

# EMPIRICAL FORMULA



Answer all the questions below and then check your answers.

1. A salt was analysed and found to contain 105.8g of sodium and 163.4g of chlorine. Find the empirical formula for this compound.

$A_r$  of sodium = 23     $A_r$  of chlorine = 35.5

2. A compound of phosphorus and oxygen contains 250g of phosphorus and 318g of oxygen. The  $M_r$  of the compound is known to be 284. Find the empirical and molecular formula of this oxide of phosphorus.



3. A compound was found to contain 4g of calcium, 1.2g of carbon and 4.8g of oxygen. The  $M_r$  of this compound is 100. Calculate the empirical and molecular formula of this compound.

4. Copper carbonate is a green substance found on copper pipes when they react with carbon dioxide in the air. Copper carbonate decomposes when heated to form copper oxide and carbon dioxide gas. 494g of copper carbonate was decomposed to form 318g of copper oxide. Write a balanced symbolic equation for this reaction using the masses given.

5. 34g of silver nitrate ( $\text{AgNO}_3$ ) underwent a displacement reaction with 2.4g of magnesium powder. This reaction produced 14.8g of magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2$ , and 21.6g of silver. Use the masses given to write a balanced symbolic equation for this reaction.

$A_r$  of silver = 108    $A_r$  of nitrogen = 14    $A_r$  of oxygen = 16    $A_r$  of magnesium = 24

6. A compound contains 40% sulfur and 60% oxygen. What is its empirical formula? What additional piece of information is needed to find its molecular formula?

7. Analysis of a compound showed that it contained 15% phosphorus and 85% chlorine. What is the empirical formula for this compound?

8. A compound with a  $M_r$  of 45 has the following % composition:

Carbon = 53.3%   hydrogen = 15.5%   nitrogen = 31.2%

What is the molecular formula for this compound?

$A_r$  of carbon = 12    $A_r$  of nitrogen = 14    $A_r$  of hydrogen = 1

## Answers

1. A salt was analysed and found to contain 105.8g of sodium and 163.4g of chlorine. Find the empirical formula.

$A_r$  of sodium = 23     $A_r$  of chlorine = 35.5

Elements present	sodium	chlorine
Mass/g	105.8g	163.4g
Divide by $A_r$	$105.8/23=4.6$	$163.4/35.5=4.6$
Divide by smallest number, in this case 4.6	1	1
Empirical formula	NaCl	

2. A compound of phosphorus and oxygen contains 250g of phosphorus and 318g of oxygen. The  $M_r$  of the compound is known to be 284. Find the empirical and molecular formula of this oxide of phosphorus.

$A_r$  of phosphorus = 31     $A_r$  of oxygen = 16

Elements present	phosphorus	oxygen
Mass/g	250	318
Divide by $A_r$	$250/31=8.06$	$318/16=19.875$
Divide by smallest number, in this case 8.06	1	2.46 (round to 2.5)
Empirical formula	$PO_{2.5}$ Double up to remove the 2.5, this gives the empirical formula: $P_2O_5$	

$P_2O_5$  has an  $M_r$  of 142. However  $M_r$  of compound is 284, that is  $284/142 = 2$ , double the  $M_r$  of the empirical formula, so its molecular formula is  $P_4O_{10}$

3. A compound was found to contain 4g of calcium, 1.2g of carbon and 4.8g of oxygen. The  $M_r$  of this compound is 100. Calculate the empirical and molecular formula of this compound.

Elements present	calcium	carbon	oxygen
Mass/g	4g	1.2g	4.8g
Divide by $A_r$	$4/40=0.1$ moles	$1.2/12=0.1$ moles	$4.8/16=0.3$
Divide by smallest number, in this case 0.1	1	1	3
Empirical formula	$CaCO_3$		

The Molecular formula and empirical formula are both the same, the compound is a  $CaCO_3$  is  $M_r = 100$

4. Copper carbonate is a green substance found on copper pipes when they react with carbon dioxide in the air. Copper carbonate decomposes when heated to form copper oxide and carbon dioxide gas. 494g of copper carbonate was decomposed to form 318g of copper oxide.

