THE MOLE NOTES

Science Exams Sorted

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The Mole Notes

If you were baking then you could measure the amount of flour, for example, in grams. In chemistry we also measure the amount of a substance in grams. The amount of substance could also be measured by counting the actual number of atoms, ions or molecules that are present in a substance. This would be a more accurate way of knowing exactly what number of particles that we are working with.

What is a mole?

A mole**:** of particles contains the same number of particles as there are atoms in exactly 12g of carbon 12. This number is 6.02×10^{23} and is called Avogadro's Number or Avogadro's constant.

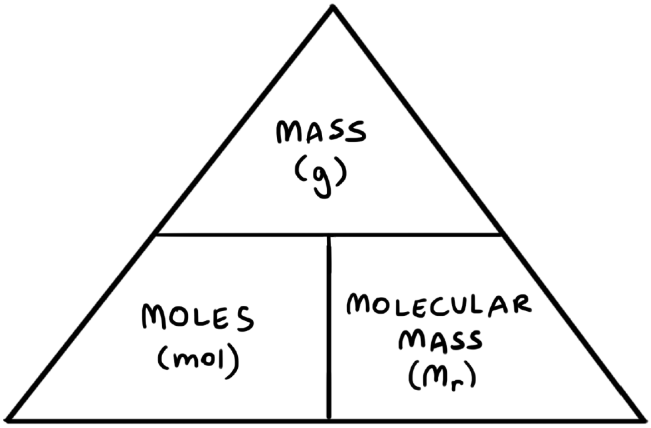
The mass of 1 mole of a substance is equal to its Relative Mass in grams.

E.g. 1. 1 mole of nitrogen atoms (N) = 14g of Nitrogen atoms.

E.g. 2. 1 mole of sodium atoms (Na) = 23g of Sodium atoms.

E.g. 3. 1 mole of Chlorine gas (Cl_2) = 71g of Chlorine gas.

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



Useful rearrangements 😊

$$mass = moles \times molecular\ mass$$

$$g = mol \times mr$$

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

Example 1:

What is the mass of 0.75 moles of carbon?

1 mole = 12g

Mass = mol × Mr

Mass = 0.75 x 12

Mass = 9g

Example 2:

How many moles of carbon are there in 10g?

12g contains 1 mole (as the Ar C = 12)

1g contains $^{1}/_{12}$mol

10g contains $^{10}/_{12}$ mol = 0.833 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: ..... **(1)**

2. 75g of C

Mol: ..... **(1)**

3. 97g of H_2O

Mol: ..... **(1)**

4. 56g of H_2

Mol: ..... **(1)**

5. 150g of NaCl

Mol: ..... **(1)**

6. 180g of $FeCl_2$

Mol: ..... **(1)**

7. 240g of Na_2SO_4

Mol: ..... **(1)**

8. 210g of $C_6H_{12}O_6$

Mol: ..... **(1)**

Total: ..... **/ 8**

Answers: 1 = 6.86 2 = 6.25 3 = 5.38 4 = 28 5 = 2.56 6 = 1.42 7 = 1.69 8 = 1.16

Equations and Moles

A balanced chemical equation tells us about the number of moles reacting and being produced.

For example, the combustion of methane:

$$CH_4\,(g) + \mathbf{2}O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}H_2O\,(g)$$

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.

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 3.2g of methane burns?

Step 1: Write a balanced equation for the reaction.

$$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$$

3.2g **?**

Step 2: Convert mass into moles.

16g of methane =1 mole (as Mr $CH_4 = 12 + 4 \times 1 = 16$)

So, 1g of methane $= {}^{1}/_{16}\ mol$

So, 3.2g of methane is ${}^{3.2}/_{16} = 0.2\ mol$

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

Now 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.

The Mr of water $= 18g$ (as Mr $H_2O = 1 \times 2 + 16$)

Mass $= \boldsymbol{mol} \times$ **Mr** Mass = 0.4×18 **Mass = 7.2g**

Example 2: What mass of salt is produced when 50g of sodium carbonate completely reacts with hydrochloric acid?

Step 1: Write a <u>balanced</u> equation for the reaction.

$$Na_2CO_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + CO_2\ (g) + H_2O\ (l)$$

50g ?

Step 2: Convert mass into moles

$$\text{The Mr of } Na_2CO_3 = 2 \times 23 + 12 + 3 \times 16 = 106$$

$$106g = 1 \text{ mole of } Na_2CO_3$$

$$1g = {}^{1}/_{106}\ mol \text{ of } Na_2CO_3$$

$$50g = {}^{50}/_{106}\ mol = 0.472\ mol \text{ of } Na_2CO_3$$

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

From the equation we can see that 1 mole of Na_2CO_3 gives 2 moles of NaCl.

$$\text{So, } 0.472\ mol \text{ of } Na_2CO_3 \text{ gives } 2 \times 0.472 = 0.943\ mol \text{ NaCl}$$

So, now we know the number of moles of NaCl all we need is to calculate its Mr.

