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)

Moles HCl = 2 x 0.100 = 0.200 moles

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

Moles NaOH = 0.20 x 0.0197 = 3.94×10^{-3} moles

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

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

Moles of MgO :

$MgO + \mathbf{2}HCl \rightarrow MgCl_2 + H_2O$

$0.196 \times \frac{1}{2} = 0.098$ 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 moles x 40.30 = 3.95g

Step 5 – Calculate the % purity

(3.95 / 4.06) x 100 = 97.3%

2. 150ml of 0.2105M nitric acid (HNO_3) was added to 1.3415g $CaCO_3$. The excess acid was back titrated with 0.1055M NaOH, it required 75.5ml to reach the end point. Calculate the percentage mass of $CaCO_3$ in the sample.

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

Moles HNO_3 = 0.2105 x 0.150 = 0.031575 moles

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

Moles NaOH = 0.1055 x 0.0755 = 7.97×10^{-3} moles

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

Excess moles HNO_3 = 0.031575 – ($7.97 \times 10^{-3} \times \frac{1}{1}$) = 0.023605 moles

Multiplied by 1 over 1 as HNO_3 and NaOH react 1:1

Moles of $CaCO_3$:

$CaCO_3 + \mathbf{2}HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$

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

Half as many moles of $CaCO_3$ are needed to neutralise the acid

Step 4 – Calculate the mass of $CaCO_3$ using the molar mass

0.0118 moles x 100.09 = 1.181g

Step 5 – Calculate the % purity

(1.181 / 1.3415) x 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 $CaCO_3$ = 100.09, molar mass of $MgCO_3$ = 84.31)

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

Moles HCl = 1 x 0.08 = 0.08 moles

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

Moles NaOH = 0.1 x 0.02 = 0.002 moles

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

Therefore, (0.002 x 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 x $\frac{1}{1}$) = 0.06 moles

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

$CaCO_3 + MgCO_3 + \mathbf{4}HCl \rightarrow CaCl_2 + MgCl_2 + 2CO_2 + 2H_2O$

Moles of $CaCO_3$ = 0.06 x $\frac{1}{4}$ = 0.015 moles

Moles of $MgCO_3$ = 0.06 x $\frac{1}{4}$ = 0.015 moles

Step 4 – Find grams using molar mass

$CaCO_3$ = 0.015 x 100.09 = 1.50g

$MgCO_3$ = 0.015 x 84.31 = 1.26g

Step 5 - % composition

This questions asks for the % of each substance

$CaCO_3$ = (1.50g / 2.76) x 100 = 54.35%

$MgCO_3$ = (1.26g / 2.76) x 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 $CaCO_3$ = 100.09, molar mass of $CaCl_2$ = 110.98)

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

Moles HCl = 0.9892 x 0.025 = 0.02473 moles

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

Moles of NaOH = 0.09312 x 0.02148 = 0.002 moles

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

Excess moles of HCl = 0.02473 – (0.002 x $\frac{1}{1}$) = 0.02273 moles

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

Moles of $CaCO_3$

$CaCO_3 + 2\ HCl \rightarrow CaCl_2 + CO_2 + H_2O$

0.02273 x $\frac{1}{2}$ = 0.011365 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 reacted with the HCl

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

Mass of $CaCO_3$ = 0.011365 x 100.09 = 1.138

Mass of $CaCl_2$ = 1.435 – 1.138 = 0.297g

Step 5 – Calculate $CaCl_2$ percentage in the original sample

(0.297 / 1.435) x 100 = 20.7%