

CHEMISTRY CALCULATIONS WS 3

Moles & Solutions

- 1 If 10.00 g of NaOH is dissolved in water and the volume is made up to 200.0 cm³, calculate the concentration in mol dm⁻³ and g dm⁻³.

g dm⁻³:
 We know 10g are present in 200cm³
 so xg will be in 1000cm³ (1dm³)
 The conc. is 50g dm⁻³

*M_r of NaOH = 23 + 16 + 1 = 40.
 50g of NaOH = $\frac{50}{40} = 1.2 \text{ mol}$.*

1.2 mol dm⁻³

- 2 Calculate the number of moles of HCl present in 50.0cm³ of 2.00 mol dm⁻³ hydrochloric acid.

*2 mol in 1 dm³
 x in 50 cm³*

x = 0.1 mol

or

$$n = CV$$

$$= \frac{50}{1000} \times 2$$

$$n = 0.1 \text{ moles}$$

- 3 Calculate the number of moles of chloride ions present in 50.0cm³ of a 0.0500 mol dm⁻³ solution of iron(III) chloride (FeCl₃) and the total concentration of all the ions present.

$$n \text{ of FeCl}_3 = \frac{0.05}{1000} \times 50 = 2.5 \times 10^{-3} \text{ mol}$$

$$n \text{ of Cl}^- = 3 \times 2.5 \times 10^{-3} = 7.5 \times 10^{-3} \text{ mol}$$

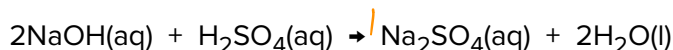
$$n \text{ of ions} = 2.5 \times 10^{-3} \times 4 = 0.01 \text{ mol}$$

$$0.01 \text{ mol in } 50 \text{ cm}^3$$

$$\text{That's } 0.2 \text{ mol dm}^{-3}$$

- 4 Sulfuric acid is titrated against 25.00cm³ of 0.2000 mol dm⁻³ sodium hydroxide solution; 23.20 cm³ of sulfuric acid is required for neutralisation. Calculate the concentration of the sulfuric acid.

These are the moles of NaOH present & NaOH : H₂SO₄ = 2 : 1

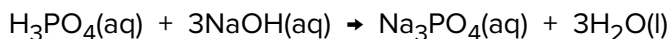


$$25 \text{ cm}^3 \text{ of } 0.2 \text{ mol dm}^{-3} \text{ is } = \frac{0.2 \times 25}{1000} = 5 \times 10^{-3} \text{ mol}$$

$$n \text{ of H}_2\text{SO}_4 \text{ used} = \frac{5 \times 10^{-3}}{2} = 2.5 \times 10^{-3} \text{ mol}$$

$$\text{conc of H}_2\text{SO}_4 = \frac{n}{V} = \frac{2.5 \times 10^{-3}}{23.2/1000} = 0.107 \text{ mol dm}^{-3}$$

- 5 For neutralisation, 25.00 cm³ of phosphoric(V) acid (H₃PO₄) requires 28.70 cm³ of NaOH of concentration 0.1500 mol dm⁻³. What is the concentration of the phosphoric(V) acid?



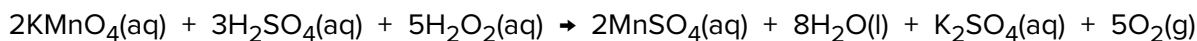
$$n \text{ in } 28.7 \text{ cm}^3 \text{ of } 0.15 \text{ mol dm}^{-3} \text{ of NaOH} = \frac{0.15 \times 28.7}{1000} = 4.3 \times 10^{-3} \text{ mol}$$

$$n \text{ of H}_3\text{PO}_4 = \frac{4.3 \times 10^{-3}}{3} = 1.43 \times 10^{-3} \text{ mol are in } 25 \text{ cm}^3$$

$$C = \frac{1.43 \times 10^{-3}}{25/1000}$$

$$= 0.057 \text{ mol dm}^{-3}$$

6 Acidified potassium manganate(VII) oxidises hydrogen peroxide to produce oxygen:



If 45.00 cm³ of 0.020 mol dm⁻³ KMnO₄ is reacted with excess H₂O₂ and H₂SO₄, calculate the volume of O₂ produced (at RTP).

