CAIE Chemistry IGCSE

3.3 The Mole and Avogadro constant

Flashcards

What is meant by ‘concentration’ and give the units

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- The concentration of a substance is the amount of solute dissolved in a measured volume of solution
- The concentration can be measured in g/dm^3 or mol/dm^3

Define the mole
(extended only)

Define the mole (extended only)

The mole is the unit for amount of any substance, containing the same number of particles as there are atoms in exactly 12 g of carbon-12 (1 mole= 6.02 x 10^{23} particles).

Define the Avogadro constant (extended only)

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The number of particles in one mole of a substance. This is 6.02×10^{23} particles.

What is the equation that relates moles with the Avogadro constant?

(extended only)

What is the equation that relates moles with the Avogadro constant? (extended only)

Number of particles =

moles x Avogadro's constant

What is the equation that relates amount of substance, mass and molar mass?

(extended only)

What is the equation that relates amount of substance, mass and molar mass? (extended only)

Mass of a substance (in g) =

Moles (mol) x Molar mass of substance(g/mol)

What is the molar mass?

(extended only)

What is the molar mass? (extended only)

The molar mass is the mass of 1 mole of the substance. It is the same as the A_r / M_r of the substance but the molar mass has a unit: g/mol

Calculate the amount of substance (no. of mol) in 300g of calcium carbonate ($CaCO_3$)

(extended only)

Calculate the amount of substance (no. of mol) in 300g of calcium carbonate ($CaCO_3$) (extended only)

1. Calculate the M_r of $CaCO_3$

   $40 + 12 + (16 \times 3) = 100$

2. Mol= Mass ÷ M_r

   300 g ÷ 100 = 3 moles of $CaCO_3$

Calculate the mass of 0.75mol of calcium (Ca)

(extended only)

Calculate the mass of 0.75mol of calcium (Ca)
(extended only)

1. Find the M_r of Ca on periodic table = 40
2. Mass= M_r x mol

40 x 0.75 = 30g

How many moles are in 5.44 g of sodium chloride?

(extended only)

How many moles are in 5.44 g of sodium chloride? (extended only)

Mr of NaCl = 23 + 35.5 = 58.5

Moles = mass / Mr

= 5.44 / 58.5

=0.0930 (3.s.f)

How many moles are in 2.35 g of aluminium? (extended only)

How many moles are in 2.35 g of aluminium?
(extended only)

Moles = mass / relative atomic mass

= 2.35 / 27

= 0.0870 (3.s.f)

Calculate the molar mass of $AlCl_3$
(moles= 4 and mass = 534g)
(extended only)

Calculate the molar mass of $AlCl_3$ (moles= 4 and mass = 534g) (extended only)

Molar mass= Mass ÷ Mol

534 g ÷ 4 mol = 133.5 g/mol

To check your answer, you can find the M_r of $AlCl_3$ by using the A_r of each element

27 + (3 x 35.5) = 133.5

Calculate the number of carbon dioxide molecules in 1.5 moles of CO_2 using Avogadro constant

(extended only)

Calculate the number of carbon dioxide molecules in 1.5 moles of CO_2 using Avogadro constant (extended only)

Number of particles = Avogadro constant x amount of substance

Number of CO_2 molecules= $6.02 \times 10^{23} \times 1.5$

Number of CO_2 molecules= 9.03×10^{23}

Calculate the number of atoms in 1.5 moles of CO_2 using Avogadro constant (extended only)

Calculate the number of atoms in 1.5 moles of CO_2 using Avogadro constant (extended only)

Number of particles = Avogadro constant x amount of substance

Number of CO_2 molecules= $6.02 \times 10^{23} \times 1.5$

Number of CO_2 molecules= 9.03×10^{23}

There are 3 atoms in each CO_2 molecule (2 O atoms and 1 C atom), so…

Number of atoms in 1.5 moles of CO_2= $9.03 \times 10^{23} \times 3$

$= 2.71 \times 10^{24}$ atoms

What is the molar volume of gas at room temperature and pressure?

(extended only)

What is the molar volume of gas at room temperature and pressure? (extended only)

$24\ dm^3$

What is RTP?
(extended only)

What is RTP? (extended only)

Room temperature and pressure:

- 20°C
- 1 atmosphere

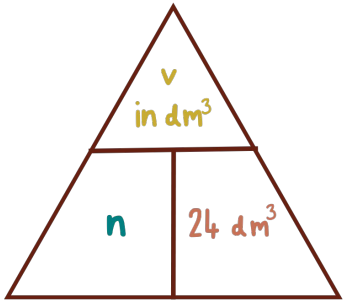
What equation links molar volume at RTP and moles?

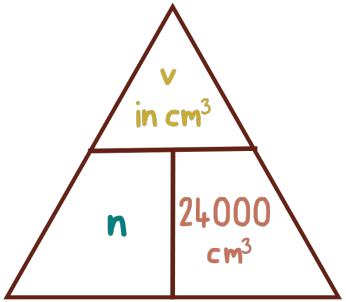
(extended only)

What equation links molar volume at RTP and moles? (extended only)

Volume of gas at RTP (dm^3) = moles x $24dm^3$

Volume of gas at RTP (cm^3) = moles x $24000cm^3$





How many moles of oxygen are in 72 dm^3 at RTP?

