
NANYANG
GIRLS' HIGH

Mole Calculations: Concentration of Aqueous Solution

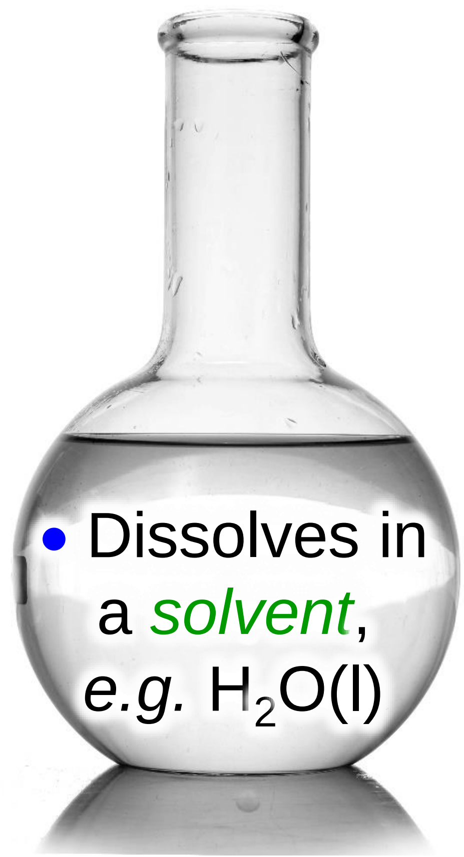
Concentration of Aqueous Solution

What is a *solution*?

Concentration of Aqueous Solution

Concentration of Aqueous Solution

- A *solute*,
  e.g. $CuSO_4$(s)



- Dissolves in a *solvent*, *e.g.* H_2O(l)

- To form a *solution*, *e.g.* $CuSO_4$(aq)

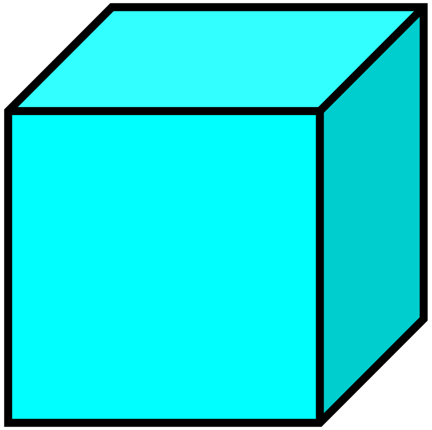
Concentration of Aqueous Solution

How far apart are the ions in a dilute aqueous solution of sodium chloride?

Concentration of Aqueous Solution

- Consider a 1.00 mol/dm^3 aqueous solution of sodium chloride, $NaCl$(aq).

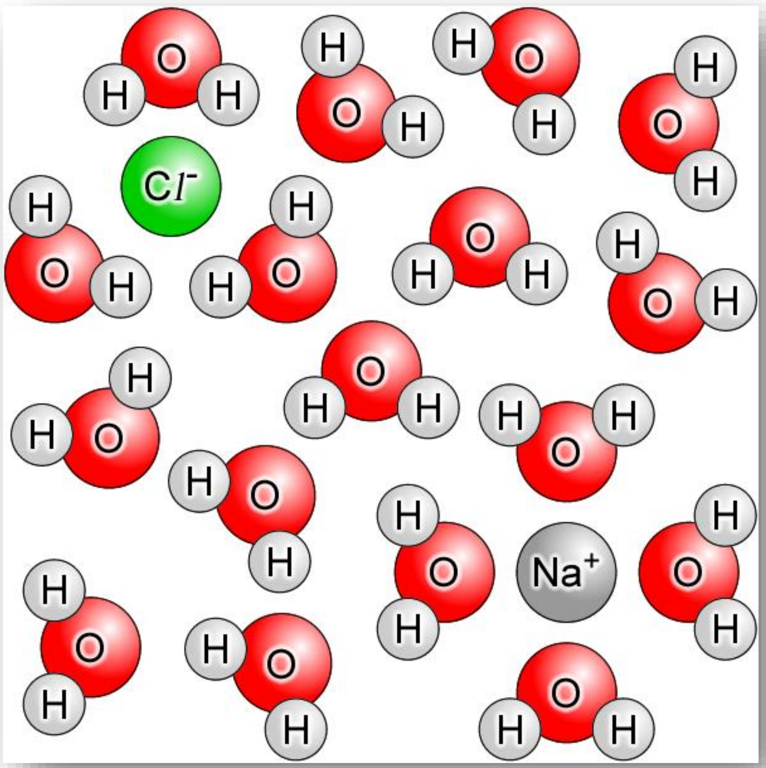
- For every 55 molecules of water, there will be one sodium ion, Na^+(aq), and one chloride ion, Cl^-(aq).



- Put another way, a cube of the solution measuring approximately $4 \times 4 \times 4$ water molecules will contain one sodium ion, Na^+(aq), and one chloride ion, Cl^-(aq).

Concentration of Aqueous Solution

- A model representing the approximate distribution of ions in 1.00 mol/dm^3 sodium chloride, NaC*l*(aq).



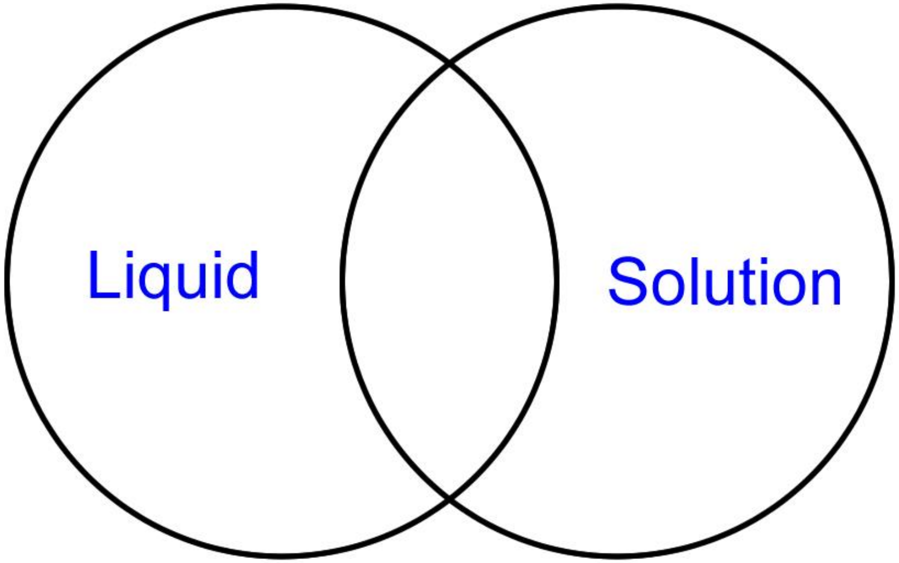
- On average, there are 2 – 4 water molecules in between the Na$^+$(aq) and C*l*$^-$(aq) ions.

