

Moles Notes

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What is a mole?

A mole: of particles contains the same number of particles as there are atoms in exactly 12 g of carbon 12.

This number is 6.02×10^{23} and is called **Avogadro's Number** or **Avogadro's constant**.

So, a mole tells us the exact number of atoms, ions or particles that we are working with in an experiment. It's a very accurate way of working with masses. Moles in chemistry have nothing to do with moles the animals 😊

Important note: if you are confident in finding the molecular mass (M_r), also known as the relative formula mass, for a substance then please do continue through this section. If you're not confident with this then **please stop here**. Go back and practise this until you are very confident with calculating M_r .

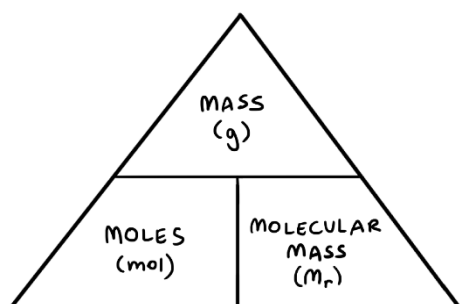
The mass of 1 mole of a substance is equal to its Relative Mass in grams.

What this means is that if you have 14 g of nitrogen atoms you would have 1 mole of nitrogen atoms.

23 g of sodium atoms = 1 mole of sodium atoms.

71 g of chlorine gas (Cl_2) = 1 mole of Chlorine gas.

How do we calculate moles? We use the following formula. Be aware of how to rearrange the formula to find each element within it.



$$\text{mass} = \text{moles} \times \text{molecular mass}$$

$$g = \text{mol} \times m_r$$

$$\text{moles} = \frac{\text{mass}}{\text{molecular mass}}$$

Example 1: What is the mass of 0.75 moles of carbon?

$$\text{Mass} = \text{mol} \times M_r$$

$$\text{Mass} = 0.75 \times 12$$

$$\text{Mass} = 9 \text{ g}$$

Example 2: How many moles of carbon are there in 10g?

$$\text{Moles} = \text{mass} \div M_r$$

$$\text{Moles} = 10 \div 12$$

$$\text{Moles} = 0.833 \text{ mol}$$

Have a go 😊 Find the number of moles of the following masses. Give your answers to 3 significant figures. Show all working.

1. 48g of Li.

Mol:

2. 97g of H_2O .

Mol:

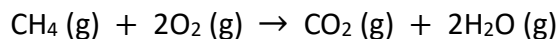
3. 240g of Na_2SO_4

Mol:

Answers: 1. = 6.86 2. = 5.38 3. = 1.69

Equations and Moles

A balanced chemical equation tells us about the number of moles reacting and being produced.
For example, in the combustion of methane below:



This equation tells us that **1 mole of methane** reacts **with 2 moles of oxygen** to give **1 mole of carbon dioxide** and **2 moles of water** vapour. The numbers are moles 😊

Exam questions involving moles and equations are typically carried out in **four** steps:

Step 1: Write a balanced equation for the reaction.

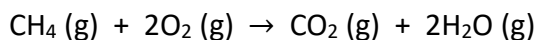
Step 2: Convert mass into moles.

Step 3: Use the equation to find the ratio of moles.

Step 4: Convert moles into a mass.

Example 1: What mass of water vapour is formed when 3.2 g of methane burns in oxygen?

Step 1: Write a balanced equation for the reaction. You may have to balance the equation, though the majority of questions are already balanced.



Step 2: Convert mass into moles.

$$\text{Moles of CH}_4 = \text{mass} \div \text{Mr}$$

$$\text{Moles of CH}_4 = 3.2 \div 16$$

$$\text{Moles of CH}_4 = 0.2 \text{ mol}$$

Step 3: Use the equation to find the ratio of moles.

From the equation above we can see that 1 mole of methane gives 2 moles of water vapour.

So the ratio is 1 : 2.

So, 0.2 mol of methane gives 0.4 mol of water vapour.

Step 4: Convert moles into mass.

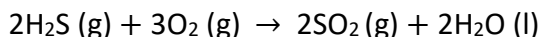
$$\text{Mass of H}_2\text{O} = \text{mol} \times \text{Mr}$$

$$\text{Mass of H}_2\text{O} = 0.4 \times 18$$

$$\text{Mass of H}_2\text{O} = 7.2 \text{ g}$$

Example 2: Hydrogen sulfide reacts with oxygen gas to produce sulfur dioxide and water. What mass of sulfur dioxide can be made from 80 g of oxygen gas?

Step 1: Write a balanced equation for the reaction.



Step 2: Convert mass into moles.

$$\text{The Mr of O}_2 = 2 \times 16 = 32$$

$$\text{Moles of O}_2 = \text{mass} \div \text{Mr}$$

$$\text{Moles of O}_2 = 80 \div 32$$

$$\text{Moles of O}_2 = 2.5 \text{ mol}$$

Step 3: Use the equation to find the ratio of moles.

From the equation we can see that 3 moles of O₂ gives 2 moles of SO₂.

$$2.5 \div 3 \times 2 = 1.666 \text{ mols of SO}_2.$$

Step 4: Convert moles into mass.

$$\text{The Mr of SO}_2 = 32 + 2(16) = 64$$

$$\text{Mass of SO}_2 = \text{mol} \times \text{Mr}$$

$$\text{Mass of SO}_2 = 1.666 \times 64$$

$$\text{Mass of SO}_2 = 106.67 \text{ g}$$

Limiting reactants

This scares quite a few students each year, but it's very straightforward. Let's put it like this...

Let's say you were baking a cake. You have 1000 g of flour, 50 eggs and 10 litres of milk. To make one cake we need to use 500 g of flour, 5 eggs and 2 litres of milk. How many cakes can we make?

