

Back Titrations

Usually performed to find the % purity of an impure substance (x). In each of the following examples substance x is added to an excess quantity of acid. The acid that does not react with substance x is titrated with a bases. We can find the number of moles of substance x that reacted, and therefore, find the mass using the molar mass.

1. 4.06 g of impure magnesium oxide (MgO, molar mass = 40.30) was completely dissolved in 100ml of 2.0M HCl (in excess). The excess acid required 19.7ml of 0.20M NaOH for neutralisation. Calculate the % purity of the magnesium oxide.

Step 1 – Find the number of moles of acid ($n=cv$)

$$\text{Moles HCl} = 2 \times 0.100 = 0.200 \text{ moles}$$

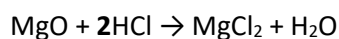
Step 2 – Find the number of moles of base ($n=cv$)

$$\text{Moles NaOH} = 0.20 \times 0.0197 = 3.94 \times 10^{-3} \text{ moles}$$

Step 3 – Find the number of moles of MgO using the excess moles of acid

$$\text{Excess moles HCl} = 0.200 - (3.94 \times 10^{-3} \times \frac{1}{1}) = 0.196 \text{ moles (HCl 1:1 NaOH)}$$

Moles of MgO :



$$0.196 \times \frac{1}{2} = 0.098 \text{ moles}$$

Half as many moles of MgO are needed to neutralise the acid

Step 4 – Calculate the mass of MgO using the molar mass

$$0.098 \text{ moles} \times 40.30 = 3.95\text{g}$$

Step 5 – Calculate the % purity

$$(3.95 / 4.06) \times 100 = 97.3\%$$

2. 150ml of 0.2105M nitric acid (HNO₃) was added to 1.3415g CaCO₃. The excess acid was back titrated with 0.1055M NaOH, it required 75.5ml to reach the end point. Calculate the percentage mass of CaCO₃ in the sample.

Step 1 – Find the number of moles of acid (n=cv)

$$\text{Moles HNO}_3 = 0.2105 \times 0.150 = 0.031575 \text{ moles}$$

Step 2 – Find the number of moles of base (n=cv)

$$\text{Moles NaOH} = 0.1055 \times 0.0755 = 7.97 \times 10^{-3} \text{ moles}$$

Step 3 – Find the moles of CaCO₃ using the excess moles of acid

$$\text{Excess moles HNO}_3 = 0.031575 - (7.97 \times 10^{-3} \times \frac{1}{1}) = 0.023605 \text{ moles}$$

Multiplied by 1 over 1 as HNO₃ and NaOH react 1:1

Moles of CaCO₃:



$$0.023605 \times \frac{1}{2} = 0.0118 \text{ moles}$$

Half as many moles of CaCO₃ are needed to neutralise the acid

Step 4 – Calculate the mass of CaCO₃ using the molar mass

$$0.0118 \text{ moles} \times 100.09 = 1.181\text{g}$$

Step 5 – Calculate the % purity

$$(1.181 / 1.3415) \times 100 = 88\%$$

3. 2.76 g sample of dolomite containing CaCO_3 and MgCO_3 is dissolved in 80ml of 1 M HCl solution. The solution is then diluted to 250ml. 25ml of this solution requires 20ml of 0.1M NaOH solution for complete neutralisation. Calculate the % composition of the sample. (molar mass of $\text{CaCO}_3 = 100.09$, molar mass of $\text{MgCO}_3 = 84.31$)

Step 1 – Find the number of moles of acid ($n=cv$)

$$\text{Moles HCl} = 1 \times 0.08 = 0.08 \text{ moles}$$

Step 2 – Find the number of moles of base ($n=cv$)

$$\text{Moles NaOH} = 0.1 \times 0.02 = 0.002 \text{ moles}$$

In this question 25ml of the 250ml solution was titrated with NaOH.

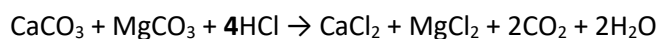
Therefore, (0.002×10) moles of NaOH are needed to neutralise all 250ml

Step 3 – Find the moles of CaCO_3 and MgCO_3 using the excess moles of acid

NaOH and HCl react 1:1

$$0.08 - (0.02 \times \frac{1}{1}) = 0.06 \text{ moles}$$

The excess moles of acid were neutralised by the CaCO_3 and MgCO_3



$$\text{Moles of CaCO}_3 = 0.06 \times \frac{1}{4} = 0.015 \text{ moles}$$

$$\text{Moles of MgCO}_3 = 0.06 \times \frac{1}{4} = 0.015 \text{ moles}$$

Step 4 – Find grams using molar mass

$$\text{CaCO}_3 = 0.015 \times 100.09 = 1.50\text{g}$$

$$\text{MgCO}_3 = 0.015 \times 84.31 = 1.26\text{g}$$

Step 5 - % composition

This questions asks for the % of each substance

$$\text{CaCO}_3 = (1.50\text{g} / 2.76) \times 100 = 54.35\%$$

$$\text{MgCO}_3 = (1.26\text{g} / 2.76) \times 100 = 45.65\%$$

4. A 1.435 g sample of dry CaCO_3 and CaCl_2 mixture was dissolved in 25.00 mL of 0.9892 M HCl solution. What was CaCl_2 percentage in original sample, if 21.48 mL of 0.09312 M NaOH was used to titrate excess HCl? (molar mass of $\text{CaCO}_3 = 100.09$, molar mass of $\text{CaCl}_2 = 110.98$)

Step 1 – Find the number of moles of acid ($n=cv$)

$$\text{Moles HCl} = 0.9892 \times 0.025 = 0.02473 \text{ moles}$$

Step 2 – Find the number of moles of base ($n=cv$)

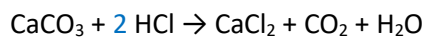
$$\text{Moles of NaOH} = 0.09312 \times 0.02148 = 0.002 \text{ moles}$$

Step 3 – Find the moles of CaCO_3 using the excess moles of acid

$$\text{Excess moles of HCl} = 0.02473 - (0.002 \times \frac{1}{1}) = 0.02273 \text{ moles}$$

Multiplied by $\frac{1}{1}$ as NaOH and HCl react 1:1

Moles of CaCO_3



$$0.02273 \times \frac{1}{2} = 0.011365 \text{ moles}$$

Multiplied by $\frac{1}{2}$ as half as many moles of CaCO_3 are needed to neutralise the acid

The CaCl_2 that was originally in the sample does not react with the HCl

Step 4 – Calculate the mass of CaCO_3 to find the mass of CaCl_2

$$\text{Mass of CaCO}_3 = 0.011365 \times 100.09 = 1.138$$

$$\text{Mass of CaCl}_2 = 1.435 - 1.138 = 0.297\text{g}$$

Step 5 – Calculate CaCl_2 percentage in the original sample

$$(0.297 / 1.435) \times 100 = 20.7\%$$