Concentration of Aqueous Solution

In what way(s) are liquids and solutions *similar* and *different*?

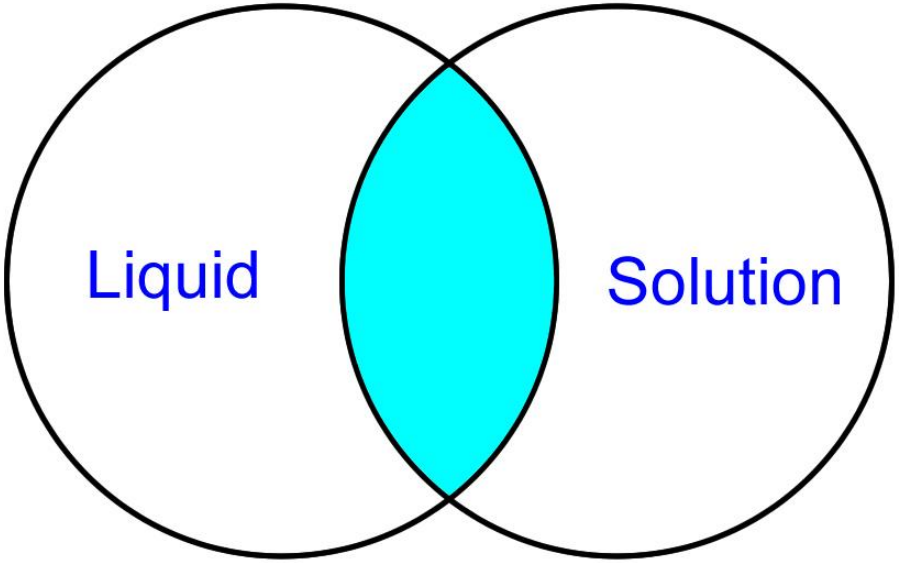
Concentration of Aqueous Solution

Higher Order Thinking – Compare and Contrast
Liquids and Solutions



Concentration of Aqueous Solution

Higher Order Thinking – Compare and Contrast
Liquids and Solutions

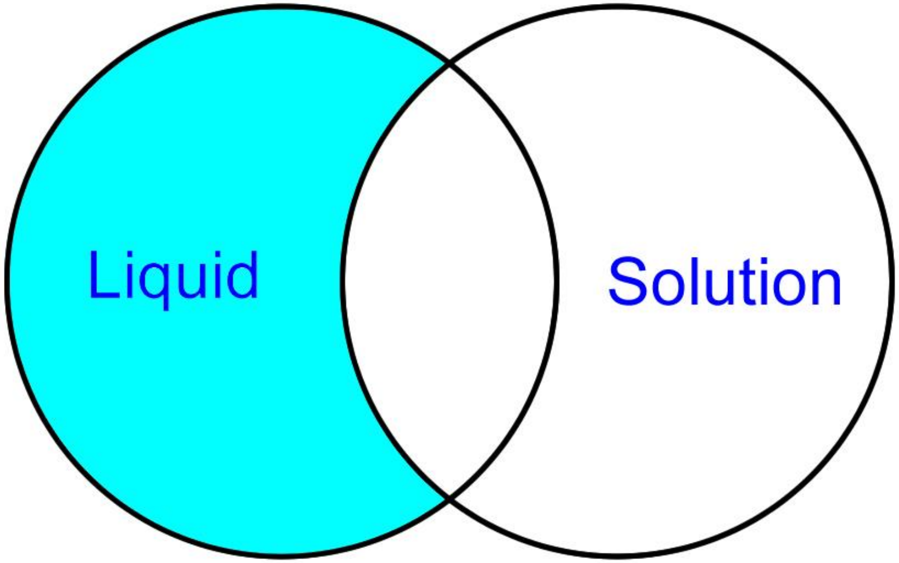


- In a *liquid* and a *solution*, the particles are closely packed together in a random arrangement. The particles can "slip and slide" over each others surface. Both have a fixed volume, but no fixed shape.

Concentration of Aqueous Solution

Higher Order Thinking – Compare and Contrast
Liquids and Solutions

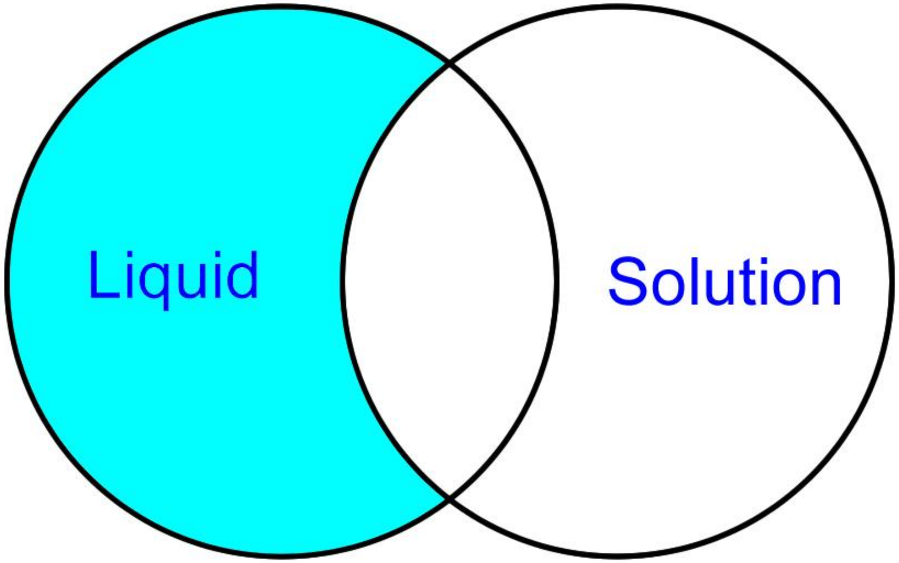
- A *liquid* is a pure substance which cannot be converted into anything more simple by a physical separation technique, *e.g.* distillation.



