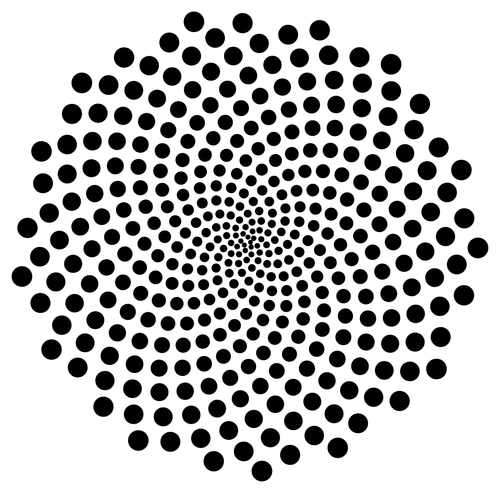
Calculations Booklet

For GCSE Chemistry



**HIGHER TIER**

Name:

Class:

Teacher:

Relative Atomic Mass (Ar)

1. Find the atomic mass of these element using a periodic table

|  |  |  |
| --- | --- | --- |
| **Element** | **Symbol** | **Relative atomic mass**   1. What do we mean by relative atomic mass?   First let’s look at the atomic structure of some atoms:  Lithium : p=\_\_ n=\_\_ e=\_\_  Nitrogen : p=\_\_ n=\_\_ e=\_\_  Chlorine : p=\_\_ n=\_\_ e=\_\_  How can we have half a neutron?? |
| Sodium | Na | 23 |
| Oxygen |  |  |
| Magnesium |  |  |
| Sulphur |  |  |
| Calcium |  |  |
| Chlorine |  |  |
| Aluminium |  |  |
| Hydrogen |  |  |
| Potassium |  |  |
| Nitrogen |  |  |

# Isotopes

**This is a rhetorical question!!**

1. Describe the atomic structure of these atoms:

Cl

**37**

**17**

Cl

**35**

**17**

p=\_\_ n=\_\_ e=\_\_ p=\_\_ n=\_\_ e=\_\_

These are both atoms of chlorine. There are called **isotopes**.

1. What is different about them? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. What is the same? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Chlorine is made of a mixture of both these isotopes.

1. What would the mean atomic mass of chlorine be? \_\_\_\_

**That’s still not 35.5. Can you think of why we still don’t have the correct value?**

**The relative atomic mass (shortened to Ar) is a w\_\_\_\_\_\_\_\_\_\_\_ average of the mass of all the atoms of an element compared to carbon -12.**

1. If there are 3 atoms of chlorine-35 and 1 of chlorine-37.

What would the mean atomic mass of chlorine be then? \_\_\_\_

**Carbon - 12 – all atomic masses are compared to the mass of carbon-12 as this can be measured extremely accurately. It has a mass of 12, so a hydrogen atom weighs 1/12 the mass of carbon-12, its mass is said to be 1.**

1. What would the mass of an atom that is double the mass of carbon -12? \_\_\_\_\_

Relative formula mass (Mr)

1. Write the formula of this molecule:
2. What is the relative atomic mass of one oxygen atom? \_\_\_\_
3. What would the mass of two oxygen atoms be? \_\_\_\_
4. What is the mass of the carbon atom? \_\_\_\_
5. Calculate the total mass of one carbon atom and two oxygen atoms: \_\_\_\_

This is called the **relative formula mass** (or Mr for short)

1. Write the formula of this molecule:
2. What is the mass of one oxygen atom? \_\_\_\_
3. What is the mass of three oxygen atoms? \_\_\_\_
4. What is the mass of the sulfur atom? \_\_\_\_
5. Calculate the total mass of one sulfur and three oxygen atoms \_\_\_\_
6. Now calculate the **relative formula masses** (called **Mr** for short) of these molecules:

**HF \_\_\_\_ NH3 \_\_\_\_**

**CH4 \_\_\_\_ CH2O \_\_\_\_**

**N2H4 \_\_\_\_ C2H5OH \_\_\_\_**

**Mg(OH)2 \_\_\_\_ C6H12O6 \_\_\_\_**

Mr and Equations

1. This equation shows the reaction between methanol and hydrogen fluoride:

**CH4O + HF****→ CH3F + H2O**

1. Count the **number** of each type of atom in the reactants:

**C \_\_**

**H \_\_**

**O \_\_**

**F \_\_**

1. Count the **number** of each type of atom in the products:

**C \_\_**

**H \_\_**

**O \_\_**

**F \_\_**

In a balanced equation, the number of each type of atom is **the same** in the reactants and the products.

