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EB Education Revision Guide

How to work with Moles and Calculations

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Relative Masses

Relative Formula Mass M_r

The relative formula mass of a compound is the relative atomic masses (A_r) of all the atoms in its formula added together.

You will need to look at the Periodic Table to find the relative atomic mass (A_r).

$^{12}_{6}C$

- 12 ⟵ Mass Number
- 6 ⟵ Atomic Number

Example

To find the M_r of sodium carbonate:

$$Na_2CO_3$$

- Find the relative atomic masses of sodium, carbon and oxygen from the Periodic Table.

Na = 23 C = 12 O = 16

- Work out how many of each atom there is in the formula.

Na = 2 atoms C = 1 atom O = 3 atoms

- Add up all the masses

(23 x 2) + 12 + (16 x 3) = 106

TOP TIP: The M_r of a compound is equal to the mass in grams of 1 mole of the compound.

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Moles

Top tip: mol is not a spelling mistake, it is the unit for the amount of substance i.e. shorthand for moles

What is a mole?

- The mass of one mole of a substance is equal to:
- the **relative atomic mass** (A_r) of its formula in grams if the substance is an **element**
- the **relative formula mass** (M_r) of its formula in grams if the substance is a **compound**
- The number of atoms, molecules or ions in one mole of a substance is called the **Avogadro constant**.

  Its value is 6.02×10^{23} per mole

Example

- The number of particles in a substance can be calculated using:
- the Avogadro constant (6.02×10^{23})
- the amount of substance i.e. how many moles, is measured in mol

Number of particles = Avogadro constant × the amount of substance in mol

How many atoms are there in 5 moles of oxygen gas?

Number of molecules: $6.02 \times 10^{23} \times 5 = 3.01 \times 10^{24}$

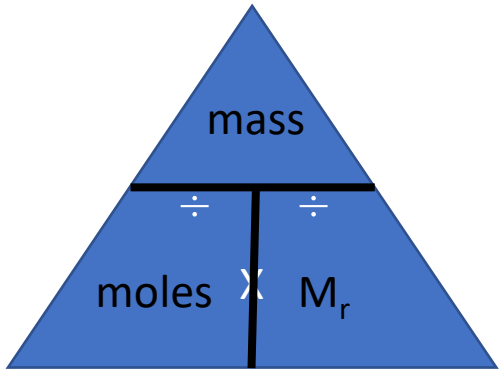
There are 2 atoms in each molecule of oxygen gas.

Number of atoms: $3.01 \times 10^{24} \times 2 = 6.02 \times 10^{24}$

Moles and Masses

Moles, Mass and M_r

You may be asked to calculate the number of particles in a given mass. In this case you need to use this formula to find the number of moles.



Example

How many magnesium atoms are there in 60g of magnesium?

A_r of Mg = 24

- Calculate the number of moles:

Moles = Mass ÷ A_r

= 60 ÷ 24 = 2.5 moles

- Multiply the number of moles by Avogadro's constant:

$6.02 \times 10^{23} \times 2.5 = 1.505 \times 10^{24}$

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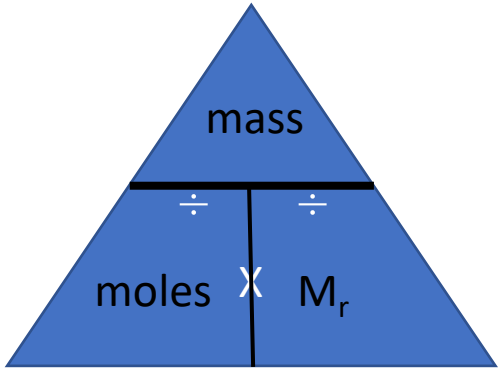

Calculating Masses

Moles, Mass and M_r

You may be asked to calculate the mass of a product formed from a given mass of a reactant, or the mass of a reactant needed to produce a given mass of a product.

Follow these steps:

- Write out the balanced equation.
- Work out Mr of the reactant and product
- Find the number of moles of the substance you know the mass of.
- Using the balanced equation – work out how many moles of the other substance there will be.
- Use the number of moles to calculate the mass.

Example

In the reaction shown by the equation below, what mass of sulphur dioxide can be made from 16g of sulphur?

$S(s) + O_2(g) \rightarrow SO_2(g)$

Ar of the S = 32 Mr of SO_2 = 64

Moles of S = 16/32 0.5 moles

1 mole of S produces 1 mole of SO_2 so 0.5 moles of S produces 0.5 moles of SO_2

Mass = moles x Mr 0.5 x 64 = 32g

Your turn:

1. The formula of copper oxide is CuO.

a) Calculate the relative formula mass of CuO.

b) What is the percentage of copper in copper oxide?

c) Work out what the maximum mass of copper is that can be produced from 4g of copper oxide.

2. Iron (II) sulphate has the formula $FeSO_4$.

a) Work out the relative formula mass of iron sulphate.

b) State the mass of 1 mole of $FeSO_4$.

c) Calculate the mass of $FeSO_4$ needed to produce 28g of iron.

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Your turn:

3 a) Magnesium can be produced from magnesium oxide.

Calculate the mass of magnesium oxide which is required to produce 1.2 tonnes of magnesium.

b) Once the reaction was completed, only 0.9 tonnes of magnesium was produced, not the 1.2 tonnes expected.

Calculate the % yield of magnesium.

4. The below equation shows the reaction between nitrogen and hydrogen to produce ammonia.

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

Calculate the mass of nitrogen required to make 6.8 tonnes of ammonia.