Concentration of Aqueous Solution

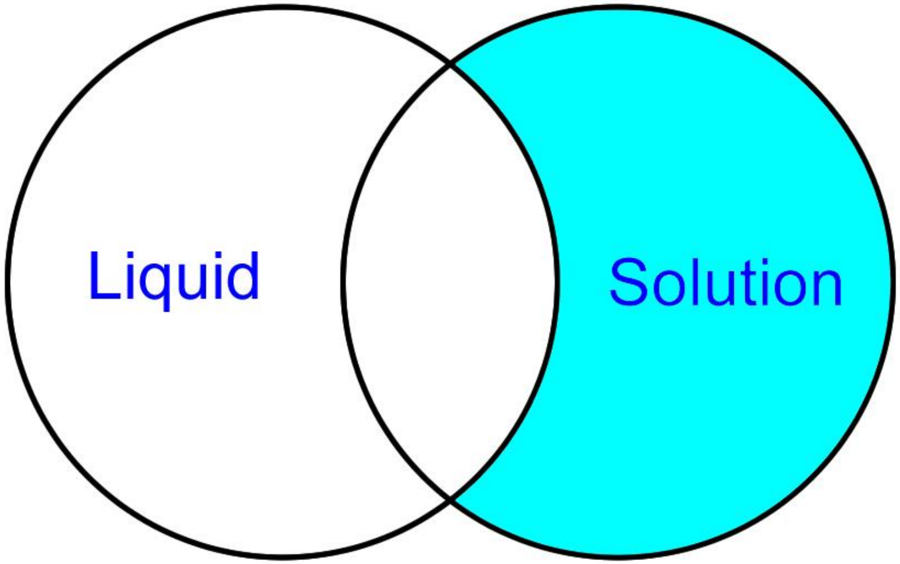
Higher Order Thinking – Compare and Contrast
Liquids and Solutions

- Examples of liquids include $H_2O(l)$, $Br_2(l)$, $Hg(l)$ and $C_2H_5OH(l)$.



Concentration of Aqueous Solution

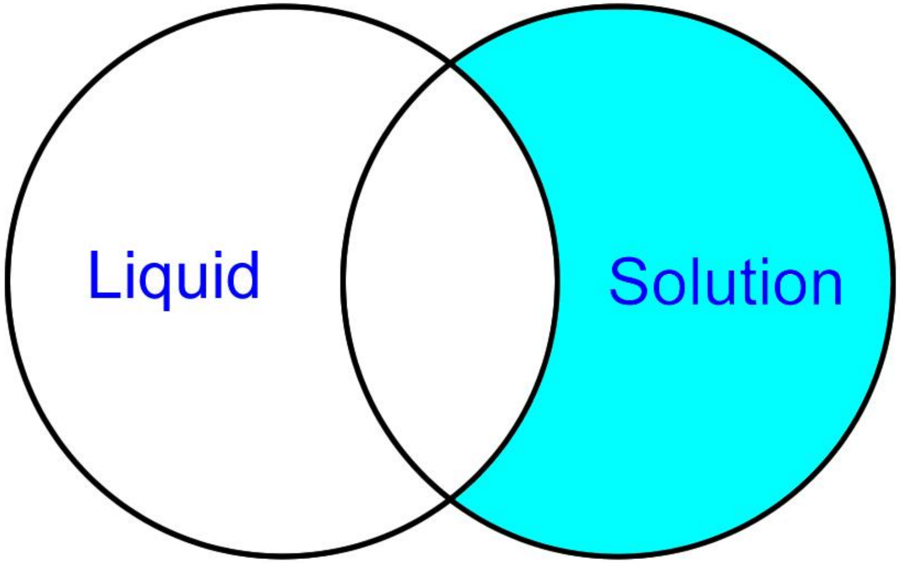
Higher Order Thinking – Compare and Contrast
Liquids and Solutions



- A *solution* is a mixture of a solvent and a solute which can be converted into more simple substances by a physical separation technique, *e.g.* distillation.

Concentration of Aqueous Solution

Higher Order Thinking – Compare and Contrast
Liquids and Solutions



- Examples of solutions include NaCl(aq), $CuSO_4$(aq), H_2SO_4(aq) and NaOH(aq).

Concentration of Aqueous Solution

How do I perform *concentration calculations*?

Concentration of Aqueous Solution

Concentration is a measure of the amount of a *solute* dissolved in a *solvent* to make *one unit volume of a solution*. Concentration can be expressed as either:

- grams per decimetre cubed, g / dm^3

or

- moles per decimetre cubed, mol / dm^3

Concentration of Aqueous Solution

- In other words, concentration is a measure of how much chemical is dissolved in a certain volume of solvent.

- A *dilute* solution

Concentration of Aqueous Solution

- In other words, concentration is a measure of how much chemical is dissolved in a certain volume of solvent.

- A *concentrated* solution

Concentration of Aqueous Solution

$$\text{concentration in mol / dm}^3 = \frac{\text{number of moles of solute}}{\text{volume of solution measured in dm}^3}$$

$$\text{concentration in g / dm}^3 = \frac{\text{mass of solute measured in g}}{\text{volume of solution measured in dm}^3}$$

$$\text{concentration in mol / dm}^3 = \frac{\text{concentration in g / dm}^3}{\text{relative molecular mass of the solute}}$$

Concentration of Aqueous Solution

- For example, if 234 g, which is 4.00 mol, of sodium chloride were dissolved in 2.00 dm^3 of distilled water, it would have a concentration of:

$$234 \div 2.00 = 117 \text{ g / dm}^3$$

or

$$4.00 \div 2.00 = 2.00 \text{ mol / dm}^3$$

Concentration of Aqueous Solution

Most concentration calculations use the unit of moles per decimetre cubed, mol / dm^3.