1. This equation shows the thermal decomposition of calcium carbonate:

**CaCO3****→ CaO + CO2**

**Formula masses of products:**

Mr of **CaO \_\_\_**

Mr of  **CO2 \_\_\_**

**Total of the formula masses \_\_\_\_\_\_\_\_**

**Formula masses of reactants:**

Mr of **CaCO3 \_\_\_**

**Total of the formula masses \_\_\_\_\_\_\_\_**

**Formula masses of products:**

Mr of **CH3F \_\_\_**

Mr of  **H2O \_\_\_**

**Total of the formula masses \_\_\_\_\_\_\_\_**

**Formula masses of reactants:**

Mr of **CH4O \_\_\_**

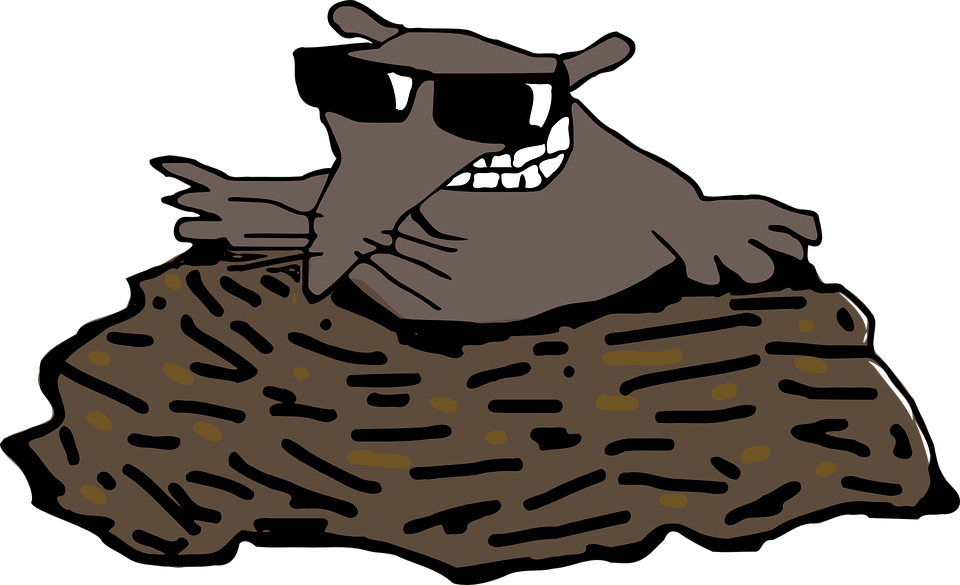
Mr of H**F \_\_\_**

**Total of the formula masses \_\_\_\_\_\_\_\_**

Moles (HT)

1. To calculate the relative formula mass of compound (Mr) add up the relative atomic mass of each atom in the compound.

# Moles



E.g. one mole of NaOH has a mass of 40g.

The quantity of a substance that is equal to its Mr is called a **mole.**

|  |  |
| --- | --- |
| **Compound** | **Relative formula mass** |
| NaOH | 23 + 16 +1 = 40 |
| KNO3 |  |
| SO2 |  |
| CaSO4 |  |
| MgCO3 |  |
| CuCO3 |  |
| HNO3 |  |
| Ca(OH)2 |  |
| Na2CO3 |  |
| H2SO4 |  |

One mole of any substance contains the same number of atoms, molecules or ions.

This number is called **Avogadro’s Number** and it equals \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Chemists often use a unit of measurement called a ‘mole’ to describe the amount they have of a substance. **Circle** the correct description of a mole.