$0.02 \text{ mol dm}^{-3} = \frac{\eta}{(45/1000) \text{ dm}^3}$
 $\eta = 0.9 \times 10^{-3} \text{ mol}$
mol of KMnO₄ ↑

$\text{KMnO}_4 : \text{O}_2$
 $2 : 5$
 $0.9 \times 10^{-3} : 2.25 \times 10^{-3} \text{ mol of O}_2 \text{ produced.}$
 $V = \eta \times 24 \text{ dm}^3 = 54 \times 10^{-3} \text{ dm}^3 \text{ or } 54 \text{ cm}^3$

7 Work out the numbers of moles present in the following solutions:

a. 20.0 cm³ of 0.220 mol dm⁻³ NaOH(aq)

$0.22 \text{ mol in } 1000 \text{ cm}^3$
 so $4.4 \times 10^{-3} \text{ mol in } 20 \text{ cm}^3$

$4.4 \times 10^{-3} \text{ mol Ans.}$

OR... $\eta = CV$
 $= \frac{0.22}{1000} (20)$
 $= 4.4 \times 10^{-3} \text{ mol.}$

b. 27.8 cm³ of 0.0840 mol dm⁻³ HCl(aq)

$0.084 \text{ mol} \rightarrow 1000 \text{ cm}^3$
 $2.33 \times 10^{-3} \text{ mol} \rightarrow 27.8 \text{ cm}^3$

$2.33 \times 10^{-3} \text{ mol}$
 OR...

$\eta = CV$
 $= \frac{0.084}{1000} \times 27.8$
 $= 2.33 \times 10^{-3} \text{ mol}$

c. 540 cm³ of 0.0200 mol dm⁻³ KMnO₄(aq)

$\eta = CV$
 $= \frac{0.02}{1000} \times 540 = 10.8 \times 10^{-3} \text{ mol}$

8 If 29.70 cm³ of sulfuric acid of concentration 0.2000 mol dm⁻³ is required for neutralisation of 25.00 cm³ of potassium hydroxide solution, calculate the concentration of the potassium hydroxide solution.

$2\text{KOH}(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
 $\eta_{\text{H}_2\text{SO}_4} = \frac{29.7 \times 0.2}{1000} = 5.94 \times 10^{-3} \text{ mol.}$
 $\eta_{\text{KOH}} = 11.88 \times 10^{-3} \text{ mol}$
This is present in 25 cm³, in 1 dm³

$\text{Conc} = \frac{11.88 \times 10^{-3} \times 1000}{25}$
 $= 0.475 \text{ mol dm}^{-3}$

9 Calcium carbonate is reacted with 50.0 cm³ of 0.500 mol dm⁻³ hydrochloric acid.



a. What mass of calcium carbonate is required for an exact reaction?

$\eta \text{ of HCl} = \frac{(0.5 \text{ mol. dm}^{-3})(50 \text{ cm}^3)}{1000 \text{ cm}^3 \text{ dm}^{-3}} = 0.025 \text{ mol}$
 $\eta \text{ of CaCO}_3 = \frac{0.025}{2} = 0.0125 \text{ mol}$
 $\text{Mass of CaCO}_3 = (0.0125)(40.1 + 12 + 48)$
 $= 1.25 \text{ g used.}$

- a. If 10.00g of hydrated copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) is dissolved in water and made up to a volume of 250.0 cm^3 , what is the concentration of the solution?

$$M_r \text{ of } \text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 159.6 + 90 = 249.6$$

$$\eta \text{ CuSO}_4 = \eta \text{ CuSO}_4 \cdot 5\text{H}_2\text{O} = \frac{10}{249.6} = 0.04006 \text{ mol}$$

0.04006 is in 250 cm^3
0.1602 will be in 1000 cm^3

$$C = 0.160 \text{ mol dm}^{-3}$$

- b. What mass of anhydrous copper sulfate would be required to make 250.0 cm^3 of solution with the same concentration as in a?

$$M_r \text{ CuSO}_4 = 159.6$$

$$\eta \text{ required} = 0.04006 \text{ mol}$$

$$\text{That quantity in grams is} = 159.6 \times 0.04006 = 6.39 \text{ g}$$

- * 13 A 3.92 g sample of hydrated sodium carbonate ($\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$) was dissolved in water and made up to a total volume of 250.0 cm^3 . Of this solution, 25.00 cm^3 was titrated against $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, and 27.40 cm^3 of the acid was required for neutralisation. Calculate the value of x in $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