Concentration calculations centre around the relationship between three variables:

- number of moles
- concentration measured in mol / dm^3
- volume measured in cm^3

$$\text{moles} = \text{concentration} \times \text{volume} \times 10^{-3}$$

or

$$\text{moles} = (\text{concentration} \times \text{volume}) \div 1000$$

- Note: $\times\ 10^{-3}$ or $\div\ 1000$ is used to convert a volume in cm^3 into a volume in dm^3.

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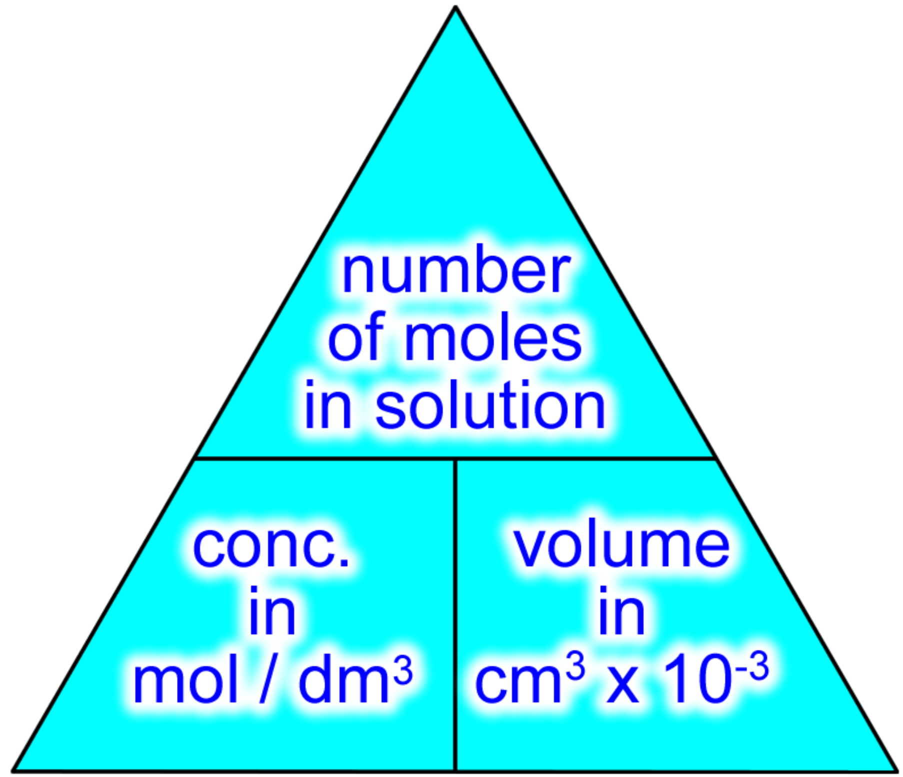
Concentration of Aqueous Solution



Concentration of Aqueous Solution

Misconception Alert!

- Do not get volume of *aqueous solution* and volume of *gas* confused with each other!

Concentration of Aqueous Solution

Misconception Alert!

- Do not get volume of *aqueous solution* and volume of *gas* confused with each other!
- You *cannot* calculate the number of moles of chemical in aqueous solution by dividing the volume of the solution by 24.0 dm^3 or 24 000 cm^3!

Concentration of Aqueous Solution

- Question 1:
How many moles of sulfuric acid (formula, H_2SO_4) are there in 300 cm^3 of a 0.200 mol / dm^3 solution?

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$$\text{moles} = \text{concentration} \times \text{volume} \times 10^{-3}$$

$$\text{moles} = 0.200 \times 300 \times 10^{-3}$$

moles of H_2SO_4 = $\underline{0.0600}$ mol

Concentration of Aqueous Solution

- Question 2:

What is the concentration of a solution that contains 0.500 mol of potassium nitrate (formula, KNO_3) dissolved in 125 cm^3 of distilled water?

Concentration of Aqueous Solution

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$$\text{moles} = \text{concentration} \times \text{volume} \times 10^{-3}$$

$$\therefore\ \text{concentration} = (\text{moles} \times 1000) \div \text{volume}$$

$$\text{concentration} = (0.500 \times 1000) \div 125$$

$$\text{concentration of } KNO_3(aq) = \underline{4.00}\ \text{mol / dm}^3$$

Concentration of Aqueous Solution

- Question 3:

What volume of a 0.800 mol / dm^3 solution of iron(III) chloride (formula, $FeCl_3$) contains 2.00 mol of the salt?

Concentration of Aqueous Solution

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What volume of a 0.800 mol / dm^3 solution of iron(III) chloride (formula, $FeCl_3$) contains 2.00 mol of the salt?

moles = concentration × volume × 10^{-3}

∴ volume = (moles × 1000) ÷ concentration

volume = (2.00 × 1000) ÷ 0.800

volume of $FeCl_3$(aq) = 2500 cm^3

Concentration of Aqueous Solution

- Question 4:

A 355 cm^3 can of Coca-Cola® contains 39.0 g of sugar (formula, $C_{12}H_{22}O_{11}$). Calculate the mole concentration of sugar in the can of Coca-Cola®.

Concentration of Aqueous Solution

- Question 4:

A 355 cm^3 can of Coca-Cola® contains 39.0 g of sugar (formula, $C_{12}H_{22}O_{11}$). Calculate the mole concentration of sugar in the can of Coca-Cola®.