The number of atoms in a molecule

The relative formula mass in grams

The number of atoms in 100g of a substance

1. Calculate the mass of one mole of:

CO2 \_\_\_\_ HCl \_\_\_\_ CaCO3 \_\_\_\_\_

C2H8 \_\_\_\_ Ba(OH)2 \_\_\_\_ C2H4O2 \_\_\_\_\_

1. Calculate the mass of the following:

2 moles of CO2 \_\_\_\_\_\_\_\_\_\_\_

The formula for calculating mass:

**Mass = Mr x No. of moles**

2 moles of HCl \_\_\_\_\_\_\_\_\_\_\_

0.5 moles of CaCO3 \_\_\_\_\_\_\_\_\_\_\_

2.5 moles of Ba(OH)2 \_\_\_\_\_\_\_\_\_\_\_

1.5 moles of C2H4O2 \_\_\_\_\_\_\_\_\_\_\_

More moles calculations (HT)

A **mole** of any substance always contains same number of particles. One mole of any substance is the relative atomic (or formula) mass of that substance in grams.

Write the equation to calculate the mass of substance from the number of moles

**m =**

Write the equation to calculate the number of moles from the mass of substance

**n =**

# Calculating the number of moles from the mass

1. What is the Mr of CH4? \_\_\_\_\_\_\_

Calculate the number of moles of CH4 in 48g \_\_\_\_\_\_\_

1. Calculate the number of moles of H2O in 90g \_\_\_\_\_\_\_
2. Calculate the number of moles of H2 in 40g \_\_\_\_\_\_\_
3. Calculate the number of moles of NH3 in 34g \_\_\_\_\_\_\_
4. Calculate the number of moles of H2SO4 in 9.8g \_\_\_\_\_\_\_
5. Calculate the number of moles of Ca(OH)2 in 37g \_\_\_\_\_\_\_

Complete this table:

|  |  |  |  |
| --- | --- | --- | --- |
| **Substance** | **Ar/Mr** | **No. of moles** | **Mass (g)** |
| Sodium |  | 1 |  |
| Magnesium |  |  | 24 |
| Barium |  | 0.1 |  |
| Chromium |  | 0.2 |  |
| Tin |  |  | 11.9 |
| HNO3 |  | 1 |  |
| CuO |  | 2 |  |
| O2 |  |  | 64 |
| H2O |  |  | 9 |
| C2H6 |  | 20 |  |

Equations

# Balancing Equations

Mg + HCl → MgCl2 + H2

H2 + O2 → H2O

NaOH + H2SO4 → Na2SO4 + H2O

# What do balanced equations show us?

**H2 + Cl2 → 2HCl**

This equation can have two meanings:

* \_\_\_ hydrogen molecule reacts with \_\_\_ chlorine molecule to produce \_\_\_ molecules of hydrogen chloride, or
* \_\_\_ mole of hydrogen reacts with \_\_\_ mole of chlorine to produce \_\_\_ moles of hydrogen chloride

**Draw molecules represented by this equation:**

**N2 + 3H2 → 2NH3**

**Draw molecules represented by this equation:**

**2H2 + O2 → 2H2O**

# Moles and Equations

**H2 + Cl2 → 2HCl**

What is the mass of one mole of: H2  \_\_\_g and Cl2  \_\_\_g ?

What is the mass of 2 moles of HCl? \_\_\_ g

What do you notice about the mass of the reactants compared to the products? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Mass change and uncertainty

# Mass change demos

**Burning Mg ribbon**

Mass of Mg ribbon at start \_\_\_\_\_\_\_\_\_\_\_\_\_

Mass of oxide at end \_\_\_\_\_\_\_\_\_\_\_\_\_

Change in mass \_\_\_\_\_\_\_\_\_\_\_\_\_

**Reaction of HCl and carbonate**

Mass of acid, flask and carbonate at start \_\_\_\_\_\_\_\_\_\_\_\_\_

Mass of acid, flask and carbonate after 2 min\_\_\_\_\_\_\_\_\_\_\_\_\_

Change in mass \_\_\_\_\_\_\_\_\_\_\_\_\_

**Burning Iron Wool**

Which end of the ruler fell?

Has the iron wool increased or decreased in mass?

