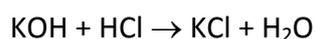


## Chemistry 91161 Carry out quantitative analysis

### Titration calculations – made simple

1. Average three (or more) titration values (mL) that are within 0.20 mL of each other. You need three for E!
2. Divide average titre by 1000 to turn it to L.
3. Multiply volume of this “stuff” by the concentration of this “stuff” to find the amount of this “stuff”, in mol. Or in other words  $n = cV$
4. Use the mol ratio to find the amount in mol,  $n$ , of the other chemical. You will be given the balanced equation.
5. Divide by the volume of this other chemical (in L) to find  $c$  (since  $c = n/V$ ). Write the final answer to 3 s.f. and put the units as  $\text{mol L}^{-1}$ .

E.g.  
 10.0 mL of a solution of potassium hydroxide was titrated with a  $0.105 \text{ mol L}^{-1}$  solution of hydrochloric acid. The titre values for the acid were 17.20, 17.10, 17.50 and 17.20 mL of the acid for neutralisation. Calculate the concentration of the potassium hydroxide solution. The equation for the reaction is:-



- 17.20, 17.10, 17.50 and 17.20 mL – average these 3. (You can average more than 3 if you wish if you have them, as long as they are within 0.20 mL from the smallest to the biggest).
- Average volume = 17.17 mL (I recommend that you keep all the figures in calculator to the end....i.e. 17.166666666)
- Average volume = 0.01717 L
- $n(\text{HCl}) = c \times V = 0.105 \times 0.01717 = 1.80285 \times 10^{-3} \text{ mol}$  (There is no need to write to 3 s.f. yet.....)
- KOH and HCl react in a 1 : 1 ratio, so....
- $n(\text{KOH}) = 1.80285 \times 10^{-3} \text{ mol}$  also (still keep the number in your calculator!!)
- Remember 10.0 mL of KOH is 0.0100 L
- $c(\text{KOH}) = n/V = 1.80285 \times 10^{-3} / 0.0100 = 0.180285 = 0.180 \text{ mol L}^{-1}$  (3 sf)

	HCl	KOH
c	$0.105 \text{ mol L}^{-1}$	③ find $C = n/V$ $0.00180285/0.0100 = 0.180285 \text{ mol L}^{-1}$
V	0.01717 L	0.0100 L
n	① $n = CV$ 0.00180285 mol	② find n by mol ratio 0.00180285 mol

④ Write answer to 3 sf with correct units  $0.180 \text{ mol L}^{-1}$  (3 sf)

The non 1 : 1 calculations will either be 2 : 1 or 1 : 2 ratios. So at step 2 you will need to either  $\times 2$  or  $\div 2$ . Which one depends on what you need to find e.g.

$\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow \text{etc}$	If you know $n(\text{Na}_2\text{CO}_3)$ and need to find $n(\text{HCl})$ , then $\times 2$
	If you know $n(\text{HCl})$ and need to find $n(\text{Na}_2\text{CO}_3)$ , then $\div 2$

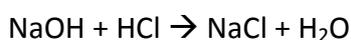
LET'S LOOK AT IT ANOTHER WAY....

It's as easy as n, n, c (okay it's not as easy as A, B, C but it's close enough).

1. Find n of the stuff you know 2 things about (its c and V)
2. Find n of the other stuff, taking into account the mole ratio
3. Find c of this other stuff, since you now have V and n
4. Write it to 3 s.f. and put the units **mol L<sup>-1</sup>** on it and you are done!! (Watch out you don't write the units as mol<sup>-1</sup> or mol<sup>-1</sup>!!! Trust me – we have seen it happen and it's WRONG!!!)

Sample calculation: Standardising a solution of sodium hydroxide using a standard solution of hydrochloric acid.

Titrate 20.0 mL aliquots of sodium hydroxide solution using 0.0950 mol L<sup>-1</sup> hydrochloric acid.