- Step 1: Calculate the relative molecular mass of $C_{12}H_{22}O_{11}$:

Concentration of Aqueous Solution

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- Step 1: Calculate the relative molecular mass of $C_{12}H_{22}O_{11}$:

$$M_r\ C_{12}H_{22}O_{11} = (12 \times 12) + (22 \times 1) + (11 \times 16)$$
$$= \underline{342}$$

Concentration of Aqueous Solution

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- Step 2: Calculate moles of $C_{12}H_{22}O_{11}$ in 39.0 g:

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$$= \underline{342}$$

- Step 2: Calculate moles of $C_{12}H_{22}O_{11}$ in 39.0 g:

$$\text{moles of } C_{12}H_{22}O_{11} = \text{mass in grams} \div M_r$$
$$= 39.0 \div 342$$
$$= \underline{0.114} \text{ mol}$$

Concentration of Aqueous Solution

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- Step 3: Convert the 0.114 mol of $C_{12}H_{22}O_{11}$ per 355 cm^3 into mol / dm^3:

Concentration of Aqueous Solution

- Question 4:

A 355 cm^3 can of Coca-Cola® contains 39.0 g of sugar (formula, $C_{12}H_{22}O_{11}$). Calculate the mole concentration of sugar in the can of Coca-Cola®.

- Step 3: Convert the 0.114 mol of $C_{12}H_{22}O_{11}$ per 355 cm^3 into mol / dm^3:

moles = concentration × volume × 10^{-3}

∴ concentration = (moles × 1000) ÷ volume

concentration = (0.114 × 1000) ÷ 355

concentration = 0.321 mol / dm^3 (3 s.f.)

Concentration of Aqueous Solution

- Question 5:

The balanced chemical equation for the reaction between hydrochloric acid and sodium carbonate is given below:

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

Calculate the volume in dm^3 of $CO_2(g)$ produced when 50.0 cm^3 of 5.00 mol /dm^3 HCl(aq) reacts with excess $Na_2CO_3(s)$.

Concentration of Aqueous Solution

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- Step 1: Calculate moles of HCl(aq) used.

Concentration of Aqueous Solution

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- Step 1: Calculate moles of HCl(aq) used.

moles of HCl(aq) used = $c \times v \times 10^{-3}$

moles of HCl(aq) used = $5.00 \times 50.0 \times 10^{-3}$

moles of HCl(aq) used = <u>0.250</u> mol

Concentration of Aqueous Solution

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- Step 2: Calculate moles of CO_2(g) produced

Concentration of Aqueous Solution

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Calculate the volume in dm^3 of $CO_2(g)$ produced when 50.0 cm^3 of 5.00 mol /dm^3 HCl(aq) reacts with excess $Na_2CO_3(s)$.

- Step 2: Calculate moles of $CO_2(g)$ produced

From the balanced chemical equation, 2 mol of HCl(aq) produce 1 mol of $CO_2(g)$, $\therefore$ 0.250 mol of HCl(aq) will produce $^1/_2 \times 0.250 = \underline{0.125}$ mol of $CO_2(g)$

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Calculate the volume in dm^3 of $CO_2(g)$ produced when 50.0 cm^3 of 5.00 mol /dm^3 HCl(aq) reacts with excess $Na_2CO_3(s)$.

- Step 3: Calculate the volume of $CO_2(g)$ produced

Concentration of Aqueous Solution

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- Step 3: Calculate the volume of $CO_2(g)$ produced

volume of gas in dm^3 = moles $\times$ 24

volume of $CO_2(g)$ = 0.125 $\times$ 24

volume of $CO_2(g)$ = <u>3.00</u> dm^3 (3 s.f.)

Concentration of Aqueous Solution

- Question 6:

The balanced chemical equation for the reaction between iron(III) chloride and sodium hydroxide is given below:

$$FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$$

Calculate the mass of $Fe(OH)_3(s)$ produced when 30.0 cm^3 of 2.00 mol / dm^3 NaOH(aq) reacts with an excess of $FeCl_3(aq)$.

Concentration of Aqueous Solution

- Question 6:

The balanced chemical equation for the reaction between iron(III) chloride and sodium hydroxide is given below:

$$FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$$

Calculate the mass of $Fe(OH)_3(s)$ produced when 30.0 cm^3 of 2.00 mol / dm^3 NaOH(aq) reacts with an excess of $FeCl_3(aq)$.

- Step 1: Calculate moles of NaOH(aq) used.

Concentration of Aqueous Solution

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- Step 1: Calculate moles of NaOH(aq) used.

moles of NaOH(aq) used = $c \times v \times 10^{-3}$

moles of NaOH(aq) used = $2.00 \times 30.0 \times 10^{-3}$

moles of NaOH(aq) used = 0.0600 mol

Concentration of Aqueous Solution

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Concentration of Aqueous Solution

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- Step 2: Calculate moles of $Fe(OH)_3(s)$ produced

From the balanced chemical equation, 3 mol of NaOH(aq) produce 1 mol of $Fe(OH)_3(s)$, $\therefore$ 0.0600 mol of NaOH(aq) will produce $^1/_3 \times 0.0600 = \underline{0.0200}$ mol of $Fe(OH)_3(s)$

Concentration of Aqueous Solution

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The balanced chemical equation for the reaction between iron(III) chloride and sodium hydroxide is given below:

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Calculate the mass of $Fe(OH)_3(s)$ produced when 30.0 cm^3 of 2.00 mol / dm^3 NaOH(aq) reacts with an excess of $FeCl_3(aq)$.

- Step 3: Calculate the mass of $Fe(OH)_3(s)$ produced

Concentration of Aqueous Solution

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Calculate the mass of $Fe(OH)_3$(s) produced when 30.0 cm^3 of 2.00 mol / dm^3 NaOH(aq) reacts with an excess of $FeCl_3$(aq).

