

Acid - base titration with conductivity sensor



Apparatus

Conductivity sensor - set to 100mS range.
50 ml capacity burette
2 x 200 ml beakers
Magnetic stirrer and follower (flea).
20 cm³ of 0.1 mol dm⁻³ Sodium Hydroxide (NaOH)
40 cm³ of 0.1 mol dm⁻³ Hydrochloric acid (HCl)
Measuring cylinders (50 ml capacity)
Funnel (small)
Retort stand and burette clamp or boss and clamps,

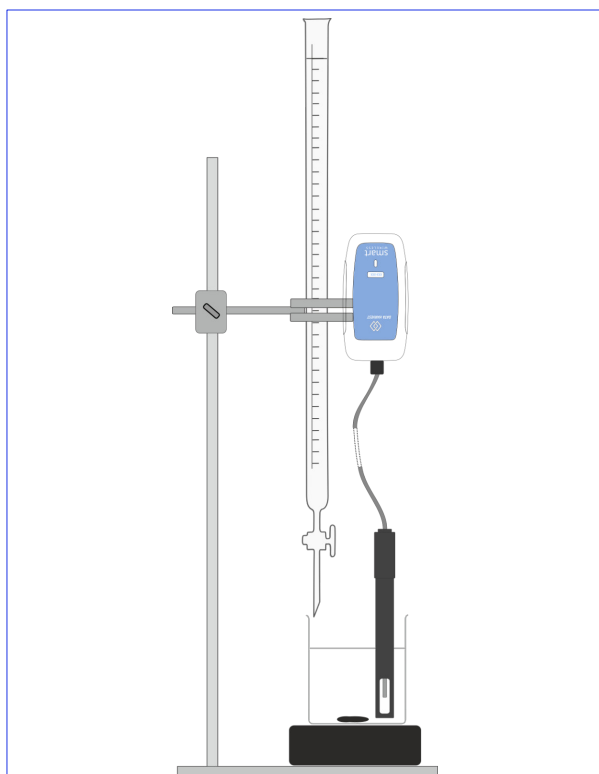
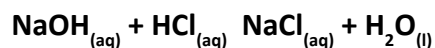
Data recording setup.

Snapshot.
Prompt for value ON
Series name Volume
Series unit cm³

Introduction

When you carry out a simple acid base titration, you use an indicator to tell you when the end point of the reaction between the acid and base has been reached. The end point is when the colour of the indicator used has a colour halfway between its extreme colours. Usually in titration experiments the indicator is chosen to make the end point coincide with the equivalence point. The equivalence point is the point when the reaction between the acid and alkali is just complete. A conductivity sensor will be used to monitor for the equivalence point (lowest point of conductivity). The experiment will use acid (Hydrochloric) and alkali (Sodium hydroxide) of the same molar strength (0.1 mol dm⁻³).

The equation of the reaction is,



Over the course of the titration, the number of free ions and their identity will change. As a result the conductance of the cell containing the solution will change as the titration is performed. When the ions are balanced the conductance will be zero or very low (water will produce ions and there is a tolerance in the sensor)

This represents a generic setup for the use of the conductivity sensor for a titration.

A beaker is used to give space for the apparatus.

The wireless conductivity electrode has a lead to connect it to the sensor body, the conductivity sensor can be positioned wherever is convenient.

Calibrating the Conductivity sensor.

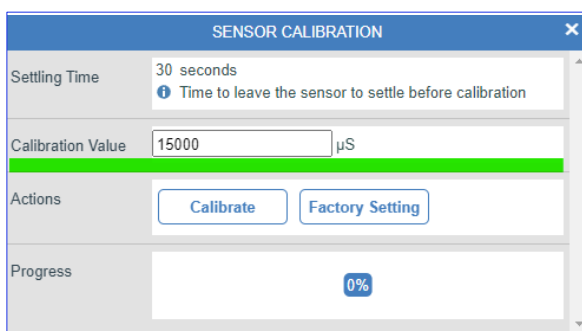
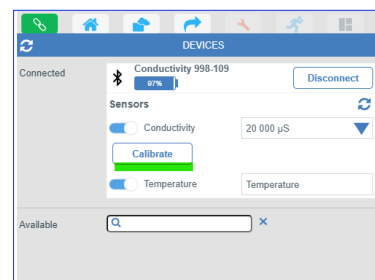
(This may have already been done for you)

It is recommended that you connect the conductivity sensor to an “alive” sensor body and place the electrode in de-ionised water for 20 minutes prior to use. This will wet the conductivity plates and reduce contamination from previous use.

You will need to connect the sensor to the ES2 software to make the electrode live. You do not have to record any data. This stage can take place before the units are given to the class.

To calibrate the sensor - electrode pairing,

1. Activate the electrode as described above.
2. Prepare a solution of known conductivity (this can be a purchased standard or one made)
3. Connect the sensor - electrode combination to the software



4. Select the devices icon and then the “calibrate” button in the conductivity sensor section.
5. A new box will open
6. Place the electrode into the standard and leave until the readings from the sensor settle.
7. Over type the calibration value with the “known” value of the standard.
8. Select the calibrate button and wait for the progress button to go to 100%.

Calibration notes

Use a fresh standard for each calibration.

The electrodes can be seen at the bottom of the electrode as a pale grey patch, use enough solution to cover the patches and “half as much again”.

The calibration is for a unique combination of the sensor body and the electrode, if a different electrode is used the calibration needs to be removed or re-done.

For an exercise like the one being described, consider if the calibration is necessary. All the practical needs to find is the volume of titrant added at the point of minimal conductivity. The conductivity value is of no other importance and its magnitude is of no importance.