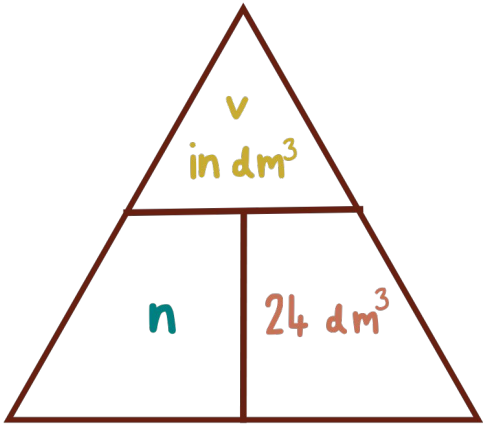
(extended only)

How many moles of oxygen are in 72 dm^3 at RTP? (extended only)

Moles = volume / 24

= 72 / 24

= 3 moles



What is a limiting reagent?
(extended only)

What is a limiting reagent? (extended only)

The reactant that is completely used up first, preventing the reaction continuing and determines the amount of product that can form.

0.953 g of magnesium reacts fully with chlorine: $Mg + Cl_2 \rightarrow MgCl_2$
What mass of magnesium chloride is formed?

(extended only)

0.953 g of magnesium reacts fully with chlorine according to the following equation. What mass of magnesium chloride would be formed?

$Mg + Cl_2 \rightarrow MgCl_2$ (extended only)

Moles of Mg = 0.953 / 24 = 0.0397

Ratio of moles of Mg:$MgCl_2$ is 1:1 so $MgCl_2$ also has 0.0397 moles.

Mass of $MgCl_2$ = 0.0397 x (24 + 35.5 +35.5) = 3.77 g (3.s.f)

How would you convert between cm_3 and dm_3? (extended only)

How would you convert between cm_3 and dm_3? (extended only)

$1dm^3 = 1000cm^3$

- Converting cm^3 to dm^3 : ÷1000
- Converting dm^3 to cm^3 : x1000

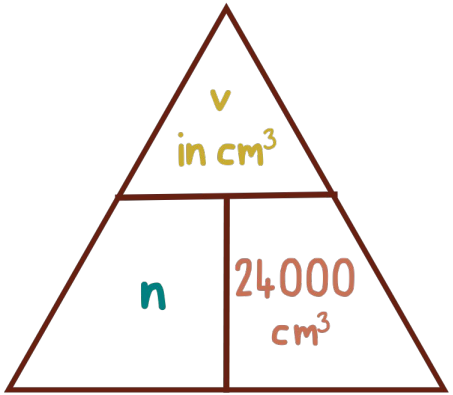
Calculate the volume of 0.5mol of hydrogen at room temperature and pressure (Molar gas volume= 24000cm^3)

(extended only)

Calculate the volume of 0.5mol of hydrogen at room temperature and pressure (Molar gas vol= 24000cm^3) (extended only)

Volume of gas in cm^3 = Number of moles x 24000cm^3

Volume of hydrogen= 0.5 x 24000 = 12000 cm^3



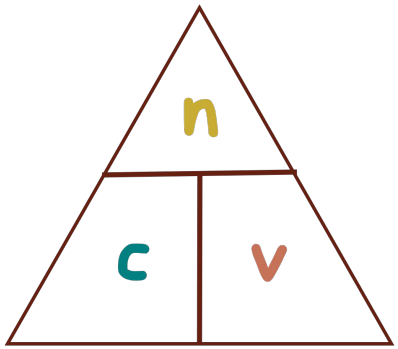
What equation links concentration, volume and amount of substance?

(extended only)

What equation links concentration, volume and amount of substance? (extended only)

Concentration (in mol/dm^3) :

$$\frac{\text{Amount of substance (mol)}}{\text{Volume } (dm^3)}$$



How would you convert between mol/dm^3 and g/dm^3? (extended only)

How would you convert between mol/dm^3 and g/dm^3? (extended only)

mol/dm^3 -> g/dm^3 multiply by the M_r

g/dm^3-> mol/dm^3 divide by the M_r

5.00 g of NaCl is dissolved in 25 cm^3 of water. Calculate the concentration of the solution in mol/dm^3.

(extended only)

5.00 g of NaCl is dissolved in 25 cm^3 of water. Calculate the concentration of the solution in mol/dm^3. (extended only)

Moles of NaCl = 5 / 58.5 = 0.0855

Volume in dm^3 = 25 / 1000 = 0.025

Concentration in mol/dm^3 = 0.0855 / 0.025

= 3.42 mol/dm^3

25 cm^3 of dilute hydrochloric acid (HCl) is neutralised by 20 cm^3 of 0.5 mol/dm^3 sodium hydroxide (NaOH). What is the concentration of the hydrochloric acid?

