally determined empirical formula, or it is a simple whole-number multiple of its empirical formula.

Step 1 → determine the molar mass of the empirical formula

Step 2 → determine the **mass ratio** of the molecular formula / empirical formula

Step 3 → multiply subscripts by the **mass ratio**

STRATEGY

Determining Molecular Formulas

What is the molecular formula of a compound with the empirical formula CClN and a molar mass of 184.5 g/mol?

Step 1 → determine the molar mass of the empirical formula

Step 2 → determine the **mass ratio** of the molecular formula / empirical formula

Step 3 → multiply subscripts by the **mass ratio**

STRATEGY

Determining Molecular Formulas

What is the molecular formula of a compound with the empirical formula CClN and a molar mass of 184.5 g/mol?

Step 1 → determine the molar mass of the empirical formula

C 1 x 12.01 g/mol
Cl 1 x 35.45 g/mol
N 1 x 14.01 g/mol
= 61.47 g/mol

Mass Ratio:

$$\frac{184.5 \text{ g/mol}}{61.47 \text{ g/mol}} = 3.001$$

Step 2 → determine the **mass ratio** of the molecular formula / empirical formula

Step 3 → multiply subscripts by the **mass ratio**

$$C_1Cl_1N_1 \times 3 = C_3Cl_3N_3$$

Calculate Empirical Formula from Percent Composition

A compound contains 75% carbon and 25% hydrogen by mass. What is the empirical formula for this compound?

A compound is 42% sodium, 19% phosphorus, and 39% oxygen by mass. What is the empirical formula of this compound?

TRY IT

Calculate Empirical Formula from Percent Composition

A compound contains 75% carbon and 25% hydrogen by mass. What is the empirical formula for this compound?

Change % into grams:

75% = 0.750 g C 25% = 0.250 g H

Find the number of moles:

0.750 g x 1 mol/12.0 g C = 0.0625 mol C

0.250 g x 1 mol/1.00 g H = 0.25 mol H

Divide by the **smallest** # moles:

0.0625 mol / 0.0625 mol = 1 C

0.25 mol / 0.0625 mol = 4 H

Determine a whole # mole ratio:

C:H 1:4 CH_4

A compound is 42% sodium, 19% phosphorus, and 39% oxygen by mass. What is the empirical formula of this compound?

Change % into grams:

0.42 g Na 0.19 g P 0.39 g O

Find the number of moles:

0.420 g x 1 mol/23.0 g Na = 0.0183 mol Na

0.190 g x 1 mol/31.0 g P = 0.0061 mol P

0.390 g x 1 mol/16.0 g O = 0.0244 mol P

Divide by the **smallest** # moles:

0.0183 mol / 0.0061 mol = 3 Na

0.0061 mol / 0.0061 mol = 1 P

0.0244 mol / 0.0061 mol = 4 O

Determine a whole # mole ratio:

Na:P:O 3:1:4 Na_3PO_4

TRY IT

Calculate Empirical Formula from Percent Composition (Done ANOTHER WAY)

A compound contains 75% carbon and 25% hydrogen by mass. What is the empirical formula for this compound?

Change % into grams:

75% = 75 g C 25% = 25 g H

Find the number of moles:

75 g x 1 mol/12.0 g C = 6.25 mol C

25 g x 1 mol/1.00 g H = 25 mol H

Divide by the **smallest** # moles:

62.5 mol / 6.25 mol = 1 C

25 mol / 6.25 mol = 4 H

Determine a whole # mole ratio:

C:H 1:4 CH_4

A compound is 42% sodium, 19% phosphorus, and 39% oxygen by mass. What is the empirical formula of this compound?