**Combustion of paper**

Mass of paper and beaker at start \_\_\_\_\_\_\_\_\_\_\_\_\_

Mass of paper and beaker end \_\_\_\_\_\_\_\_\_\_\_\_\_

Change in mass \_\_\_\_\_\_\_\_\_\_\_\_\_

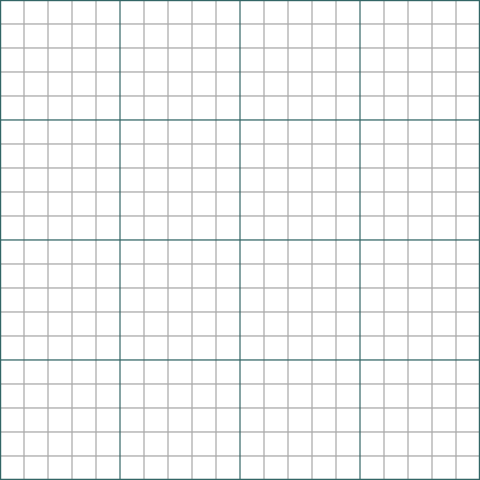
## Explaining Mass Change and Conservation in Mass

Explain how the mass measured has changed, but the Conservation of Mass is still true.

# Uncertainty

**Put your results here**

|  |  |  |  |
| --- | --- | --- | --- |
| Repeat | Time when the solution went cloudy. | Time when the cross disappeared. | Time when the light sensor dropped below 50 lux. |
| 1 | 42s |  | 56s |
| 2 | 88s |  | 58s |
| 3 | 29s |  | 55s |



Which method has the most uncertainty?

How can you tell?

Do any of these methods have no uncertainty?

Reacting Masses (HT)

# Calculating masses of products and reactants

Here is the balanced equation for the reaction that produces bleach:

2NaOH + Cl2 → NaOCl + NaCl + H2O

If we start with 100g of NaOH, what mass of NaOCl can we make?

* Work out the no. of moles of NaOH (You will need to find the Mr of NaOH first).

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* The equation tells that 2 moles of NaOH produces 1 mole of NaOCl (i.e. it is halved).

What will be the number of moles of NaOCl produced?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* What will the mass of that no. of moles of NaOCl be? (You need to work out the Mr)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Try these examples

1. 80g of Methane (CH4) react to produce what mass of water (H2O)?

CH4 + 2O2 → CO2 + 2H2O

1. 280g of Nitrogen react to produce what mass of ammonia (NH3)?

N2 + 3H2 → 2NH3

1. 10g of Calcium carbonate (CaCO3) react to produce what mass of Calcium oxide (CaO)?

CaCO3 → CaO + CO2

1. What mass of oxygen (O2) will react with exactly 60g of Calcium?

2Ca + O2 → 2CaO

1. What mass of oxygen is needed to complete combust 32g of Methane (CH4)?

CH4 + 2O2 → CO2 + 2H2O

Using moles to balance equations (HT)

1. If Iron is burnt in oxygen, there are a number of different oxides that can form. We can use the masses of reactants and products to balance the combustion equation. We can find values for *a* and *b*: *a***Fe** **+** *b***O2** **→** *c***FeOx**

If 224g of iron reacts with 192g of oxygen,

* 1. How many moles of Fe are in 224g? \_\_\_\_\_\_\_\_\_
  2. How many moles of O2 are in 192g? \_\_\_\_\_\_\_\_\_

We need to simplify these numbers by dividing both by the smaller value.

*a* = \_\_\_\_ *b* = \_\_\_\_

1. When potassium nitrate (KNO3) is heated, it decomposes into potassium nitrite (KNO2) and oxygen (O2). 20.2g of KNO3 decomposes into 17.0g of KNO2 and 3.2g of O2. Find values for *a,* *b* and *c*:

*a* **KNO3** **→** *b* **KNO2 +** *c* **O2**

* 1. How many moles of KNO3 are in 20.2g? \_\_\_\_\_\_\_\_\_
  2. How many moles of KNO2 are in 17.0g? \_\_\_\_\_\_\_\_\_
  3. How many moles of O2 are in 3.2g? \_\_\_\_\_\_\_\_\_

We need to simplify these numbers by dividing both by the smallest value.