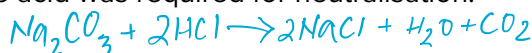
$$M_r \text{ of } \text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} = 106 + 18x$$

$$M_r \text{ of HCl} = 36.5$$

$$\eta \text{ of HCl} = \frac{0.1 \times 27.4}{1000} = 2.74 \times 10^{-3} \text{ mol}$$

$$\eta \text{ of } \text{Na}_2\text{CO}_3 = 1.37 \times 10^{-3} \text{ mol}$$

$$\text{mass of } \text{Na}_2\text{CO}_3 = 0.145 \text{ g was present in the } 25 \text{ cm}^3 \text{ sol of } \text{Na}_2\text{CO}_3$$



1.45g were in the 250 cm^3

$$\text{Na}_2\text{CO}_3 : x \text{ H}_2\text{O}$$

$$1.45 \text{ g} : 2.47 \text{ g}$$

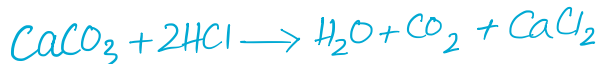
$$0.01368 \text{ mol} : 0.137 \text{ mol}$$

$$1 : 10$$

$$x = 10.$$

divided by M_r to get moles.

- 14 Limestone is impure calcium carbonate (CaCO_3): 2.00 g of limestone is put into a beaker and 60.00 cm^3 of $3.000 \text{ mol dm}^{-3}$ hydrochloric acid is added. They are left to react and then the impurities are filtered off and the solution is made up to a total volume of 100.0 cm^3 . Of this solution, 25.00 cm^3 requires 35.50 cm^3 of $1.000 \text{ mol dm}^{-3}$ sodium hydroxide for neutralisation. Work out the percentage CaCO_3 in the limestone (assume that none of the impurities reacts with hydrochloric acid).

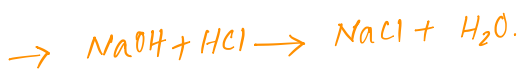


$$\eta \text{ of HCl} = C \cdot V = \frac{3 \times 60}{1000} = 0.18 \text{ mol}$$

$$\eta \text{ of NaOH} = \frac{1 \times 35.5}{1000} = 0.0355 \text{ mol}$$

$$\eta \text{ of HCl in } 25 \text{ cm}^3 = 0.0355 \text{ mol}$$

$$\eta \text{ HCl in } 100 \text{ cm}^3 = 0.0355 \times 4 = 0.142 \text{ mol}$$



Left over HCl after it reacted with CaCO_3 .

If the sample was 100% CaCO_3 , then 2g would be 0.02 mol which would react with 0.04 mol of HCl. 100 cm^3 of sol contains the left over HCl.

Amount of HCl that actually reacted = $0.182 - 0.142 = 0.038 \text{ mol}$

mol of $\text{CaCO}_3 = \frac{0.038}{2} = 0.019 \text{ mol}$

mass $\text{CaCO}_3 = 0.019 \times 100.1 = 1.9019 \text{ g}$

% by mass of $\text{CaCO}_3 = \frac{1.9019}{2} \times 100 = 95.1\% \text{ Ans}$

- 15 A 25.0 cm^3 sample of a solution of copper(II) nitrate is added to 10.0 cm^3 of 1 mol dm^{-3} potassium iodide. The iodine produced is titrated against $0.0200 \text{ mol dm}^{-3}$ sodium thiosulfate solution using starch indicator near the end point. 22.50 cm^3 of the sodium thiosulfate solution was required for the titration. Calculate the concentration of the copper(II) nitrate solution.



$$n \text{ of KI} = \frac{1 \times 10}{1000} = 0.01 \text{ mol}$$



$$n \text{ of Na}_2\text{S}_2\text{O}_3 = \frac{0.02 \times 22.5}{1000} = 450 \times 10^{-6} \text{ mol}$$

$$n \text{ of I}_2 = 2.25 \times 10^{-4} \text{ mol} \quad \leftarrow \begin{matrix} \times \frac{1}{2} \\ \times 2 \end{matrix}$$

$$n \text{ Cu}(\text{NO}_3)_2 = 450 \times 10^{-6} \text{ mol}$$

$$\text{Conc.} = \frac{450 \times 10^{-6}}{25/1000} = 0.018 \text{ mol dm}^{-3}$$