Your turn:

5. Salicylic acid can be reacted with ethanoic anhydride to produce aspirin.

The equation for the reaction is below:

$$\underset{\text{salicylic acid}}{C_7H_6O_3} + C_4H_6O_3 \longrightarrow \underset{\text{aspirin}}{C_9H_8O_4} + CH_3COOH$$

Work out the maximum mass of aspirin that can be produced from reacting 100g of salicylic acid.

6. Graphite is used in pencils, and it can sometimes be called 'pencil lead'.

Aaron wanted to calculate the number of carbon atoms in some graphite in his pencil.
He measured the mass at 0.321g.

a) Work out the amount, in mol, of carbon atoms in the graphite.

b) Calculate the number of carbon atoms present in the graphite using the Avogadro constant.

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Answers:

1a) The formula of copper oxide is CuO.
Calculate the relative formula mass of CuO.

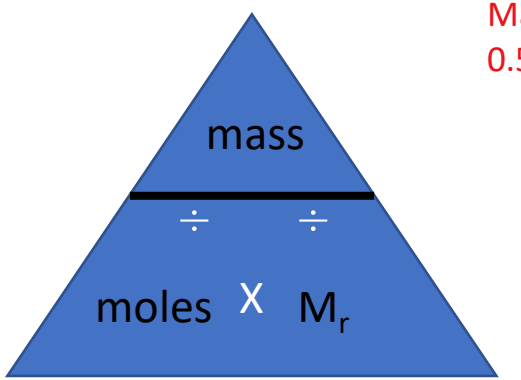
Cu = 64
O = 16 64 + 16 = 80

b) What is the percentage of copper in copper oxide?

64/80 x 100 = 80%

c) Work out what the maximum mass of copper is that can be produced from 4g of copper oxide.

Mass = Moles x Mr 4/80 = 0.05 moles
0.05 x 64 = 3.2g



2. Iron (II) sulphate has the formula $FeSO_4$.

a) Work out the relative formula mass of iron sulphate.

O = 16
S = 32
Fe = 56 56 + 32 + (16 x 4) = 152

b) State the mass of 1 mole of $FeSO_4$.

152g

c) Calculate the mass of $FeSO_4$ needed to produce 28g of iron.

Mass = Moles x Mr 28/56 = 0.5 moles
0.5 x 152 = 76 g

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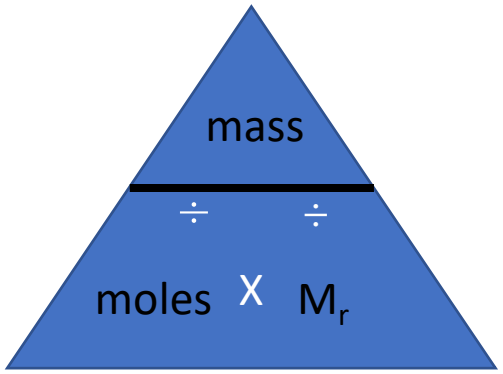


Answers:

3 a) Magnesium can be produced from magnesium oxide.

Calculate the mass of magnesium oxide which is required to produce 1.2 tonnes of magnesium.

O = 16
Mg = 24 M_r of MgO = 40

Mass = moles x M_r 1.2/24 = 0.05
0.05 x 40 = 2

b) Once the reaction was completed, only 0.9 tonnes of magnesium was produced, not the 1.2 tonnes expected.

Calculate the % yield of magnesium.

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

0.9/1.2 x 100 = 75%

4. The below equation shows the reaction between nitrogen and hydrogen to produce ammonia.

$$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$$

Calculate the mass of nitrogen required to make 6.8 tonnes of ammonia.

H = 1
N = 14 M_r of NH_3 = 17 M_r of N_2 = 28

6.8/17 = 0.4 moles
0.4 moles ammonia from 0.2 moles nitrogen (1:2 ratio)
0.2 x 28 = 5.6

Your turn:

5. Salicylic acid can be reacted with ethanoic anhydride to produce aspirin.

The equation for the reaction is below:

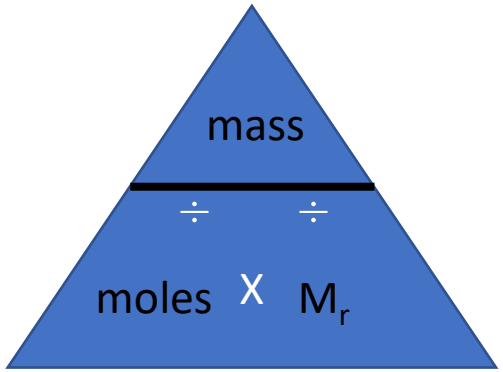
$C_7H_6O_3$ + $C_4H_6O_3$ ⟶ $C_9H_8O_4$ + CH_3COOH

salicylic acid — aspirin

Work out the maximum mass of aspirin that can be produced from reacting 100g of salicylic acid.

C = 12
H = 1
O = 16 M_r of $C_7H_6O_3$ = 138
M_r of $C_9H_8O_4$ = 180

100/138 = 0.725 moles
0.725 x 180 = 130.4g



6. Graphite is used in pencils, and it can sometimes be called 'pencil lead'.

Aaron wanted to calculate the number of carbon atoms in some graphite in his pencil.
He measured the mass at 0.321g.

a) Work out the amount, in mol, of carbon atoms in the graphite.

C = 12
Moles = Mass/Mr
0.321/12 (Graphite is made of carbon) = 0.02675 moles

b) Calculate the number of carbon atoms present in the graphite using the Avogadro constant.

Moles x Avogadro's constant
0.02675 x 6.02 x10^{23} = 1.61 x 10^{22}

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