

## Solution and concentration calculations - answers at the end of the booklet

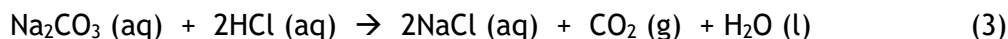
- a) Calculate the concentration of a solution (in  $\text{mol dm}^{-3}$ ) which contains 0.2 moles of sodium chloride dissolved in  $25\text{cm}^3$  (1)
- b) A solution of ammonium iodide ( $\text{NH}_4\text{I}$ ) is made by dissolving 2.9 grams in  $250\text{ cm}^3$  of water. Calculate the concentration of the solution in  $\text{mol dm}^{-3}$  (2)
- c) A solution of magnesium carbonate,  $\text{MgCO}_3$ , has a concentration of  $0.4\text{ mol dm}^{-3}$ . Calculate its concentration in  $\text{g dm}^{-3}$  (2)
- d) A solution was made by bubbling  $72\text{ cm}^3$  of ammonia gas (at room temperature and pressure) into  $50\text{ cm}^3$  of water. Calculate the concentration of the resulting solution assuming all the ammonia dissolved. (2)
- e) What mass of hydrated sodium carbonate,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ , must be dissolved in  $250\text{cm}^3$  of solution in order to give a concentration of  $0.0500\text{ mol dm}^{-3}$ ? (3)

## Calculations from experiments - answers at the end of the booklet

- a) What is the minimum volume of  $2.00\text{ mol dm}^{-3}$  hydrochloric acid needed to react with  $1.20\text{ g}$  magnesium carbonate,  $\text{MgCO}_3$ ?



- b)  $25.0\text{ cm}^3$  of a  $0.200\text{ mol dm}^{-3}$  solution of sodium carbonate was neutralised by  $20.0\text{ cm}^3$  of dilute hydrochloric acid. Find the concentration, in  $\text{g dm}^{-3}$ , of the acid using the equation for the reaction below.



- c) What volume of oxygen (at RTP) could be obtained from decomposition of  $100\text{ cm}^3$  of a  $2.00\text{ mol dm}^{-3}$  solution of hydrogen peroxide?



## Extension question (hints on the next page)

*This is a deliberately challenging question! The idea is to see how many parts of the calculation you are able to do - not necessarily to be able to get to the right answer straight away. On the next page the steps have been broken down for you.*

A sample of sodium hydrogen carbonate crystals,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ , had been heated too strongly and lost some of its waters of crystallisation.

2.696 g of the solid were dissolved in water and made up to  $250 \text{ cm}^3$  in a volumetric flask.

In a series of titrations,  $25.0 \text{ cm}^3$  portions of the solution were titrated with  $0.10 \text{ mol dm}^{-3}$  hydrochloric acid, giving the results shown below:

Titration number	1 (rough)	2	3
Final burette reading / $\text{cm}^3$	22.00	23.00	22.15
Initial burette reading / $\text{cm}^3$	1.00	2.35	1.60

Determine the percentage of loss of mass from the crystals using these titration results.

(10 marks)

# CK Science Tuition

Extension question - hints on how to break down this question  
(explanation will also be given on video)

**Step one:** analyse the titration results to find the number of moles of hydrochloric acid used.

- Work out the volume of acid added (the titre) for each of the three sets of titration results
- Choose only *concordant* results - they must differ by no more than  $0.2 \text{ cm}^3$ . (*hint - only two results are concordant*).
- Find the mean of these results to get your volume of acid in  $\text{cm}^3$ .
- Convert the volume to  $\text{dm}^3$  and use the concentration of acid given to work out number of moles of HCl in the titration volume.

**Step two:** use moles of acid in titration to work out moles of sodium carbonate in the solid sample.

- Write a balanced equation for the reaction between sodium carbonate and hydrochloric acid (use the formula  $\text{Na}_2\text{CO}_3$ , without the waters of crystallisation as these would just form part of the solution when the solid dissolves).
- Work out the moles of sodium carbonate in the  $25\text{cm}^3$  titration sample using the moles of acid and the ratio in the balanced equation.
- There would be 10x as many moles in the original solid sample, because it was made up to  $250\text{cm}^3$  and then only  $25\text{cm}^3$  samples were titrated.

**Step three:** work out how the mass of the sample has changed.

- Work out the Mr of the hydrated salt,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ .
- You know how many moles of  $\text{Na}_2\text{CO}_3$  there are in the sample, so you can work out the maximum mass of the sample - what it would be if all the water were still present.
- You know the actual mass of the sample, so you can work out how much mass was lost by heating.
- Now divide the mass lost by the original (maximum) mass to get the percentage of mass lost.