Data collection setup

Mode = Snapshot

Manual entry = Prompt for value on each sample

Series name = Volume

Series unit = cm³

Note

- Super and sub scripts are not available for text entry.
- Students can use alternatives e.g. burette reading etc.
- The value added will be the meniscus value of the burette



Practical notes.

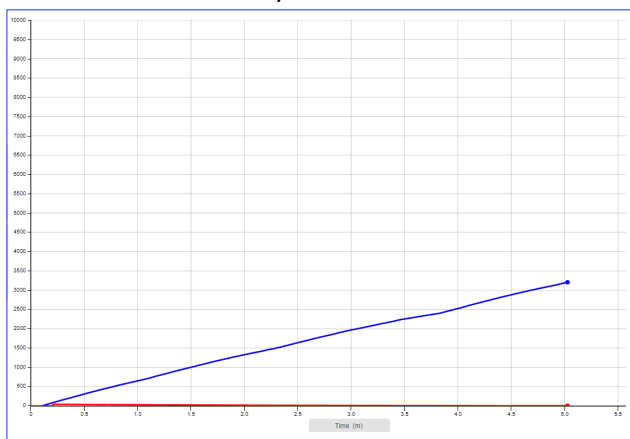
When entering the volume added, you are entering the **total** volume added to that point; read the volume directly off the burette and enter it into the dialogue box. Try to be accurate to the burette, if the burette indicates you have added 39.7 cm^3 , enter that as the value not 40.

If the conductivity gives its maximum reading for the first part of the experiment this is not a problem, we are looking for the electrical neutral point which will be revealed as the experiment continues.

For best accuracy in the end point, the volume added from the burette should change when the titration reaches about 8 cm^3 in total (with the solutions indicated, the neutral point should be 10 cm^3). This is because the solutions are equal molar and will neutralise with equal volumes (assuming the molar value for each solution is accurate and equal)

Method

1. If required, calibrate the sensor against a known standard.
2. Set up the apparatus as suggested in the diagram.
3. Connect the Conductivity sensor to the software, check the range is correct for the practical activity. We would suggest 100 mS (you may want to change this if you do a second high accuracy titration)
4. Put the acid and the water together in a large beaker and position under the burette, position the conductivity electrode so it is secure and will not spill the apparatus. Check the volume of acid and water covers the open cell of the electrode.
5. Fill the beaker with the alkali and level to read an exact zero (not it is not normal to have alkali in the burette, so check you have the solutions the right way round for this activity)
6. Use the details in this sheet to set up a snapshot recording that prompts for the value of the burette.
7. Select start, and when prompted enter the start value of the burette.
8. Run 10 cm^3 from the burette into the beaker, let the conductivity value settle, record the next value. Repeat, as the volume of the burette gets closer to the volume of acid added run a smaller amount to increase the "granularity" of the data (this will give a better estimate of the equivalence point).
9. Once conductivity has started to increase, add at least 20 cm^3 and select stop, save the data. The additional addition is to ensure you have recorded the true conductivity minima.



Example data.

An example data set.

When data is collected with snapshot it will often default to Bar Chart layout.

Convert to line graph by selecting the grey icon to the top left of the chart area and selecting the sine wave icon in the list of options given.

In this case the axis are at default.

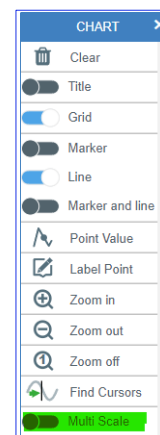
Change the axis to scale independent of each other and set to min - max.

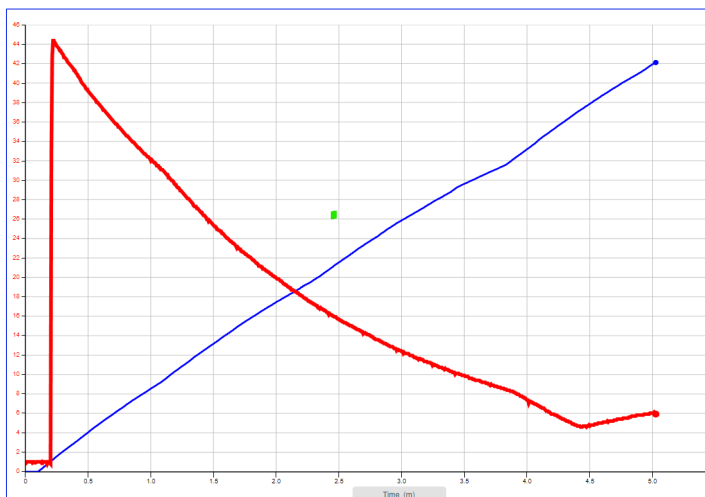
To set the axes to independent select the three stacked dots to the top right of the chart and select multi - scale option.

With this option the axis label(s) will show you which scale is in use, select the axis label to change the scale axis.

Use the Values tool to align to the minimum conductivity point and read off the Volume.

To interpolate the value use the Cross - hair tool.





By using each axis size as independent of each other you can maximise the scale for each data set and bring out the detail.

The graph should show a V shaped line, the point of the V represents the point when the hydrogen ions are no longer being replaced by the sodium ions. The sharp rise in conductance after this point represents the increase in conductance due to the addition of hydroxide ions to the solution.

If you wish a volume - conductivity plot, click on the axis labels and select the item you wish to be on the x or y axis.

Questions

The conductance of a cell will depend upon:

- The number of free ions in the cell
- The number of charges on the ion
- The speed at which the ions can move

1. What factors will affect the speed at which the ions move?
2. When conductance is plotted against the volume of the solution added how will the end point be determined?
3. Why is the extra distilled water added to the hydrochloric acid before the titration begins?
4. Explain the shape of the graph in terms of the molar conductivity of the ions.
5. What are the most useful applications of conductance measurements for the determination of end points?