CHEMICAL FORMULA #2

Determining The Empirical Formula From Masses Of Elements –

1. Divide mass of each element by their respective relative atomic mass;
2. Divide each obtained value from Step 01 by the smallest one of all the above obtained values from Step 01. If the results are all whole numbers, they will be the subscripts in the formula. Otherwise, it will be needed to multiply by some factor.

Note: To find a whole-number factor to multiply all these results by 2 or 3 to obtain integers.

Determining The Empirical Formula From Percentage Composition –

1. Convert the percentages into numerical values;
2. Divide mass of each element by their respective relative atomic mass;
3. Divide each obtained value from Step 01 by the smallest one of all the above obtained values from Step 01. If the results are all whole numbers, they will be the subscripts in the formula. Otherwise, it will be needed to multiply by some factor.

Note: To find a whole-number factor to multiply all these results by 2 or 3 to obtain integers.

Question :
Find the empirical formula of the following compounds which contains:

a. 5.85 g K 2.10 g N 4.80 g O

	K	N	O
	5.85 g	2.10 g	4.80 g
STEP-1: g / mass / A_r	$\frac{5.85}{39}$ = 0.150	$\frac{2.10}{14}$ = 0.150	$\frac{4.80}{16}$ = 0.300
STEP-2: divide ALL values by SMALLEST one among them	$\frac{0.150}{0.150}$ = 1	$\frac{0.150}{0.150}$ = 1	$\frac{0.300}{0.150}$ = 2

∴ EMPIRICAL FORMULA is KNO_2

b. 3.22 g Na 4.48 g S 3.36 g O

Na	S	O
3.22 g	4.48 g	3.36 g
$\frac{3.22}{23}$	$\frac{4.48}{32}$	$\frac{3.36}{16}$
= 0.140	= 0.140	= 0.210
$\frac{0.140}{0.140}$	$\frac{0.140}{0.140}$	$\frac{0.210}{0.140}$
= 1 x 2	= 1 x 2	= 1.5 x 2
= 2	= 2	= 3

∴ EMPIRICAL FORMULA is $Na_2S_2O_3$.

c. 92.31 % C the rest is H (by mass)

C	H
92.31 %	100 − 92.31 = 7.69 %
$\frac{92.31}{100} \times 100$ = 92.31 g	$\frac{7.69}{100} \times 100$ = 7.69 g
$\frac{92.31}{12}$ = 7.693	$\frac{7.69}{1}$ = 7.690
$\frac{7.693}{7.690}$ = 1.00 ≈ 1	$\frac{7.690}{7.690}$ = 1

d)	40 % Ca	12 % C	48 % O	(by mass)
e)	29.1 % Na	40.5 % S	and the rest is Oxygen	(by mass)
f)	81.81 % C	and the rest is Hydrogen		(by mass)
g)	5.88 % H	94.12 % O		(by mass)
h)	27.27 % C	72.73 % O		(by mass)

d)

Ca	C	O
40·/.	12·/.	48·/.
$\frac{40}{100} \times 100$ = 40g	$\frac{12}{100} \times 100$ = 12g	$\frac{48}{100} \times 100$ = 48g
$\frac{40}{40}$ = 1.000	$\frac{12}{12}$ = 1.000	$\frac{48}{16}$ = 3.000
$\frac{1.000}{1.000}$ = 1	$\frac{1.000}{1.000}$ = 1	$\frac{3.000}{1.000}$ = 3

∴ EMPIRICAL FORMULA is $CaCO_3$

e)

Na	S	O
29.1·/.	40.5·/.	100 - 29.1 - 40.5 = 30.4·/.
$\frac{29.1}{100} \times 100$ = 29.1g	$\frac{40.5}{100} \times 100$ = 40.5g	$\frac{30.4}{100} \times 100$ = 30.4g
$\frac{29.1}{23}$ = 1.2652	$\frac{40.5}{32}$ 1.190625	$\frac{30.4}{16}$ = 1.9000

$= 1 \times 2$ $= 2$	$= 1.007$ $\approx 1 \times 2 = 2$	$= 1.512 \times 2$ $= 3.024 \approx 3$

∴ EMPIRICAL FORMULA is $Na_2S_2O_3$.

f)

C	H
81.81 %	100 − 81.81 = 18.19 %
$\frac{81.81}{100} \times 100$ = 81.81 g	$\frac{18.19}{100} \times 100$ = 18.1
$\frac{81.81}{12}$ = 6.8175	$\frac{18.19}{1}$ = 18.1900
$\frac{6.8175}{6.8175}$ $= 1 \times 3$ = 3	$\frac{18.1900}{6.8175}$ $= 2.668 \times 3$ $= 8.004 \simeq 8$

∴ Empirical formula is C_3H_8.

g)

H	O
5.88 %	94.12 %
$\frac{5.88}{100} \times 100$ = 5.88 g	$\frac{94.12}{100} \times 100$ = 94.12 g
$\frac{5.88}{1}$ = 5.880	$\frac{94.12}{16}$ = 5.883
$\frac{5.880}{5.880}$ = 1	$\frac{5.883}{5.880}$ = 1.0005 ≈ 1

∴ EMPIRICAL FORMULA is HO

h)

C	O
27.27 %	72.73 %
$\frac{27.27}{100} \times 100$ = 27.27 g.	$\frac{72.73}{100} \times 100$ = 72.73 g.
$\frac{27.27}{12}$	$\frac{72.73}{16}$

$\frac{27.27}{12}$ $= 2.2725$	$\frac{72.73}{16}$ $= 4.5456$
$\frac{2.2725}{2.2725}$ $= 1$	$\frac{4.5456}{2.2725}$ $= 2$

∴ EMPIRICAL FORMULA is CO_2.

Determining the Molecular Formula from Percentage Composition and Molecular Weight –

The molecular weight is some multiple of the empirical formula weight, which is obtained by summing the atomic weights of the atoms in the empirical formula. For any molecular compound, it can be written as

$$\text{Molecular weight} = n \times \text{Empirical formula weight}$$

$n \rightarrow$ the number of empirical formula units in the molecule

Once the empirical formula for a compound is determined, its empirical formula weight can be calculated. If its molecular weight is experimentally determined, n (the number of empirical formula units in the molecule) can be calculated and then the molecular formula.