(extended only)

25 cm^3 of dilute hydrochloric acid (HCl) is neutralised by 20 cm^3 of 0.5 mol/dm^3 sodium hydroxide (NaOH). What is the concentration of the hydrochloric acid? (extended only)

1. Convert volumes from cm^3 to dm^3: $25cm^3 = 0.025dm^3$ $20cm^3 = 0.020dm^3$
2. Work out the moles of NaOH: Number of moles= Conc. x Vol 0.5 x 0.02 = 0.01 mol
3. Work out the mole ratio by balancing the chemical equation:
   $HCl + NaOH \rightarrow NaCl + H_2O$ 1:1 ratio so number of moles of NaOH= number of moles of HCl
   So number of moles of HCl = 0.01mol
4. Work out the concentration of HCl: Conc. = Number of moles ÷ Volume
   0.01 ÷ 0.025 = $0.4mol/dm^3$

A molecule has the empirical formula $C_4H_3O_2$ and a relative molecular mass of 166. What is the molecular formula?

(extended only)

A molecule has the empirical formula $C_4H_3O_2$ and a relative molecular mass of 166.What is the molecular formula? (extended only)

Empirical M_r = (12 x 4) + (1 x 3) + (16 x 2) = 83

Relative molecular mass = 166

Compare molecular mass with empirical mass = 166 / 83 = 2

So the molecular formula is double the empirical formula: $C_8H_6O_4$

Find the empirical formula of the following compound using their percentage masses:

Al 20.2% Cl 79.8%

(extended only)

Find the empirical formula of the following compound using their percentage masses (extended only):

Al 20.2% Cl 79.8%

1. Write the relative atomic masses (A_r) of each element
   Al = 27 Cl = 35.5
2. Divide the percentage masses by the A_r of each element
   Al= 20.2 ÷ 27 = 0.748 Cl= 79.8 ÷ 35.5 = 2.248
3. Divide by the smallest answer from step 2 to find the ratio of atoms of each element
   Al= 0.748 ÷ 0.748 = 1 Cl= 2.248 ÷ 0.748 = 3
   This is the simplest whole number ratio for Al : Cl = 1:3
   So the answer is $AlCl_3$

Calculate the empirical formula for a compound containing 7.83g of Iron (Fe) and 3.37g of oxygen (O)

(extended only)

Calculate the empirical formula for a compound containing 7.83g of Iron (Fe) and 3.37g of oxygen (O) (extended only)

Element	Fe	O
Relative atomic mass (A_r)	56	16
Mass (in g)	7.83	3.37
Work out the moles	7.83g ÷ 56 = 0.14	3.37 ÷ 16 = 0.21
Divide by the smallest number to find the molar ratio	0.14 ÷ 0.14 = 1	0.21 ÷ 0.14 = 1.5
Multiply by x to reach lowest whole number ratio	1 x 2 = 2	1.5 x 2 = 3
Empirical formula	Fe_2O_3	

What is meant by the term theoretical yield?

(extended only)

What is meant by the term theoretical yield? (extended only)

The maximum amount of product that would be collected under perfect reaction conditions.

Give 3 reasons why the theoretical yield of a product is not obtained (extended only)

Give 3 reasons why the theoretical yield of a product is not obtained (extended only)

1. Reaction may not go to completion because it is reversible
2. Some of the product may be lost when it is separated from the reaction mixture
3. Some of the reactants may react in ways different to the expected reaction

How can percentage yield be calculated?
(extended only)

How can percentage yield be calculated? (extended only)

$$\text{Percentage yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100$$

What is the percentage yield of NH_3 if 40.5 g of NH_3 is produced from 20.0 mol H_2 and excess N_2?

(extended only)

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(extended only)

Equation: $N_2 + 3H_2 \rightarrow 2NH_3$

Moles of ammonia = 20/1.5 = 13.3 moles

Mass of ammonia = 13.3 x (14+1+1+1) = 227 g

Percentage yield = (40.5/227) x 100 = 17.9%

How can the percentage composition of an element in a compound be calculated?

(extended only)

How can the percentage composition of an element in a compound be calculated? (extended only)

Percentage mass =

$$\frac{\text{Total } A_r \text{ of the element}}{M_r \text{ of the compound}} \times 100$$

Calculate the percentage of calcium in calcium hydroxide

(extended only)

Calculate the percentage of calcium in calcium hydroxide (extended only)

1. Deduce formula of calcium hydroxide: $Ca(OH)_2$ since Ca2+ needs 2 OH- ions to neutralise the charge
2. Work out the M_r of $Ca(OH)_2$: 40 + (16 x 2) + (1 x 2) = 74
3. % mass: (40 ÷ 74) x 100 = 54.1 %

How can the percentage purity of a sample be calculated?

(extended only)

How can the percentage purity of a sample be calculated? (extended only)

Percentage purity =

$$\frac{\text{Mass of the pure substance}}{\text{Mass of the sample}} \times 100$$

A solution of sodium chloride contains 0.64g of NaCl in 100g of water. Calculate the percentage purity by mass of NaCl

(extended only)

A solution of sodium chloride contains 0.64g of NaCl in 100g of water. Calculate the percentage purity by mass of NaCl (extended only)

% purity of NaCl =

$$\frac{0.64g}{100g} \times 100 = 0.64\%$$