	Rough	1	2	3	4
Final volume (mL)	21.16	41.21	20.75	40.95	20.50
Initial volume (mL)	0.10	21.16	0.60	20.75	0.30
Volume used (mL)	21.06	20.05	20.15	20.20	20.20

Select at least three concordant results:

You could select 20.05 mL and 20.15 mL and 20.20 mL and 20.20 mL, or you might decide to just use the last three (20.15 mL, 20.20 mL and 20.20 mL).

Alternatively this student could have chosen to stop after titration 3 as 20.05 mL, 20.15 mL and 20.20 mL are all within 0.2 mL of each other.

The student could even use 20.05 mL and 20.20 mL and 20.20 mL but you have to wonder why they would choose to discard the 20.15 mL.

You must show which values you have selected.

$$V(\text{HCl}) = (20.05 + 20.15 + 20.20 + 20.20) / 4$$

$$V(\text{HCl}) = 20.15 \text{ mL} = 0.02015 \text{ L}$$

1.  $n(\text{HCl}) = cV = 0.0950 \times 0.02015 = 0.00191425 \text{ mol}$
2.  $n(\text{NaOH}) = 0.00191425 \text{ mol}$
3.  $c(\text{NaOH}) = n/V = 0.00191425 / 0.0200 = 0.0957125$  so  $c(\text{NaOH}) = 0.0957 \text{ mol L}^{-1}$

	HCl	NaOH
c	0.0950 mol L <sup>-1</sup>	③ 0.0957 mol L <sup>-1</sup>
V	0.02015 mL	0.0200 mL
n	① 0.00191425 mol	② 0.00191425 mol

### Key words

Aliquot - fixed volume of solution delivered by a pipette.

Burette - delivers a volume between 0.00 and 50.00 mL.

Concordant – consistent values ; within small (acceptable) differences of other values for A, M or E.

Conical flask - flask with sloping sides which avoid loss of solutions due to splashing.

End point - point in the titration at which the indicator changes colour.

Equivalence point - when the amount of acid/base has been neutralised by the base/acid.

Funnel - used to fill the burette; must be removed before you start the titration

Indicator - chemical that changes colour with a change in pH; for acid-base titrations we often use phenolphthalein.

Pipette - used to deliver an exact volume (eg 10.00 mL, 20.00 mL, 25.00 mL, etc).

Titration - volumetric analysis using burettes and pipettes to accurately determine the concentration of a substance.

Titre - the volume of solution delivered by the burette to reach equivalence point.

Wash bottle - contains distilled water to rinse out flask between titrations and to wash splashes down the inside of the conical flask during titration.

### Titration procedure

- All glass apparatus should be clean. If not wash with tap water and rise with distilled water.
- Rinse the pipette with the solution it is to contain to remove any water clinging to the inside of the pipette, which would otherwise dilute the solution you are pipetting.
- Rinse the burette with the solution it is to contain to remove any water clinging to the inside of the burette, which would otherwise dilute the solution you are using.
- Fill the burette with the solution remembering to fill the jet and check there are no air bubbles in it.
- Using the pipette, transfer an aliquot (eg 20.00 mL (titres to 2 d.p)) of the solution into the conical flask.
- Add 3 or 4 drops of indicator to the conical flask.
- Carry out a rough titration by adding approximately 1 mL portions of the solution from the burette, with constant swirling of the conical flask, until the indicator changes colour. This titre gives you a rough estimate of the volume required.
- Repeat the titration with constant swirling of the flask, but add 1 mL less than was used in the rough titration. Then, carefully add one or two drops of solution at a time from the burette until a colour change is observed. Swirl the conical flask after each addition of the solution from the burette and use the deionised water from the wash-bottle to rinse any solution on the side of the flask into acid-base mixture.
- Using phenolphthalein the colour change is colourless to pink (if base is added to acid) or pink to colourless (if acid is added to base).
- Read the burette to 2 decimal places.
- Repeat the titrations until at least three concordant results are obtained.