Change % into grams:

42% = 42 g Na 19% = 19 g P 39% = 39 g O

Find the number of moles:

42 g x 1 mol/23.0 g Na = 1.83 mol Na

19 g x 1 mol/31.0 g P = 0.61 mol P

39 g x 1 mol/16.0 g O = 2.44 mol P

Divide by the **smallest** # moles:

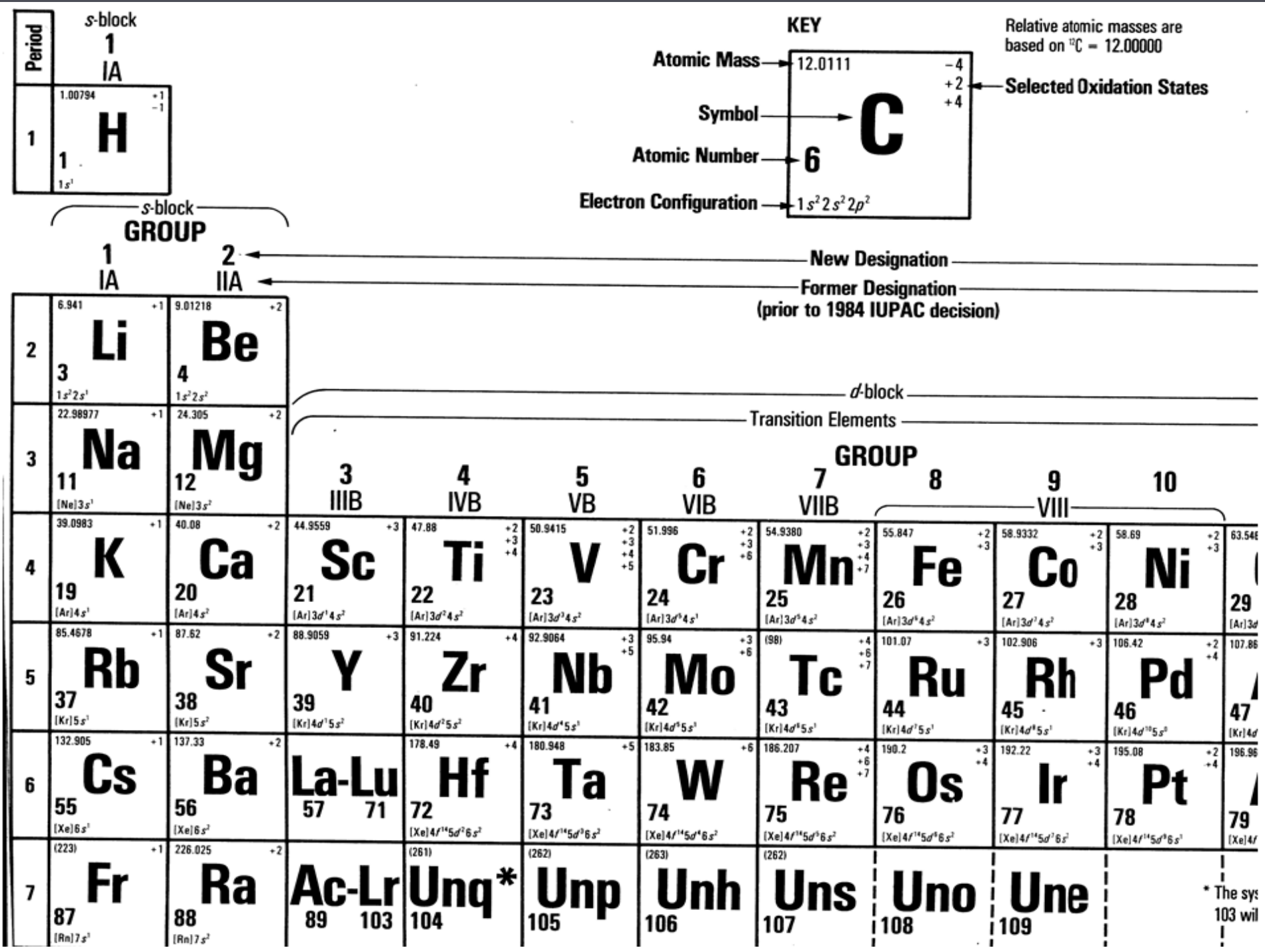
1.83 mol / 0.61 mol = 3 Na

0.61 mol / 0.61 mol = 1 P

2.44 mol / 0.61 mol = 4 O

Determine a whole # mole ratio:

Na:P:O 3:1:4 Na_3PO_4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s-block
1
IA
1
1.00794
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−1
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KEY
Atomic Mass
Symbol
Atomic Number
Electron Configuration
12.0111
−4
+2
+4
C
6
1s²2s²2p²
Selected Oxidation States
Relative atomic masses are based on ¹²C = 12.00000
s-block
GROUP
1
IA
2
IIA
New Designation
Former Designation
(prior to 1984 IUPAC decision)
d-block
Transition Elements
GROUP
3
IIIB
4
IVB
5
VB
6
VIB
7
VIIB
8
9
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2
6.941
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+1
K
19
[Ar]4s¹
40.08
+2
Ca
20
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+3
Sc
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47.88
+2
+3
+4
Ti
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+4
+5
V
23
[Ar]3d³4s²
51.996
+2
+3
+6
Cr
24
[Ar]3d⁵4s¹
54.9380
+2
+3
+4
+7
Mn
25
[Ar]3d⁵4s²
55.847
+2
+3
Fe
26
[Ar]3d⁶4s²
58.9332
+2
+3
Co
27
[Ar]3d⁷4s²
58.69
+2
+3
Ni
28
[Ar]3d⁸4s²
63.54
29
5
85.4678
+1
Rb
37
[Kr]5s¹
87.62
+2
Sr
38
[Kr]5s²
88.9059
+3
Y
39
[Kr]4d¹5s²
91.224
+4
Zr
40
[Kr]4d²5s²
92.9064
+3
+5
Nb
41
[Kr]4d⁴5s¹
95.94
+3
+6
Mo
42
[Kr]4d⁵5s¹
(98)
+4
+6
+7
Tc
43
[Kr]4d⁵5s²
101.07
+3
Ru
44
[Kr]4d⁷5s¹
102.906
+3
Rh
45
[Kr]4d⁸5s¹
106.42
+2
+4
Pd
46
[Kr]4d¹⁰5s⁰
107.86
47
6
132.905
+1
Cs
55
[Xe]6s¹
137.33
+2
Ba
56
[Xe]6s²
La-Lu
57
71
178.49
+4
Hf
72
[Xe]4f¹⁴5d²6s²
180.948
+5
Ta
73
[Xe]4f¹⁴5d³6s²
183.85
+6
W
74
[Xe]4f¹⁴5d⁴6s²
186.207
+4
+6
+7
Re
75
[Xe]4f¹⁴5d⁵6s²
190.2
+3
+4
Os
76
[Xe]4f¹⁴5d⁶6s²
192.22
+3
+4
Ir
77
[Xe]4f¹⁴5d⁷6s²
195.08
+2
+4
Pt
78
[Xe]4f¹⁴5d⁹6s¹
196.96
79
7
(223)
+1
Fr
87
[Rn]7s¹
226.025
+2
Ra
88
[Rn]7s²
Ac-Lr
89
103
(261)
Unq*
104
(262)
Unp
105
(263)
Unh
106
(262)
Uns
107
Uno
108
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109
* The sys
103 wil

