

Exercise walk-through

3.3

The mole and the Avogadro constant

IGCSE Chemistry

The mole and molar mass

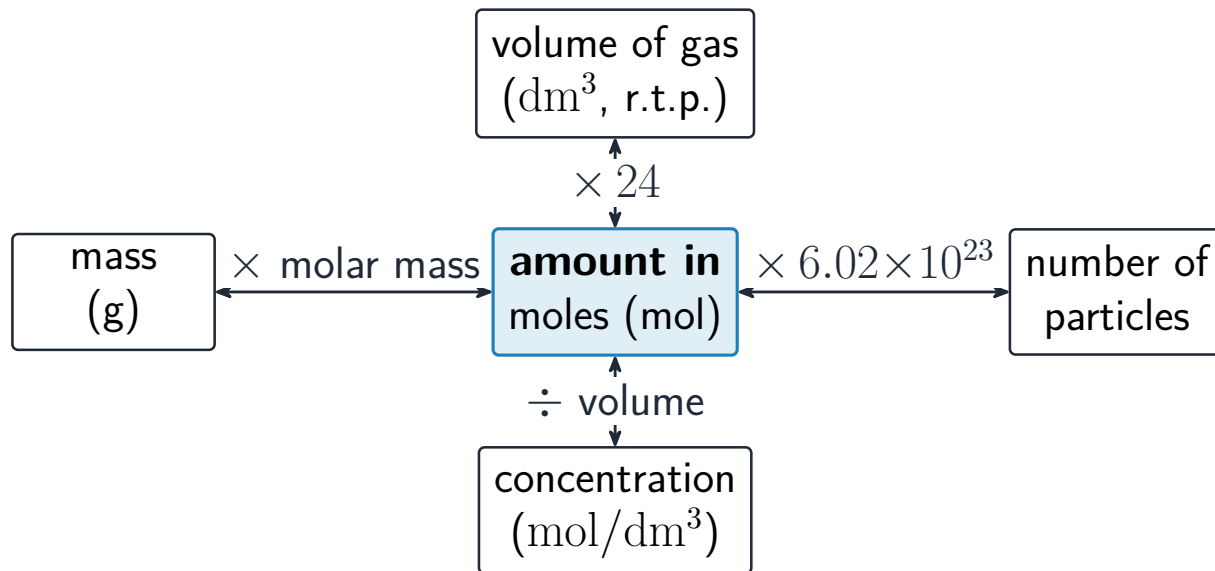
One **mole** = 6.02×10^{23} particles (the **Avogadro constant**).

$$n = \frac{\text{mass}}{\text{molar mass}}$$

Example

36 g of water: $n = \frac{36}{18} = 2 \text{ mol.}$

The mole and molar mass, in detail



One **mole** = 6.02×10^{23} particles (the **Avogadro constant**).

Gas volumes and concentration

At r.t.p. one mole of **any** gas fills 24 dm^3 .

$$V = n \times 24$$

Example

0.25 mol CO_2 : $V = 0.25 \times 24 = 6 \text{ dm}^3$.

$$\text{conc (mol/dm}^3\text{)} = \frac{n}{V(\text{dm}^3)}$$

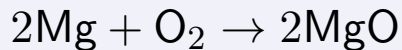
Convert volume first: $1 \text{ dm}^3 = 1000 \text{ cm}^3$.

Reaction calculations

Three steps:

- 1 known mass $\rightarrow$ moles
- 2 use the equation **ratio**
- 3 moles $\rightarrow$ mass / volume

12 g Mg burns: mass of MgO?



$$\text{moles Mg} = 12/24 = 0.5$$

$$\text{ratio } 1:1 \Rightarrow 0.5 \text{ mol MgO}$$

$$\text{mass} = 0.5 \times 40 = \mathbf{20 \text{ g}}$$

Exercises 2.1·2.2

2.1 Find the amount (in mol) in 8.0 g of NaOH ($M_r = 40$). [2]

2.2 Find the volume of 0.50 mol of a gas at r.t.p. [2]

Exercises 2.1·2.2

2.1 Find the amount (in mol) in 8.0 g of NaOH ($M_r = 40$). [2]

2.1

- $n = m/M_r$

$$n = \frac{m}{M_r} = \frac{8.0 \text{ g}}{40 \text{ g mol}^{-1}} = \mathbf{0.20 \text{ mol}}$$