- Step 3: Calculate the mass of $Fe(OH)_3$(s) produced

$$\text{mass in grams} = \text{moles} \times M_r$$

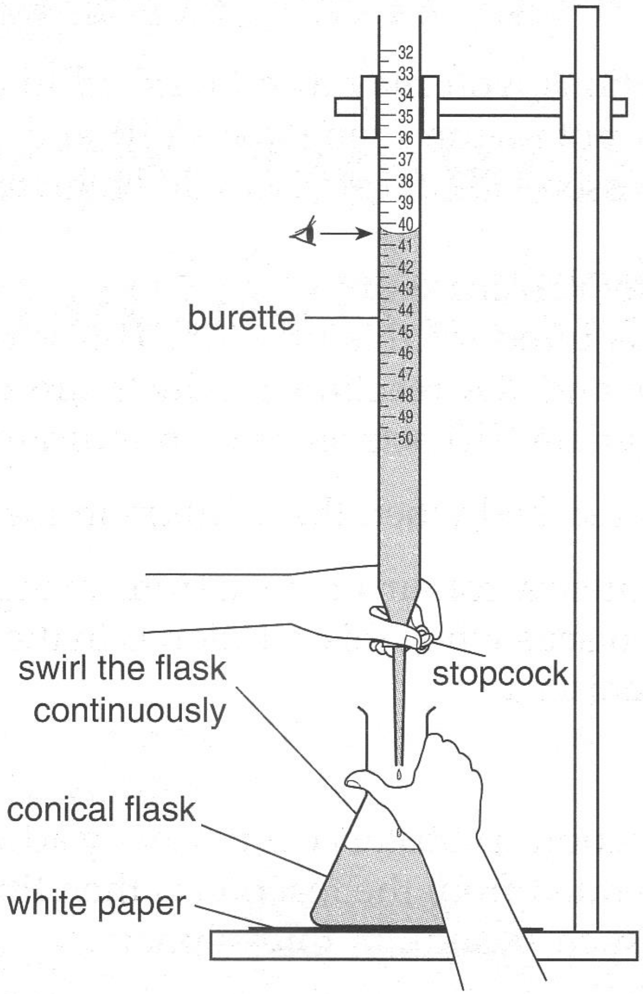
$$\text{mass of } Fe(OH)_3(s) = 0.0200 \times (56 + (3 \times (16 + 1)))$$

$$\text{mass of } Fe(OH)_3(s) = \underline{2.14}\text{ g (3 s.f.)}$$

Titration

What is a *titration*?

Titration



- Titration is a type of *quantitative analysis*. A known volume and concentration of solution **A** is reacted with a known volume of solution **B** in order to determine the concentration of solution **B**.

- For example, aqueous sulfuric acid reacts with aqueous potassium hydroxide according to the following balanced chemical equation:

$$H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

- If the concentration and volume of the aqueous sulfuric acid are known, and the volume of the aqueous potassium hydroxide is known, then the concentration of the aqueous potassium hydroxide can be calculated.

Titration

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Titration

- Question 7:

25.00 cm^3 of a 0.300 mol / dm^3 solution of sulphuric acid were exactly neutralised by 45.00 cm^3 of aqueous potassium hydroxide. Calculate the concentration of the aqueous potassium hydroxide.

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

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$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

- Step 1: Calculate the moles of H_2SO_4(aq) used:

Titration

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$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

- Step 1: Calculate the moles of $H_2SO_4(aq)$ used:

$$\text{moles} = c \times v \times 10^{-3}$$

$$\text{moles of } H_2SO_4 \text{ used} = 0.30 \times 25.00 \times 10^{-3} = \underline{0.0075}\ \text{mol}$$

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$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

- Step 2: With reference to the balanced chemical equation, calculate the moles of KOH(aq) used:

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$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

• Step 2: With reference to the balanced chemical equation, calculate the moles of KOH(aq) used:

from the balanced chemical equation, 1 mol of H_2SO_4 reacts with 2 mol of KOH

$\therefore$ 0.0075 mol of H_2SO_4 reacts with $^2/_1 \times 0.0075$ = <u>0.015 mol</u> of KOH

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$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

- Step 3: Convert the 0.015 mol of KOH(aq) per 45.00 cm^3 into mol / dm^3:

Titration

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25.00 cm^3 of a 0.300 mol / dm^3 solution of sulphuric acid were exactly neutralised by 45.00 cm^3 of aqueous potassium hydroxide. Calculate the concentration of the aqueous potassium hydroxide.

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

- Step 3: Convert the 0.015 mol of KOH(aq) per 45.00 cm^3 into mol / dm^3:

there are $0.015 \div 45.00 =$ <u>0.000333</u> mol of KOH in 1.00 cm^3 of solution

$\therefore$ there are $0.000333 \times 1000 = 0.333$ mol of KOH in 1000 cm^3 of solution, *i.e.* <u>0.333</u> mol / dm^3 (3 s.f.)

Titration

- Question 8:

The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^-) and aqueous iron(II) ions (Fe^{2+}) is given below:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{2+}(aq) + 4H_2O(l)$$

22.0 cm^3 of 0.0200 mol / dm^3 $MnO_4^-(aq)$ were found to react exactly with 25.0 cm^3 of $Fe^{2+}(aq)$. Calculate the mass concentration in g / mol of $Fe^{2+}(aq)$ as $FeSO_4(aq)$.

Titration

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The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^-) and aqueous iron(II) ions (Fe^{2+}) is given below:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{2+}(aq) + 4H_2O(l)$$

22.0 cm^3 of 0.0200 mol / dm^3 $MnO_4^-(aq)$ were found to react exactly with 25.0 cm^3 of $Fe^{2+}(aq)$. Calculate the mass concentration in g / mol of $Fe^{2+}(aq)$ as $FeSO_4(aq)$.

- Step 1: Calculate moles of $MnO_4^-(aq)$ used:

Titration

- Question 8:

The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^{-}) and aqueous iron(II) ions (Fe^{2+}) is given below:

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22.0 cm^3 of 0.0200 mol / dm^3 $MnO_4^{-}(aq)$ were found to react exactly with 25.0 cm^3 of $Fe^{2+}(aq)$. Calculate the mass concentration in g / mol of $Fe^{2+}(aq)$ as $FeSO_4(aq)$.