Then we can use the equation, **Mass** $= \boldsymbol{mol} \times$ **Mr.**

Step 4: Convert moles into mass.

$$\text{The Mr of NaCl} = 23 + 35.5 = 58.5$$

$$\text{So, 1 mole of NaCl} = 58.5g$$

$$\textbf{Mass} = \boldsymbol{mol} \times \textbf{Mr}$$

$$\text{Mass} = 0.943 \times 58.5$$

$$\textbf{Mass} = \textbf{55.2g}$$

Exam note:

Whenever you are carrying out a calculation of this type you should work through these four steps and make sure you lay out your work clearly, showing what you are doing at each stage.

Moles and Gases

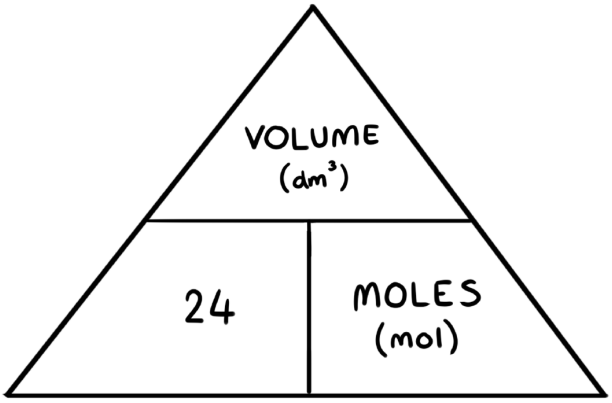
Questions on moles with gases come up here and there in exam papers. They are lovely, quick questions to get 😊 just learn the equation and be able to rearrange it and you'll be fully set for questions on these.

The rule: One mole of any gas occupies a volume of **24 decimetres cubed** (dm^3) or **24,000 centimetres cubed** (cm^3) at room temperature and pressure.

1 decimetre cubed is equal to 1000 centimetres cubed

$1dm^3 = 1000\ cm^3$

The Equation



Useful rearrangements 😊

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

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

Examples

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

1. 72 dm^3 of oxygen (O_2).

$$\text{Moles} = \frac{volume\ (dm^3)}{24} = \frac{72}{24} = 3 \text{ moles}$$

2. 12 dm^3 of hydrogen (H_2)

$$\text{Moles} = \frac{volume\ (dm^3)}{24} = \frac{12}{24} = 0.5 \text{ moles}$$

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

1. 6 moles of nitrogen gas (N_2).

$$volume\ (dm^3) = 6\ \times 24 = 144 \text{ dm}^3$$

2. 0.75 moles of ethane (C_2H_6).

$$volume\ (dm^3) = 0.75\ \times 24 = 18 \text{ dm}^3$$

Questions involving gases and masses

You could see a question that has both a gas calculation and a mole calculation in it. They are nice and straight forward there's just an extra step in them. The question might ask:

"Q. Find the mass of carbon dioxide formed when 750 cm^3 of propane reacts completely with oxygen."

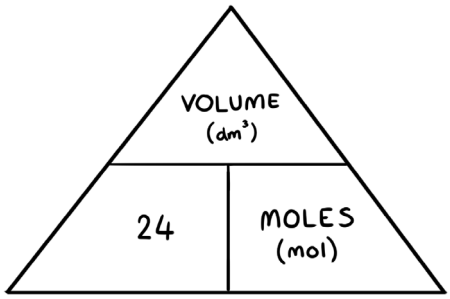
$$C_3H_8\,(g) + 5O_2\,(g) \longrightarrow 3CO_2\,(g) + 4H_2O\,(l)$$

In order to answer this question, we must first use the gas equation to find the number of moles of CO_2 produced. We must then use the mole equation to find the mass from the moles 😊

Stage 1: find the number of moles of CO_2.

But first we must convert the cm^3 to dm^3. We do this by dividing 750 by 1000.

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



The moles of propane are 0.03125

The ratio of C_3H_8 to CO_2 is 1 : 3

We must multiply 0.03125 by 3 to find the moles of CO_2.

$$\text{Moles of } CO_2 = 0.03125 \times 3$$

$$\text{Moles of } CO_2 = 0.09375 \text{ mols}$$

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

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

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

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

The mass of CO_2 formed is 4.125 g