2.2 Find the volume of 0.50 mol of a gas at r.t.p. [2]

2.2

- at r.t.p., 1 mol of gas occupies 24 dm³

$$V = n \times V_m = 0.50 \text{ mol} \times 24 \text{ dm}^3 \text{mol}^{-1} = \mathbf{12 \text{ dm}^3}$$

Exercises 2.3·2.4

2.3 Calculate the number of moles in 8.8 g of carbon dioxide. ($M_r = 44.$) [2]

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Exercises 2.3·2.4

2.3 Calculate the number of moles in 8.8 g of carbon dioxide. ($M_r = 44.$) [2]

2.3

- $n = m/M_r$

$$n = \frac{m}{M_r} = \frac{8.8 \text{ g}}{44 \text{ g mol}^{-1}} = \mathbf{0.20 \text{ mol}}$$

2.4 Calculate the volume, at r.t.p., of 0.25 mol of hydrogen gas. [2]

2.4

- $V = n \times 24 \text{ dm}^3\text{mol}^{-1}$

$$V = n \times V_m = 0.25 \text{ mol} \times 24 \text{ dm}^3\text{mol}^{-1} = \mathbf{6.0 \text{ dm}^3}$$

- that is 6000 cm^3

Exercise 2.5

2.5 Determine the empirical formula of a compound containing 52.2% carbon, 13.0% hydrogen and 34.8% oxygen. (A_r : C 12, H 1, O 16.) [3]

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2.5

- divide each % by A_r

$$\frac{52.2}{12} = 4.35, \quad \frac{13.0}{1} = 13.0, \quad \frac{34.8}{16} = 2.175$$

- divide by the smallest (2.175) $\rightarrow 2 : 6 : 1$
- empirical formula **C₂H₆O**

Exercise 3.1

3.1 The number of moles in 22 g of CO_2 ($M_r = 44$) is:

[1]

☐

A 0.25

B 0.50

C 1.0

D 2.0

Exercise 3.1

3.1 The number of moles in 22 g of CO_2 ($M_r = 44$) is:

[1]

☐

A 0.25

B 0.50

C 1.0

D 2.0

3.1 B

$$n = \frac{m}{M_r} = \frac{22 \text{ g}}{44 \text{ g mol}^{-1}} = \mathbf{0.50} \text{ mol}$$

- A is half of that; C and D treat 22 g as 1 or 2 mol

Exercise 3.2 (a)

3.2 Magnesium burns: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ (A_r : Mg = 24, O = 16).

(a) Find the moles in 12 g of magnesium.

[1]

Exercise 3.2 (a)

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(a) Find the moles in 12 g of magnesium.

[1]

(a)

$$n(\text{Mg}) = \frac{m}{A_r} = \frac{12 \text{ g}}{24 \text{ g mol}^{-1}} = \mathbf{0.50 \text{ mol}}$$

Exercise 3.2 (b)

3.2 Magnesium burns: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ (A_r : Mg = 24, O = 16).

(b) Find the mass of magnesium oxide formed.

[3]

Exercise 3.2 (b)

3.2 Magnesium burns: $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$ (A_r : Mg = 24, O = 16).

(b) Find the mass of magnesium oxide formed.

[3]

(b)

- ratio Mg : MgO = 1 : 1, so 0.50 mol MgO
- $M_r(\text{MgO}) = 24 + 16 = 40$

$$m = n \times M_r = 0.50 \text{ mol} \times 40 \text{ g mol}^{-1} = \mathbf{20 \text{ g}}$$

Exercise 3.3 (a)

3.3 25.0 cm³ of sodium hydroxide is neutralised by 20.0 cm³ of 0.10 mol/dm³ HCl.
 $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$.

(a) Find the moles of HCl.

[2]

Exercise 3.3 (a)

3.3 25.0 cm³ of sodium hydroxide is neutralised by 20.0 cm³ of 0.10 mol/dm³ HCl.
NaOH + HCl -> NaCl + H2O.

(a) Find the moles of HCl.

[2]

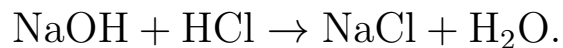
(a)

- $n = c \times V$ with V in dm³

$$n(\text{HCl}) = 0.10 \text{ mol dm}^{-3} \times \frac{20.0}{1000} \text{ dm}^3 = \mathbf{0.0020 \text{ mol}}$$

Exercise 3.3 (b)

3.3 25.0 cm³ of sodium hydroxide is neutralised by 20.0 cm³ of 0.10 mol/dm³ HCl.