- Step 1: Calculate moles of $MnO_4^{-}(aq)$ used:

$$\text{moles} = c \times v \times 10^{-3}$$

$$\text{moles of } MnO_4^{-}(aq) \text{ used} = 0.0200 \times 22.0 \times 10^{-3}$$

$$\text{moles of } MnO_4^{-}(aq) \text{ used} = \underline{0.000440} \text{ mol}$$

Titration

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The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^-) and aqueous iron(II) ions (Fe^{2+}) is given below:

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- Step 2: With reference to the balanced chemical equation, calculate the moles of $Fe^{2+}(aq)$ used:

Titration

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- Step 2: With reference to the balanced chemical equation, calculate the moles of $Fe^{2+}(aq)$ used:

from the balanced chemical equation,
1 mol of $MnO_4^-(aq)$ reacts with 5 mol of $Fe^{2+}(aq)$,
$\therefore$ 0.000440 mol of $MnO_4^-(aq)$ react with $^5/_1 \times 0.000440$
= 0.00220 mol of $Fe^{2+}(aq)$

Titration

- Question 8:

The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^-) and aqueous iron(II) ions (Fe^{2+}) is given below:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{2+}(aq) + 4H_2O(l)$$

22.0 cm^3 of 0.0200 mol / dm^3 MnO_4^-(aq) were found to react exactly with 25.0 cm^3 of Fe^{2+}(aq). Calculate the mass concentration in g / mol of Fe^{2+}(aq) as $FeSO_4$(aq).

- Step 3: Convert the 0.00220 mol of Fe^{2+}(aq) per 25.0 cm^3 into mol / dm^3:

Titration

- Question 8:

The balanced chemical equation for the reaction between aqueous manganate(VII) ions (MnO_4^-) and aqueous iron(II) ions (Fe^{2+}) is given below:

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{2+}(aq) + 4H_2O(l)$$

22.0 cm^3 of 0.0200 mol / dm^3 $MnO_4^-(aq)$ were found to react exactly with 25.0 cm^3 of $Fe^{2+}(aq)$. Calculate the mass concentration in g / mol of $Fe^{2+}(aq)$ as $FeSO_4(aq)$.

- Step 3: Convert the 0.00220 mol of $Fe^{2+}(aq)$ per 25.0 cm^3 into mol / dm^3:

there are 0.00220 ÷ 25 = 0.0000880 mol of $Fe^{2+}(aq)$ in 1.00 cm^3 of solution

∴ there are 0.0000880 × 1000 = 0.0880 mol of $Fe^{2+}(aq)$ in 1000 cm^3 of solution, *i.e.* 0.0880 mol / dm^3

Titration

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- Step 4: Convert the mole concentration of $Fe^{2+}(aq)$ into a mass concentration for $FeSO_4(aq)$:

Titration

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- Step 4: Convert the mole concentration of $Fe^{2+}(aq)$ into a mass concentration for $FeSO_4(aq)$:

mass in grams = moles $\times$ M_r

mass of $FeSO_4$ = 0.0880 $\times$ (56 + 32 + (4 $\times$ 16))

mass of $FeSO_4$ = <u>13.376</u> g *i.e.* <u>13.4</u> g / dm^3 (3 s.f.)

Limiting Reagent

In a chemical reaction, what is meant by the term *limiting reagent*?

Limiting Reagent

- 18 Research Chemists need to wear gloves in order to do an experiment.
- 32 gloves (assume equal numbers of left and right) are available.
- How many chemists wear a pair of gloves?
- How many chemists are without a pair of gloves?
- How many gloves are left-over?
- What is available in excess?
- What is the limiting factor?

Limiting Reagent

- 18 Research Chemists need to wear gloves in order to do an experiment.
- 32 gloves (assume equal numbers of left and right) are available.
- How many chemists wear a pair of gloves? 16.
- How many chemists are without a pair of gloves? 2.
- How many gloves are left-over? 0.
- What is available in excess? Chemists.
- What is the limiting factor? Gloves.

Limiting Reagent

- 15 Research Chemists need to wear gloves in order to do an experiment.
- 44 gloves (assume equal numbers of left and right) are available.
- How many chemists wear a pair of gloves?
- How many chemists are without a pair of gloves?
- How many gloves are left-over?
- What is available in excess?
- What is the limiting factor?

Limiting Reagent

- 15 Research Chemists need to wear gloves in order to do an experiment.
- 44 gloves (assume equal numbers of left and right) are available.
- How many chemists wear a pair of gloves? 15.
- How many chemists are without a pair of gloves? 0.
- How many gloves are left-over? 14.
- What is available in excess? Gloves.
- What is the limiting factor? Chemists.

Limiting Reagent

- Sometimes, when two reagents are mixed together in the laboratory, one reagent may be added in *excess* while the other reagent will *limit* the amount of reaction product that is formed.

- The reagent that limits the amount of reaction product formed is known as the *limiting reagent*.

Limiting Reagent

- Consider the reaction between aqueous iron(III) chloride and aqueous sodium hydroxide:

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \rightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

- In a reaction, 2 mol of $FeCl_{3(aq)}$ are added to 5 mol of $NaOH_{(aq)}$. What is the limiting reagent?

Limiting Reagent

- Consider the reaction between aqueous iron(III) chloride and aqueous sodium hydroxide:

$$FeCl_{3(aq)} + 3NaOH_{(aq)} \rightarrow Fe(OH)_{3(s)} + 3NaCl_{(aq)}$$

- In a reaction, 2 mol of $FeCl_{3(aq)}$ are added to 5 mol of $NaOH_{(aq)}$. What is the limiting reagent?

- According to the balanced chemical equation, 1 mol of $FeCl_{3(aq)}$ reacts with 3 mol of $NaOH_{(aq)}$. Therefore 2 mol of $FeCl_{3(aq)}$ will react with $2 \times 3 = 6$ mol of $NaOH_{(aq)}$. However, only 5 mol of $NaOH_{(aq)}$ are available, therefore *$NaOH_{(aq)}$ is the limiting reagent*.

Percentage Composition

How can I determine the *percentage composition* of a mixture?

Percentage Composition

- Chemical reactions can be used to determine the *percentage composition* of a mixture. For example, the percentage calcium carbonate (formula, $CaCO_3$) in a rock sample can be determined by titration.

Percentage Composition

- A rock discovered on the surface of Mars is known to be a mixture of calcium carbonate and an inert mineral.
- 5.00 g of the rock is weighed out and powdered. The calcium carbonate in the rock is found to react exactly with 70.0 cm^3 of 1.00 mol / dm^3 hydrochloric acid.
- What percentage of the rock, by mass, is calcium carbonate?