Yes, we can make a maximum of 2 cakes. What was the thing that prevented us from making more? What reactant **limits us from making more product** 😊 Yes! It's the flour! We have more than enough eggs and milk to make more cakes but we will run out of flour after 2 cakes. So the flour is the limiting reactant in this example 😊

Limiting reactants: are reactants that get fully used up in a reaction so it **limits** the amount of product(s) which can be made.

What effect do limiting reactants have on the reaction? The limiting reactant limits how much product is formed.

Can we tell which reactant is the limiting reactant from the question? Depending on the question, yes 😊, if one reactant is described as being in excess, then this one is not the limiting reactant.

In excess: means that there is more of that reactant than you need to do the practical.

Questions on limiting reactants look and work very much like standard mole calculation questions. Let's look at some examples of questions involving limiting reactants.

Example 3: In a chemical reaction, 4 moles of reactant A react with 3 moles of reactant B to produce product C. If you start with 6 moles of A and 5 moles of B, which reactant is the limiting reactant?
Circle the letter of the correct answer.

A

Reactant A

B

Reactant B

C

Reactants A and B

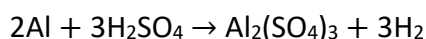
D

Neither A or B

Correct answer: A is the correct answer.

Explanation: we notice the ratio from the question is 1 : 0.75 so 6 moles of reactant A would need 4.5 moles of reactant B to fully react. We have 5 mols of reactant B so it is in excess and reactant A is the limiting factor.

Example 4: A student reacts 25 grams of aluminium with 50 grams of sulfuric acid.
The equation for the reaction is:



a. Calculate the number of moles of aluminium used in the reaction.

$$\text{Moles of Al} = \text{mass} \div \text{Mr}$$

$$\text{Moles of Al} = 25 \div 27 = 0.925 \text{ mols}$$

b. Calculate the number of moles of sulfuric acid used in the reaction.

$$\text{Moles of H}_2\text{SO}_4 = \text{mass} \div \text{Mr}$$

$$\text{Moles of H}_2\text{SO}_4 = 50 \div 98$$

$$\text{Moles of H}_2\text{SO}_4 = 0.510 \text{ mols}$$

c. Determine the limiting reactant in this reaction and give a reason for your answer.

We have 0.925 mols of Al. How many mols of H₂SO₄ will this react with?

Ratio of number of moles of aluminium to sulfuric acid is 2 : 3

$$\text{Moles of H}_2\text{SO}_4 \text{ that would be need to fully react with the Al} = (0.925 \div 2) \times 3$$

$$\text{Moles of H}_2\text{SO}_4 \text{ that would be need to fully react with the Al} = 1.3875 \text{ mols}$$

There is only 0.510 mol of H₂SO₄ present and we would need 1.3875 mols. So H₂SO₄ is the limiting reactant.

Moles and Gases

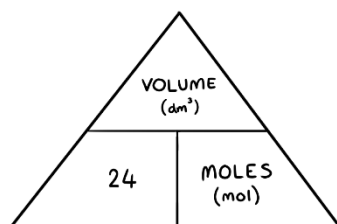
Questions on moles with gases come up here and there in exam papers. They are lovely, quick questions to get 😊 just learn the rule and the equation and you'll be fully set for questions on these.

The rule: one mole of any gas occupies a volume of **24 decimetres cubed (dm³)** or **24,000 centimetres cubed (cm³)** at room temperature and pressure.

1 decimetre cubed is equal to 1000 centimetres cubed

$$1 \text{ dm}^3 = 1000 \text{ cm}^3$$

The Equation



$$\text{moles} = \frac{\text{volume (dm}^3\text{)}}{24}$$

$$\text{volume (dm}^3\text{)} = \text{moles} \times 24$$

Let's look at a few examples 😊

Example 5: Find the number of moles of the following gases (measured at room temperature and pressure).

1. 72 dm³ of oxygen (O₂). Moles = $\frac{\text{volume (dm}^3\text{)}}{24} = \frac{72}{24} = 3 \text{ moles}$

2. 12 dm³ of hydrogen (H₂) Moles = $\frac{\text{volume (dm}^3\text{)}}{24} = \frac{12}{24} = 0.5 \text{ moles}$

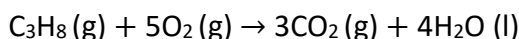
Example 6: Find the volume of the following gases (measured at room temperature and pressure).

1. 6 moles of nitrogen gas (N₂). $\text{volume (dm}^3\text{)} = 6 \times 24 = 144 \text{ dm}^3$

2. 0.75 moles of ethane (C₂H₆). $\text{volume (dm}^3\text{)} = 0.75 \times 24 = 18 \text{ dm}^3$

Example 7: Find the mass of carbon dioxide formed when 750 cm³ of propane reacts completely with oxygen.

The equation for the reaction is given below.



Stage 1: find the number of moles of propane and use this to find the moles of CO₂.

But first we must convert the cm³ to dm³. We do this by dividing 750 by 1000.

$$\text{Moles} = \frac{\text{volume (dm}^3\text{)}}{24} = \frac{0.750}{24} = 0.03125 \text{ moles}$$

The moles of propane are 0.03125

The ratio of C₃H₈ to CO₂ is 1 : 3

We must multiply 0.03125 by 3 to find the moles of CO₂.

$$\text{Moles of CO}_2 = 0.03125 \times 3$$

$$\text{Moles of CO}_2 = 0.09375 \text{ mols}$$

Stage 2: use the mole equation to find the mass from the moles.

$$\text{Mass} = \text{mol} \times \text{Mr}$$

$$\text{Mass} = 0.09375 \times 44$$

$$\text{Mass} = 4.125 \text{ g}$$

The mass of CO₂ formed is **4.125 g**