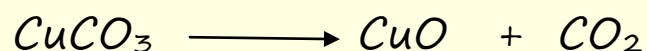
a. Calculate the mass of carbon dioxide gas released.

Mass of reactants and products must be the same.  $494 - 318 = 176$ g of  $CO_2$

b. Write balanced symbolic equation for this reaction using the masses given.

Substances present	Copper carbonate	Copper oxide	Carbon dioxide
Mass/g	494g	318g	176g
Divide by $M_r$	$494/123.5=4$	$318/79.5 = 4$	$176/44=4$
Divide by smallest, in this case 4	1	1	1

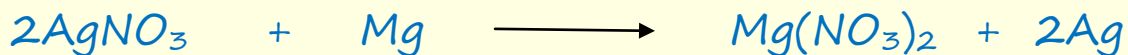
In this case we have 1 mole of each of the reactants and products. So equation is simply:



5. 34g of silver nitrate ( $\text{AgNO}_3$ ) underwent a displacement reaction with 2.4g of magnesium powder. This reaction produced 14.8g of magnesium nitrate,  $\text{Mg}(\text{NO}_3)_2$ , and 21.6g of silver. Use the masses given to write a balanced symbolic equation for this reaction.

Substances present	Silver nitrate $\text{AgNO}_3$	magnesium	Magnesium nitrate $\text{Mg}(\text{NO}_3)_2$	silver
Mass/g	34g	2.4g	14.8	21.6
Divide by $M_r$ / $A_r$	$34/170=0.2$	$2.4/24=0.1$	$14.8/148=0.1$	$21.6/106=0.2$
Divide by smallest number, in this case 0.1	2	1	1	2

This give



6. A compound contains 40% sulfur and 60% oxygen. What is its empirical formula? What additional piece of information is needed to find its molecular formula?

$A_r$  of sulfur = 32    $A_r$  of oxygen = 16

If you are given the composition as a % then to convert to masses simply assume you have 100g of the substance, then the % will be the same as masses - simple!

Elements present	sulfur	oxygen
Mass/g	40	60
Divide by $A_r$	$40/32 =$ 1.25	$60/16 =$ 3.75
Divide by smallest number, in this case 0.1	$1.25/1.25 =$ 1	$3.75/1.25 =$ 3
Empirical formula	$\text{SO}_3$	

So the empirical formula is  $\text{SO}_3$ . To find its actual molecular formula we would need to know the  $M_r$  of the compound.

7. Analysis of a compound showed that it contained 15% phosphorus and 85% chlorine. What is the empirical formula for this compound?

$A_r$  of phosphorus = 31     $A_r$  of chlorine = 35.5

Elements present	phosphorus	chlorine
Mass/g	15	85
Divide by $A_r$	$15/31 =$ 0.48	$85/35.5 =$ 2.39
Divide by smallest number, in this case 0.1	$0.48/0.48 =$ 1	$2.39/0.48 =$ 5
Empirical formula	PCl <sub>5</sub>	

8. A compound with a  $M_r$  of 45 has the following % composition:

Carbon = 53.3%      hydrogen = 15.5%      nitrogen = 31.2%

What is the molecular formula for this compound?

$A_r$  of carbon = 12     $A_r$  of nitrogen = 14     $A_r$  of hydrogen = 1

Elements present	carbon	hydrogen	nitrogen
Mass/g	53.3	15.5	31.2
Divide by $A_r$	$53.3/12 = 4.44$	$15.5/1 = 15.5$	$31.2/14 = 2.22$
Divide by smallest number, in this case 2.22	2	7	1
Empirical formula	C <sub>2</sub> H <sub>7</sub> N		

So empirical formula is C<sub>2</sub>H<sub>7</sub>N. The  $M_r$  of this is 45. So the empirical formula is the same as the molecular formula.