(b) Find the concentration of the sodium hydroxide.

[2]

Exercise 3.3 (b)

3.3 25.0 cm³ of sodium hydroxide is neutralised by 20.0 cm³ of 0.10 mol/dm³ HCl.
NaOH + HCl -> NaCl + H2O.

(b) Find the concentration of the sodium hydroxide. [2]

(b)

- ratio 1 : 1, so 0.0020 mol NaOH in 25.0 cm³

$$c = \frac{n}{V} = \frac{0.0020 \text{ mol}}{25.0/1000 \text{ dm}^3} = \mathbf{0.080 \text{ mol dm}^{-3}}$$

Exercise 3.4 (a)

3.4 Calcium carbonate decomposes when heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A student heats 25.0 g of calcium carbonate until there is no further change. (A_r : Ca 40, C 12, O 16.)

(a) Calculate the number of moles of calcium carbonate used.

[2]

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(a) Calculate the number of moles of calcium carbonate used. [2]

(a)

- $M_r(\text{CaCO}_3) = 40 + 12 + 48 = 100$

$$n = \frac{m}{M_r} = \frac{25.0 \text{ g}}{100 \text{ g mol}^{-1}} = \mathbf{0.250 \text{ mol}}$$

Exercise 3.4 (b)

3.4 Calcium carbonate decomposes when heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A student heats 25.0 g of calcium carbonate until there is no further change. (A_r : Ca 40, C 12, O 16.)

(b) Determine the maximum mass of calcium oxide that can be formed. [3]

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(b) Determine the maximum mass of calcium oxide that can be formed. [3]

(b)

- ratio 1 : 1, so $n(\text{CaO}) = 0.250 \text{ mol}$
- $M_r(\text{CaO}) = 40 + 16 = 56$

$$m = n \times M_r = 0.250 \text{ mol} \times 56 \text{ g mol}^{-1} = \mathbf{14.0 \text{ g}}$$

Exercise 3.4 (c)

3.4 Calcium carbonate decomposes when heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A student heats 25.0 g of calcium carbonate until there is no further change. (A_r : Ca 40, C 12, O 16.)

(c) The student collects 12.6 g of calcium oxide. Calculate the percentage yield. [2]

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(c)

$$\text{percentage yield} = \frac{\text{actual mass}}{\text{theoretical mass}} \times 100\% = \frac{12.6 \text{ g}}{14.0 \text{ g}} \times 100\% = \mathbf{90.0\%}$$

Exercise 3.4 (d)

3.4 Calcium carbonate decomposes when heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A student heats 25.0 g of calcium carbonate until there is no further change. (A_r : Ca 40, C 12, O 16.)

(d) Calculate the volume of carbon dioxide, at r.t.p., released in the reaction. [2]

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(d) Calculate the volume of carbon dioxide, at r.t.p., released in the reaction. [2]

(d)

- $n(\text{CO}_2) = 0.250 \text{ mol}$

$$V = n \times V_m = 0.250 \text{ mol} \times 24 \text{ dm}^3 \text{ mol}^{-1} = \mathbf{6.0 \text{ dm}^3}$$

Exercise 3.4 (e)

3.4 Calcium carbonate decomposes when heated: $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$. A student heats 25.0 g of calcium carbonate until there is no further change. (A_r : Ca 40, C 12, O 16.)

(e) The carbon dioxide is bubbled through 50.0 cm³ of limewater of concentration 0.0200 mol/dm³. Calculate the number of moles of calcium hydroxide present, and state whether it is enough to react with all the gas. [3]

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(e) The carbon dioxide is bubbled through 50.0 cm³ of limewater of concentration 0.0200 mol dm⁻³. Calculate the number of moles of calcium hydroxide present, and state whether it is enough to react with all the gas. [3]

(e)

$$n(\text{Ca}(\text{OH})_2) = 0.0200 \text{ mol dm}^{-3} \times \frac{50.0}{1000} \text{ dm}^3 = \mathbf{1.00 \times 10^{-3} \text{ mol}}$$

- this is far less than 0.250 mol of CO₂, so the limewater is **not enough**