*a* = \_\_\_\_ *b* = \_\_\_\_ *c* = \_\_\_\_

Rewrite the balanced equation:

1. When nitric acid [HNO3] reacts with Zinc oxide [ZnO], it produces zinc nitrite [Zn(NO3)2] and water [H2O]. 63g of HNO3 reacts with 40.5g of ZnO to make 94.5g of Zn(NO3)2 and 9.0g of H2O. Find values for *a,* *b ,c* and *d*:

*a* **HNO3** **+** *b* **ZnO** **→** *c* **Zn(NO3)2 +** *d* **H2O**

* 1. How many moles of HNO3 are 63.0g? \_\_\_\_\_\_\_\_\_
  2. How many moles of ZnOare in 40.5g? \_\_\_\_\_\_\_\_\_
  3. How many moles of Zn(NO3)2are in 94.5g? \_\_\_\_\_\_\_\_\_
  4. How many moles of H2Oare in 9.0g? \_\_\_\_\_\_\_\_\_

We need to simplify these numbers by dividing both by the smallest value.

*a* = \_\_\_\_ *b* = \_\_\_\_ *c* = \_\_\_\_ *d* = \_\_\_\_

Rewrite the balanced equation:

Limiting Reactant (HT)

In chemical reactions, often there is not the exact amount of each substance needed to react with each other. One substance will be in e\_\_\_\_\_\_\_\_ (XS). The other is said to be the l\_\_\_\_\_\_\_\_\_\_\_ r\_\_\_\_\_\_\_\_\_\_\_.

E.g. In the combustion of carbon, if 24g of carbon and 48g of oxygen are used.

C + O2 → CO2

1. How many moles of C are there? \_\_\_\_\_\_\_\_\_
2. How many moles of O2 are there? \_\_\_\_\_\_\_\_\_
3. Which substance is in excess? \_\_\_\_\_\_\_\_\_
4. Which is the limiting reactant? \_\_\_\_\_\_\_\_\_
5. What is the maximum no. of moles of CO2 that can be produced? \_\_\_\_\_\_\_\_\_\_
6. What is the maximum mass of CO2 that can be produced? \_\_\_\_\_\_\_\_\_\_
7. Determine the maximum mass of ammonia (NH3) that can be produced from 7g of Nitrogen and 4.5g of hydrogen.

N2 + 3H2 → 2NH3

1. Determine the maximum mass of MgO that can be produced from 72g of Magnesium and 72g of oxygen.

2Mg + O2 → 2MgO

1. Determine the maximum mass of CO2 that can be produced from 800g of methane and 720g of oxygen.

CH4 + 2O2 → CO2 + 2H2O

Concentration of Solutions

c=m/v

We can calculate the concentration of a solution by using this equation:

**Concentration** (g/dm3) **= mass** (g) **÷ volume** (dm3)

1. If 20g of sodium chloride is dissolved in 1 dm3 of solution, what is the concentration in g/dm3?
2. If 25g of glucose is dissolved in 5 dm3 of solution, what is the concentration in g/dm3?
3. If 1g of zinc chloride is dissolved in 0.1 dm3 of solution, what is the concentration in g/dm3?
4. If 0.05g of copper sulfate is dissolved in 0.125 dm3 of solution, what is the concentration in g/dm3?

# Converting cm3 to dm3

To use the equation above we need to convert any volumes given in cm3 to dm3.

We do this by dividing by 1000.

**1000cm3 = 1 dm3**

Convert the following volumes to dm3:

1. 2000cm3 = \_\_\_\_\_\_\_\_ dm3  b. 500cm3 = \_\_\_\_\_\_\_\_ dm3
2. 100cm3 = \_\_\_\_\_\_\_\_ dm3  d. 1500cm3 = \_\_\_\_\_\_\_\_ dm3
3. If 2g of lithium chloride is dissolved in 100 cm3 of solution, what is the concentration in g/dm3?
4. If 2.5g of tin nitrate is dissolved in 5000 cm3 of solution, what is the concentration in g/dm3?
5. If 6.5g of zinc chloride is dissolved in 250 cm3 of solution, what is the concentration in g/dm3?
6. If 0.01g of copper sulfate is dissolved in 1 cm3 of solution, what is the concentration in g/dm3?