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lation States

s-block

p-block

GROUP

10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 0
								4.00260 0 **He** 2 $1s^2$
			10.81 +3 **B** 5 $1s^2 2s^2 2p^1$	12.0111 −4 +2 +4 **C** 6 $1s^2 2s^2 2p^2$	14.0067 −3 −2 −1 +1 +2 +3 +4 +5 **N** 7 $1s^2 2s^2 2p^3$	15.9994 −2 **O** 8 $1s^2 2s^2 2p^4$	18.998403 −1 **F** 9 $1s^2 2s^2 2p^5$	20.179 0 **Ne** 10 $1s^2 2s^2 2p^6$
			26.98154 +3 **Al** 13 [Ne]$3s^2 3p^1$	28.0855 −4 +2 +4 **Si** 14 [Ne]$3s^2 3p^2$	30.97376 −3 +3 +5 **P** 15 [Ne]$3s^2 3p^3$	32.06 −2 +4 +6 **S** 16 [Ne]$3s^2 3p^4$	35.453 −1 +1 +3 +5 +7 **Cl** 17 [Ne]$3s^2 3p^5$	39.948 0 **Ar** 18 [Ne]$3s^2 3p^6$
58.69 +2 +3 **Ni** 28 [Ar]$3d^8 4s^2$	63.546 +1 +2 **Cu** 29 [Ar]$3d^{10} 4s^1$	65.39 +2 **Zn** 30 [Ar]$3d^{10} 4s^2$	69.72 +3 **Ga** 31 [Ar]$3d^{10} 4s^2 4p^1$	72.59 −4 +2 +4 **Ge** 32 [Ar]$3d^{10} 4s^2 4p^2$	74.9216 −3 +3 +5 **As** 33 [Ar]$3d^{10} 4s^2 4p^3$	78.96 −2 +4 +6 **Se** 34 [Ar]$3d^{10} 4s^2 4p^4$	79.904 −1 +1 +5 **Br** 35 [Ar]$3d^{10} 4s^2 4p^5$	83.80 0 +2 **Kr** 36 [Ar]$3d^{10} 4s^2 4p^6$
106.42 +2 +4 **Pd** 46 [Kr]$4d^{10} 5s^0$	107.868 +1 **Ag** 47 [Kr]$4d^{10} 5s^1$	112.41 +2 **Cd** 48 [Kr]$4d^{10} 5s^2$	114.82 +3 **In** 49 [Kr]$4d^{10} 5s^2 5p^1$	118.71 +2 +4 **Sn** 50 [Kr]$4d^{10} 5s^2 5p^2$	121.75 −3 +3 +5 **Sb** 51 [Kr]$4d^{10} 5s^2 5p^3$	127.60 −2 +4 +6 **Te** 52 [Kr]$4d^{10} 5s^2 5p^4$	126.905 −1 +1 +5 +7 **I** 53 [Kr]$4d^{10} 5s^2 5p^5$	131.29 0 +2 +4 +6 **Xe** 54 [Kr]$4d^{10} 5s^2 5p^6$
195.08 +2 +4 **Pt** 78 [Xe]$4f^{14} 5d^9 6s^1$	196.967 +1 +3 **Au** 79 [Xe]$4f^{14} 5d^{10} 6s^1$	200.59 +1 +2 **Hg** 80 [Xe]$4f^{14} 5d^{10} 6s^2$	204.383 +1 +3 **Tl** 81 [Xe]$4f^{14} 5d^{10} 6s^2 6p^1$	207.2 +2 +4 **Pb** 82 [Xe]$4f^{14} 5d^{10} 6s^2 6p^2$	208.980 +3 +5 **Bi** 83 [Xe]$4f^{14} 5d^{10} 6s^2 6p^3$	(209) +2 +4 **Po** 84 [Xe]$4f^{14} 5d^{10} 6s^2 6p^4$	(210) **At** 85 [Xe]$4f^{14} 5d^{10} 6s^2 6p^5$	(222) 0 **Rn** 86 [Xe]$4f^{14} 5d^{10} 6s^2 6p^6$

Polyatomic Ions

Name	Formula	Name	Formula
perPhosphate	$(PO_5)^{-3}$	perCarbonate	$(CO_4)^{-2}$
Phosphate	$(PO_4)^{-3}$	**Carbonate**	$(CO_3)^{-2}$
Phosphite	$(PO_3)^{-3}$	Carbonite	$(CO_2)^{-2}$
hypoPhosphite	$(PO_2)^{-3}$	hypocarbonite	$(CO)^{-2}$
perChlorate	$(ClO_4)^{-1}$	perNitrate	$(NO_4)^{-}$
Chlorate	$(ClO_3)^{-1}$	**Nitrate**	$(NO_3)^{-}$
Chlorite	$(ClO_2)^{-1}$	Nitrite	$(NO_2)^{-}$
hypoChlorite	$(ClO)^{-1}$	Hyponitrite	$(NO)^{-}$
perSulfate	$(SO_5)^{-2}$	perChromate	$(CrO_5)^{-2}$
Sulfate	$(SO_4)^{-2}$	**Chromate**	$(CrO_4)^{-2}$
Sulfite	$(SO_3)^{-2}$	Chromite	$(CrO_3)^{-2}$
hyposulfite	$(SO_2)^{-2}$	Hypochromite	$(CrO_2)^{-2}$
Acetate	$(C_2H_3O_2)^{-1}$	**Cyanide**	$(CN)^{-1}$
Hydroxide	$(OH)^{-1}$	**Manganate**	$(MnO_4)^{-2}$

Ammonium
$(NH_4)^{+1}$