## Solution and concentration calculations - answers

- a) Calculate the concentration of a solution (in mol dm<sup>-3</sup>) which contains 0.2 moles of sodium chloride dissolved in 25cm<sup>3</sup> (1)  
 $25 / 1000 = 0.025 \text{ dm}^3$   
 $\text{Concentration} = 0.2 / 0.025 = 8.0 \text{ mol dm}^{-3}$
- b) A solution of ammonium iodide (NH<sub>4</sub>I) is made by dissolving 2.9 grams in 250 cm<sup>3</sup> of water. Calculate the concentration of the solution in mol dm<sup>-3</sup> (2)  
 $M_r \text{ NH}_4\text{I} = 145$   
 $\text{Moles} = 2.9 / 145 = 0.0200$        $\text{vol} = 250 / 1000 = 0.250 \text{ dm}^3$   
 $\text{Concentration} = 0.0200 / 0.25 = 0.0800 \text{ mol dm}^{-3}$
- c) A solution of magnesium carbonate, MgCO<sub>3</sub>, has a concentration of 0.4 mol dm<sup>-3</sup>. Calculate its concentration in g dm<sup>-3</sup> (2)  
 $M_r \text{ MgCO}_3 = 84$   
 $\text{Mass} = 84 \times 0.4 = 33.6$   
 $\text{Concentration} = 33.6 \text{ g dm}^{-3}$
- d) A solution was made by bubbling 72 cm<sup>3</sup> of ammonia gas (at room temperature and pressure) into 50 cm<sup>3</sup> of water. Calculate the concentration of the resulting solution assuming all the ammonia dissolved. (2)  
 $\text{Volume ammonia} = 72 / 1000 = 0.072 \text{ dm}^3$   
 $\text{Moles ammonia} = 0.072 / 24 = 0.003 \text{ mol}$   
*(you could also make this one step by dividing 72 by 24000)*  
 $\text{Volume solution} = 50 / 1000 = 0.05 \text{ dm}^3$   
 $\text{Concentration} = 0.003 / 0.05 = 0.06 \text{ mol dm}^{-3}$
- e) What mass of hydrated sodium carbonate, Na<sub>2</sub>CO<sub>3</sub>·10H<sub>2</sub>O, must be dissolved in 250cm<sup>3</sup> of solution in order to give a concentration of 0.0500 mol dm<sup>-3</sup>? (3)  
 $\text{Volume of solution} = 250/1000 = 0.25 \text{ dm}^3$   
 $\text{Moles} = 0.25 \times 0.05 = 0.0125$   
 $M_r \text{ Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} = 106 (\text{Na}_2\text{CO}_3) + 180 (10\text{H}_2\text{O}) = 286$   
 $\text{Mass} = 0.0125 \times 286 = 3.575 \text{ g}$

## Calculations from experiments - answers

- a) What is the minimum volume of 2.00 mol dm<sup>-3</sup> hydrochloric acid needed to react with 1.20 g magnesium carbonate, MgCO<sub>3</sub>?



$$M_r \text{ MgCO}_3 = 84$$

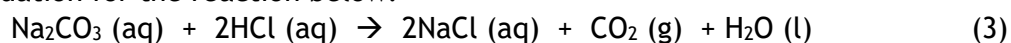
$$\text{Mol MgCO}_3 = 1.2 / 84 = 0.01429$$

$$\text{Mol HCl} = 0.01429 \times 2 = 0.02858$$

$$\text{Volume of HCl} = \text{moles} / \text{concentration} = 0.02858 / 2 = 0.01429 \text{ dm}^3$$

$$(\times 1000 = 14.29 \text{ cm}^3)$$

- b) 25.0 cm<sup>3</sup> of a 0.200 mol dm<sup>-3</sup> solution of sodium carbonate was neutralised by 20.0 cm<sup>3</sup> of dilute hydrochloric acid. Find the concentration, in g dm<sup>-3</sup>, of the acid using the equation for the reaction below.



Mol sodium carbonate =  $0.2 \times (25/1000) = 0.005$

Mol HCl =  $0.005 \times 2 = 0.01$

Concentration in mol dm<sup>-3</sup> =  $0.01 / (20/1000) = 0.5 \text{ mol dm}^{-3}$

M<sub>r</sub> HCl = 36.5

Concentration in g dm<sup>-3</sup> =  $0.5 \times 36.5 = 18.25 \text{ g dm}^{-3}$

- c) What volume of oxygen (at RTP) could be obtained from decomposition of 100 cm<sup>3</sup> of a 2.00 mol dm<sup>-3</sup> solution of hydrogen peroxide?



Volume hydrogen peroxide =  $100/1000 = 0.1 \text{ dm}^3$

Mol hydrogen peroxide =  $0.1 \times 2 = 0.2 \text{ mol}$

Mol oxygen =  $0.2 / 2 = 0.1 \text{ mol}$

Volume oxygen =  $0.1 \times 24 = 2.4 \text{ dm}^3$  OR  $2400 \text{ cm}^3$