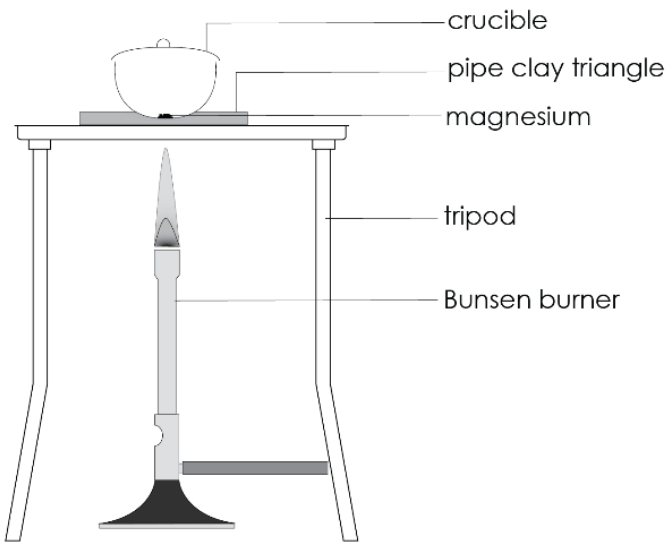
Amount of substance in moles

Scientists can use analytical techniques such as combustion analysis to determine the empirical formula of a compound. During combustion analysis, a sample of a substance is burned in excess oxygen and the mass of the oxide produced is measured.

To determine the empirical formula of magnesium oxide, a piece of magnesium ribbon is placed in a crucible and exposed to oxygen. A combustion reaction occurs and magnesium oxide is produced.



The empirical formula of the magnesium oxide produced can be worked out using the masses of magnesium and oxygen used.

1. Finding the empirical formula of a compound is important because, in combination with other information such as the compound's molar mass, it allows scientists to determine the actual molecular formula of a compound and make predictions about its properties.

(a) Define the term empirical formula.

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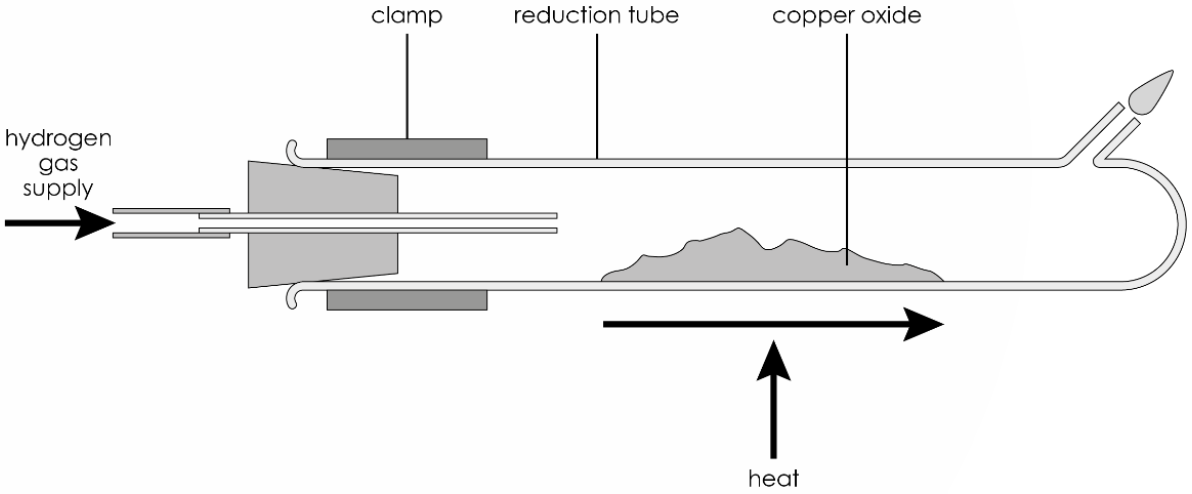
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(b) Write the empirical formula for each of the molecular formulas in the table. For some compounds, the empirical and molecular formulas are identical.

Molecular formula	Empirical formula
Fe_2O_3	
P_4O_{10}	
Na_2O	
$C_8H_{20}S_2$	
$C_6H_{12}O_6$	

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2. In an experiment used to determine the empirical formula of a sample of copper oxide, the copper oxide was heated strongly inside a tube while hydrogen gas was passed over the top. The hydrogen reacted with the oxygen from the metal oxide to produce water vapour and the copper remained in the crucible.



The initial mass of the copper oxide used was 2.72 g and final mass of the copper was 2.42 g.

(a) Calculate the mass of oxygen lost from the copper oxide.

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(b) Use your answer to **part (a)** and the information provided above to complete the steps in the table below to work out the empirical formula of the copper oxide formed in this experiment.

	Copper	Oxygen
Mass		
Number of moles $= \frac{\text{mass of substance}}{\text{molar mass of substance}}$		
Divide each number of moles by the smallest number to find the reacting ratio		
Whole number ratio of moles		
Empirical formula of copper oxide:		

(c) Use your answer to **part (b)** to write a balanced symbol equation for the reaction between copper oxide and hydrogen gas to produce copper and water.

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3. Nitrogen oxides have the general formula (N_xO_y) where the values of x and y can vary. Some common nitrogen oxides include nitrogen monoxide (NO), nitrogen dioxide (NO_2) and nitrous oxide (N_2O).

(a) Write the balanced symbol equation for the formation of nitrogen monoxide from nitrogen gas (N_2) and oxygen gas (O_2).

(b) Calculate the number of moles of nitrogen monoxide gas in a volume of 2 dm^3. You should assume that all gases have a molar volume of 24 dm^3.

(c) Use your answers to **parts (a)** and **(b)** to show that 1 dm^3 of nitrogen gas is needed to produce 2 dm^3 of nitrogen monoxide.

Combustion analysis of a sample of a nitrogen oxide showed that it had an empirical formula of NO_2.

Further analysis of the sample showed that the molar mass of the nitrogen oxide was 92 g/mol.

(d) Use this information to determine the molecular formula of this nitrogen oxide.

A sample of a different nitrogen oxide is analysed and found to have been made from 5.0 g of nitrogen and 14.3 g of oxygen.

(e) Work out the empirical formula of this nitrogen oxide.
Hint: Remember the steps used in ***question 2 part (b)***.

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4. Blue hydrated copper(II) sulfate crystals contain water of crystallisation. The formula for hydrated copper(II) sulfate is $CuSO_4.xH_2O$, where the value of x can vary. For example, $CuSO_4.5H_2O$ contains five molecules of water of crystallisation.
The value of x can be determined by heating the hydrated copper(II) sulfate crystals to remove the water of crystallisation, producing white anhydrous copper(II) sulfate in a process called dehydration.
In one experiment, 5.00 g of a sample of hydrated copper(II) sulfate crystals were heated until the mass of the anhydrous copper(II) sulfate left was constant at 2.80 g.

(a) Calculate the mass of water produced from the hydrated copper(II) sulfate crystals.

(b) Work out the value of x in $CuSO_4.xH_2O$ for this sample of hydrated copper(II) sulfate.
The molar masses are: $CuSO_4$ $A_r = 159.5$ H_2O $A_r = 18.0$
Hint: Use the steps from ***question 2****.*

Which question(s) did you get wrong? Why?

What will you do next time you're asked a similar question?

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