Concentration of Solutions (HT)

**Rearrange the equation: Concentration = Mass / Volume**

**Mass = Volume =**

1. If 20g of sodium bromide is dissolved to form a solution of concentration 2 g/dm3, what is the volume of the solution?
2. If 100g of sucrose is dissolved to form a solution of concentration 25 g/dm3, what is the volume of the solution?
3. What zinc fluoride is dissolved in 0.1 dm3 of solution, to form a solution with a concentration of 6g/dm3?
4. What iron nitrate is dissolved in 40 dm3 of solution, to form a solution with a concentration of 8g/dm3?

# Using mol/dm3

More often concentration of a solution is measured in mol/dm3.

c=n/v

**Concentration = No. of moles / Volume**

First, we need to convert mass to moles by **dividing by the Mr**

Then, we **divide the no. of moles by the volume** (in dm3)

1. If 5.85g of NaCl is dissolved in 1 dm3 of solution, what is the concentration in mol/dm3?
2. If 190g of MgCl2 is dissolved in 5 dm3 of solution, what is the concentration in mol/dm3?
3. If 10.3g of ZnF2 is dissolved in 0.2 dm3 of solution, what is the concentration in mol/dm3?
4. If 3.19g of CuSO4 is dissolved in 25 cm3 of solution, what is the concentration in mol/dm3?

More Concentration of Solutions (HT)

**Rearrange the equation: Concentration = No. of moles / Volume**

**No. of moles = Volume =**

1. If 166g of LiBr is dissolved to form a solution of concentration 1 mol/dm3, what is the volume of the solution?
2. If 72g of glucose (Mr = 180) is dissolved to form a solution of concentration 0.25 mol/dm3, what is the volume of the solution in cm3?
3. What mass of MgSO4 is dissolved in 0.1 dm3 of solution, to form a solution with a concentration of 0.2 mol/dm3?
4. What mass of NaOH is dissolved in 100 cm3 of solution, to form a solution with a concentration of 0.4 mol/dm3?

# Using concentrations (CHALLENGE !!)

If the volumes of two solutions that react completely are known and the concentration of one solution is known, the concentration of the other solution can be calculated.

1. If 100 cm3 of 0.25 mol/dm3 NaOH completely neutralise 150 cm3 of HCl, what is the concentration of the HCl solution?
   1. Write a balanced equation for this reaction:
   2. How many moles of NaOH are there?
   3. So how many moles of HCl must be present?
   4. Calculate the concentration of the HCl.
2. If 30 cm3 of 0.25 mol/dm3 KOH completely neutralise 15 cm3 of HCl, what is the concentration of the HCl solution?

Moles and Gases (HT)

One mole of any gas occupies same volume.

vg = n x 24

The volume of one mole of any gas at room temperature and pressure (called rtp) [20oC and 1 atmosphere pressure] is **24 dm3**.

**Calculate the volume of these gases at rtp (remember to include the unit of volume):**

1. 1 mol of He \_\_\_\_\_\_ 2) 1 mol of CO2 \_\_\_\_\_\_ 3) 2 mol of O2 \_\_\_\_\_\_
2. 10 mol of SO3 \_\_\_\_\_\_ 5) 0.2 mol of H2 \_\_\_\_\_\_ 6) 100 mol of Ne \_\_\_\_\_\_

**You can also calculate the volume of a gas using its mass, by first converting this to no. of moles:**

1. 60g of Ne **60 ÷20 =\_\_\_ x 24 =** \_\_\_\_dm3 8) 80g of CH4 \_\_\_\_\_\_
2. 22g of CO2 \_\_\_\_\_\_ 10) 100g of H2 \_\_\_\_\_\_

The volumes of gaseous reactants and products can be calculated from the balanced equation for the reaction.

