

TITRATIONS

413 Team 2

19

If acid is added to base the curves are flipped horizontally

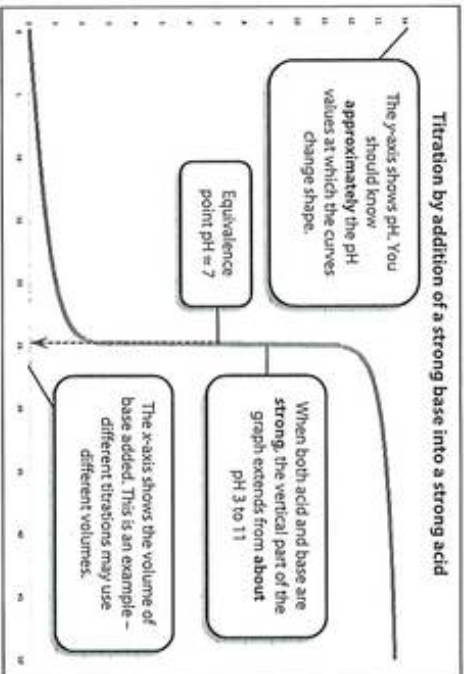
Titration by addition of a strong base into a strong acid

The y-axis shows pH. You should know approximately the pH values at which the curves change shape.

When both acid and base are strong, the vertical part of the graph extends from about pH 3 to 11

The x-axis shows the volume of base added. This is an example – different situations may use different volumes.

Equivalence point pH = 7



Indicator	pH range of colour change
Methyl orange	3.2 to 4.4
Phenolphthalein	8.2 to 10.0
Bromophenol blue	3.0 to 4.6
Litmus	5.0 to 8.0

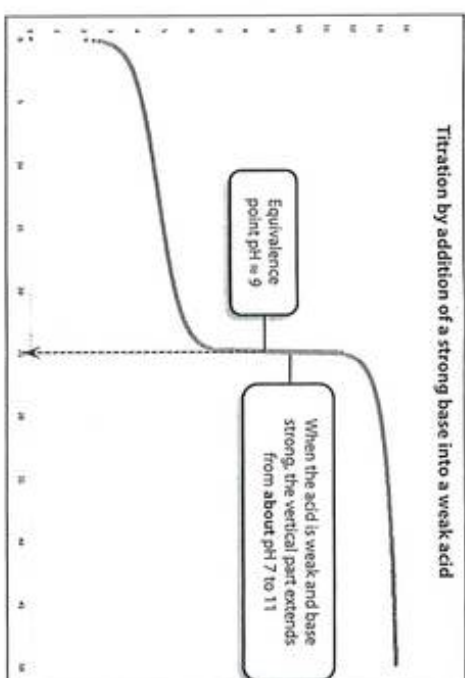
EXAM TIP
You do not need to remember any of these values

SELECTING INDICATORS FOR ACID-BASE TITRATIONS

Titration by addition of a strong base into a weak acid

Equivalence point pH = 9

When the acid is weak and base strong, the vertical part extends from about pH 7 to 11

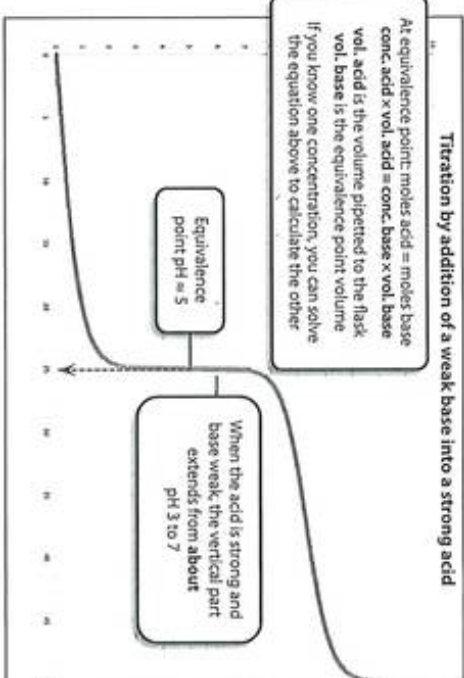


Titration by addition of a weak base into a strong acid

At equivalence point: moles acid = moles base
 $\text{conc. acid} \times \text{vol. acid} = \text{conc. base} \times \text{vol. base}$
vol. acid is the volume pipetted to the flask
vol. base is the equivalence point volume
If you know one concentration, you can solve the equation above to calculate the other

Equivalence point pH = 5

When the acid is strong and base weak, the vertical part extends from about pH 3 to 7



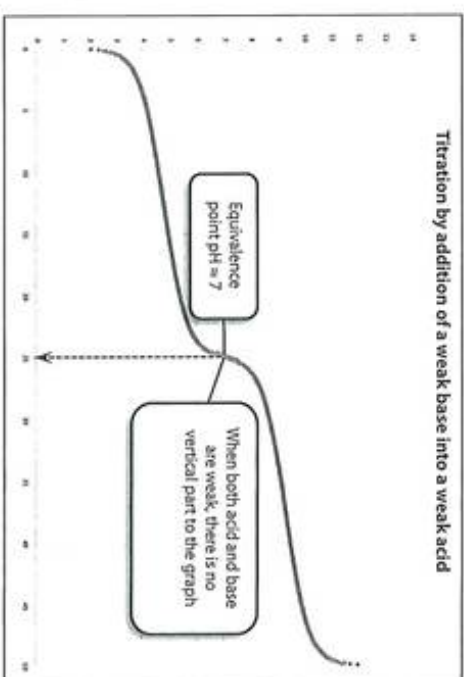
EXAM TIP

You need to know the shapes of the curves shown here. You may be asked to sketch the shape, explain the shape or use the shape to select an indicator that would change colour at the end point.

Titration by addition of a weak base into a weak acid

Equivalence point pH = 7

When both acid and base are weak, there is no vertical part to the graph



The end point is where the indicator changes colour. It should be the same as the equivalence point for an accurate titration.

An acid-base indicator is a weak acid – an equilibrium mixture of an ionised and unionised form where the two forms are of different colours. The structure of methyl orange in its protonated and deprotonated forms is shown on the right. By Le Chatelier's principle, when acid is added, $[\text{H}^+]$ increases and the position of equilibrium moves left (more red). When base is added, $[\text{H}^+]$ decreases and the position of equilibrium moves right (more yellow). If pH < 3.1, methyl orange appears red; if pH > 4.4, it appears yellow; if pH is between 3.1 and 4.4, it looks orange.

Different acid-base indicators are different colours in different pH ranges. To accurately indicate the equivalence point of a titration, they must change colour over a range of pH values that is within the vertical part of the titration curve. Methyl orange will work well for the titration of a strong acid as the vertical part of the curve begins at a pH value less than 3.1 and ends above 4.4. However, for weak acids, methyl orange will indicate an inaccurate equivalence point. The pH will increase above 3.1 after only a small amount of base is added – increasing gradually as more base is added and eventually rising above 4.4 before all of the acid has been neutralised. So, the colour will start to change (to orange) before the equivalence point in the titration has been reached.

Titration of weak acids with strong bases have a vertical part of the curves from about pH 7 to 11. The table above shows phenolphthalein changes colour within this range and would be a suitable indicator.

When both acid and base are weak, it is not possible to perform a titration with an indicator. There is no vertical part to the graph, and so no indicator would change colour at the equivalence point.