Percentage Composition

- Step 1: Write a balanced chemical equation for the reaction between calcium carbonate and hydrochloric acid.

Percentage Composition

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$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Percentage Composition

- Step 1: Write a balanced chemical equation for the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

- Step 2: Calculate the number of moles of hydrochloric acid used.

Percentage Composition

- Step 1: Write a balanced chemical equation for the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

- Step 2: Calculate the number of moles of hydrochloric acid used.

moles = concentration $\times$ volume $\times$ 10^{-3}

moles HCl(aq) = 1.00 $\times$ 70.0 $\times$ 10^{-3}

moles of HCl(aq) = 0.070 mol

Percentage Composition

- Step 3: Calculate the number of moles of calcium carbonate that react with 0.070 mol of hydrochloric acid.

Percentage Composition

- Step 3: Calculate the number of moles of calcium carbonate that react with 0.070 mol of hydrochloric acid.

From the balanced chemical equation, 2 mol of HCl(aq) react with 1 mol of $CaCO_3$(s).

Therefore 0.070 mol of HCl(aq) will react with

$0.070 \times {}^{1}/_{2} = 0.035$ mol $CaCO_3$(s)

Percentage Composition

- Step 4: Calculate the mass in grams of calcium carbonate present in 0.035 mol.

Percentage Composition

- Step 4: Calculate the mass in grams of calcium carbonate present in 0.035 mol.

M_r of $CaCO_3(s)$
$= 40.0 + 12.0 + (3 \times 16.0)$
$= 100$

mass in grams = M_r × number of moles

mass of $CaCO_3(s) = 100 \times 0.035$
$= 3.50$ g

Percentage Composition

- Step 5: Express the 3.50 g of calcium carbonate as a percentage of the 5.00 g rock.

Percentage Composition

- Step 5: Express the 3.50 g of calcium carbonate as a percentage of the 5.00 g rock.

percentage $CaCO_3(s)$ in the rock
$= (3.50 \div 5.00) \times 100$
$= \underline{70.0}\ \%$ (3 s.f.)

Percentage Yield

What is meant by the term *percentage yield*?

Percentage Yield

- Not all chemical reactions go to completion, *i.e.* not all chemical reactions produce as much product as the amount calculated in theory.

Percentage Yield

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- For example, if a reaction that is *calculated to produce 80.0 g* of reaction product *only produces 60.0 g* of reaction product, then the percentage yield of the reaction is:

Percentage Yield

- Not all chemical reactions go to completion, *i.e.* not all chemical reactions produce as much product as the amount calculated in theory.

- For example, if a reaction that is *calculated to produce 80.0 g* of reaction product *only produces 60.0 g* of reaction product, then the percentage yield of the reaction is:

(experimental yield ÷ theoretical yield) × 100

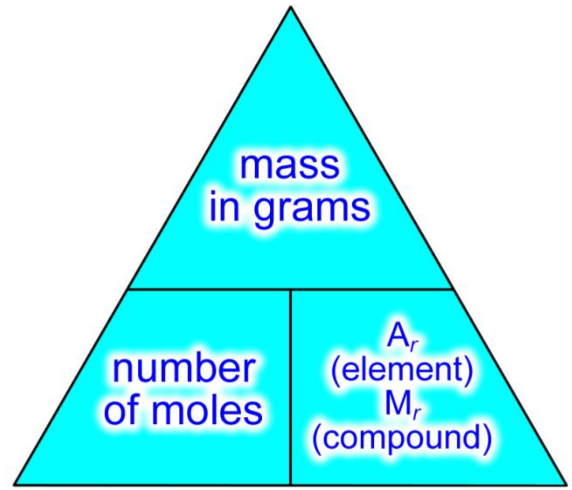
(60.0 ÷ 80.0) × 100

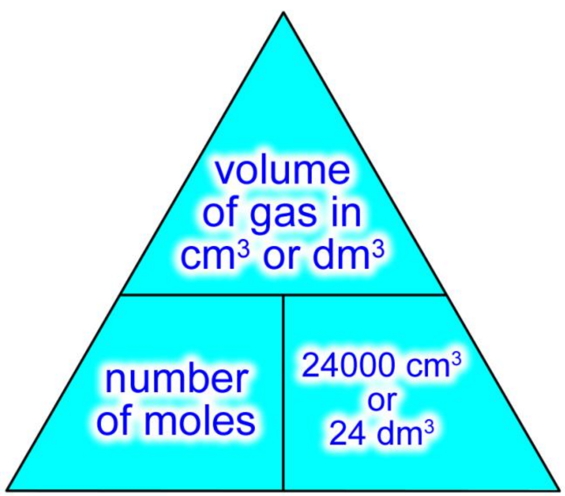
= 75.0 %

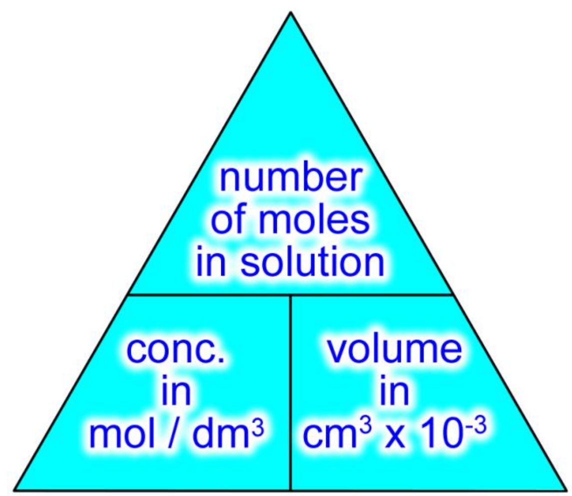
Concentration of Aqueous Solution

Could I please have a summary of the *formulae* that are used for *mole calculations*?

Summary of Mole Concept







Concentration of Aqueous Solution

Presentation on

Concentration of Aqueous Solution

by Dr. Chris Slatter
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31st July 2015


Take
What
You
Need
Love
Faith
Patience
Courage
Understanding
Peace
Passion
Health
Strength
Beauty
Freedom
Forgiveness
Kindness
Wisdom
Motivation
Hope