For example: N2 + 3H2 → 2NH3

1. If 20 mol of nitrogen are used, how many mol of H2 will they react with? \_\_\_\_\_\_\_\_
2. How many mol of ammonia (NH3) will be produced? \_\_\_\_\_\_\_\_

Rearrange the equation: **Volume of Gas = no. of moles x 24**

**No. of moles =**

**Calculate the no. of moles of these gases at rtp (remember to check the unit of volume):**

1. 96 dm3 of He \_\_\_\_\_\_ 11) 240 dm3 of CH4 \_\_\_\_\_\_ 12) 12 dm3 of N2 \_\_\_\_\_\_
2. 6 dm3 of SO2 \_\_\_\_\_\_ 14) 240 cm3 of H2 \_\_\_\_\_\_ 15) 48000 cm3 of Ne \_\_\_\_\_\_

**You can also calculate mass of a gas, by first calculating the no. of moles:**

1. 72 dm3 of CH4 **72 ÷24 =\_\_\_ x Mr =** \_\_\_\_dm3 17) 60dm3 of NH3 \_\_\_\_\_\_

18) 1.44 dm3 of C2H6 \_\_\_\_\_\_ 19) 12000cm3 of H2 \_\_\_\_\_\_

Percentage Yield

This is the amount of product produced compared to the maximum that can be made from the reactants.

To calculate it, you use this equation:

**Percentage yield = Amount of product actually produced x 100%**

**Maximum amount of product possible**

1. A reaction produces a theoretical yield of 200g but only makes 150g. What is the percentage yield?
2. A reaction produces 60g of product but in theory makes 80g. What is the percentage yield?
3. How much reactant is needed to make 40g of product if the percentage yield is 75%?

**Very few chemical reactions have a yield of 100%.**

* Try a list some reasons why.







# Higher Tier (Using the calculations from p9):

1. Calculate the maximum amount of Cu that could be produced if 63.8g of CuSO4 (Mr = 159.5) are fully reacted:

This is called the **maximum theoretical yield.**

If only 15.24g are produced, what is the percentage yield? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**CuSO4 + Zn → Cu + ZnSO4**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Calculate the maximum amount of CaO that could be produced if 60g of CaCO3 are fully reacted:

This is called the **maximum theoretical yield.**

If only 23.52g are produced, what is the percentage yield? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**CaCO3 → CaO + CO2**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Calculate the maximum amount of CH4O that could be produced if 1.1g of H2 are fully reacted:

This is called the **maximum theoretical yield.**

If only 6.6g are produced, what is the percentage yield? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**CH2O2 + 2H2 → CH4O + H2O**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Atom Economy

The atom economy is the percentage of starting materials that end up as useful products.

**Atom economy = Relative formula mass of desired product from equation × 100**

**Sum of relative formula masses of all reactants from equation**

1. In a reaction to produce H2 gas, what is the atom economy of the following reaction?

**CO2 + CH4 → CO + 2H2**

* 1. Add up the Mr of all the reactants \_\_\_\_\_\_\_
  2. Calculate the Mr of the **useful** product (multiplying by 2 as there is a **2** in front) \_\_\_\_\_\_\_
  3. Calculate the percentage atom economy \_\_\_\_\_\_\_%

1. In a reaction to produce Cu metal, what is the atom economy of the following reaction?

**CuCl2 + Zn → ZnCl2 + Cu**

* 1. Add up the Mr of all the reactants \_\_\_\_\_\_\_
  2. Calculate the Mr of the **useful** product \_\_\_\_\_\_\_
  3. Calculate the percentage atom economy \_\_\_\_\_\_\_%

1. In a reaction to produce SO3 gas, what is the atom economy of the following reaction?

**2SO2 + O2 → 2SO3**

* 1. Add up the Mr of all the reactants \_\_\_\_\_\_\_
  2. Calculate the Mr of the **useful** product \_\_\_\_\_\_\_
  3. Calculate the percentage atom economy \_\_\_\_\_\_\_%
  4. How could you have spotted the answer to this without working it out?

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It is important for sustainable development and for economic reasons to use reactions with high atom economy. **(HT only)**

**Which method would be best to choose?**

**What other factors might you want to take into account?**

**There is more than one way to produce hydrogen gas.**

**Calculate the atom economy for each method:**

1. **Mg + 2HCl → MgCl2 + H2**
2. **2Na + 2H2O → 2NaCl + H2**
3. **2Al + 6NaOH → 3H2 + 2Na3AlO3**

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