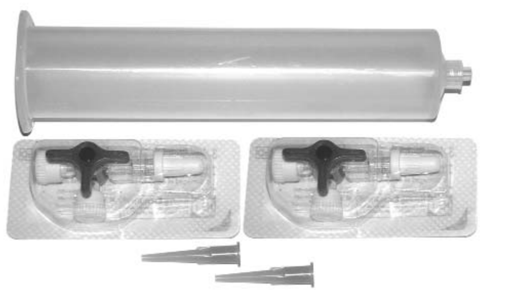

Drop / Bubble Counter

(Product No. 3266)

Ranges:
1. Drop / Bubble Count: 0 - 10 000
2. Volume (23 drops/cm^3) 0 - 120 cm^3
3. Volume (24 drops/cm^3) 0 - 120 cm^3
4. Volume (25 drops/cm^3) 0 - 120 cm^3
5. Volume (26 drops/cm^3) 0 - 120 cm^3
6. Volume (27 drops/cm^3) 0 - 120 cm^3
7. Volume (28 drops/cm^3) 0 - 120 cm^3
8. Volume (29 drops/cm^3) 0 - 120 cm^3

DATA HARVEST

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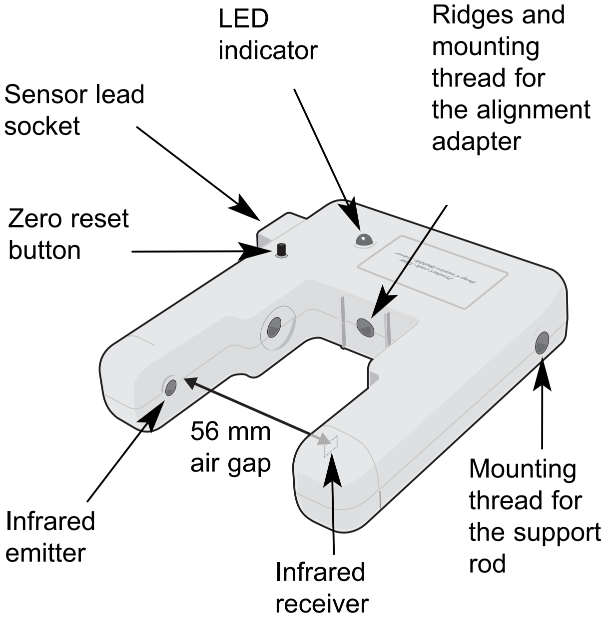
DS 066 No 1

Introduction

The *Smart Q* Drop / Bubble Counter can be used to count either drops of fluid falling from a dropping device e.g. during a titration, or bubbles rising through fluid in a column.

The *Smart Q* Drop / Bubble Counter has an infrared emitter and a receiver separated by a 56 mm air gap. When the light beam from the emitter is interrupted (e.g. by a drop or bubble) it creates a digital signal that is counted by the Sensor's internal counter module.

The red LED is an indicator, which will blink as a drop or bubble passes through the infrared beam. There is a small button close to the indicator that can be pressed to reset a count to zero.



The *Smart Q* Drop / Bubble Counter is equipped with a microcontroller that greatly improves its accuracy, precision and consistency. The microcontroller contains the calibration for each range.

The ranges are:

- The **Drop / Bubble Count** range. The absolute number of drops or bubbles detected as they pass through the infrared beam is counted. Data is displayed as the total number of drops or bubbles rather than volume.

  Note: *If the number of drops per cm^3 is known, data can be converted into volume in cm^3 using the Function Wizard in the Graph program of Sensing Science Laboratory software.*

- The preset calibrated **Volume** ranges, which are 23 drops/cm^3, 24 drops/cm^3, 25 drops/cm^3, 26 drops/cm^3, 27 drops/cm^3, 28 drops/cm^3 and 29 drops/cm^3. When any of these ranges are selected the drops counted are automatically converted and displayed as volume in cm^3.

The stored calibration for the selected range will be automatically loaded into the *EasySense* unit when the Drop / Bubble Counter is connected.

The Drop / Bubble Counter is supplied with:

- A steel support rod (80 mm long x 10 mm diameter with a M6 thread). This support rod can be screwed into the mounting threads, which are found at the base and sides of the Sensor. The rod can be used for clamping into a suitable holding device.

- A plastic reagent reservoir (syringe body), two 3-way stopcock fittings and two plastic tips (all with twist fittings).
- An alignment adapter with securing screw. This adapter is used to align drops from the reagent reservoir into the Sensors light beam.

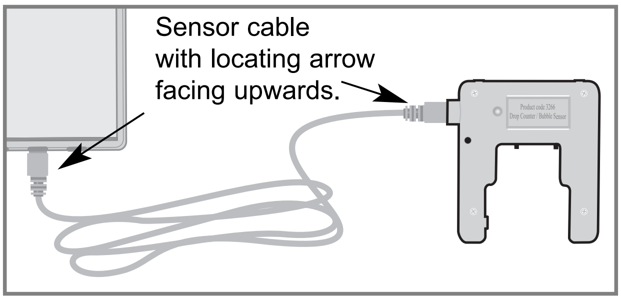
Investigations

Acid-base titrations – used as a Drop Counter with the *Smart Q* pH Sensor to record a pH vs. volume graph e.g. sodium hydroxide with hydrochloric or ethanoic acid, ammonia with hydrochloric or ethanoic acid, sodium carbonate with hydrochloric acid, etc.

Conductometric titrations - used as a Drop Counter with the *Smart Q* Conductivity Sensor to record conductivity vs. volume graph e.g. the equivalence point of barium hydroxide and sulphuric acid, sodium hydroxide with hydrochloric acid, ethanoic acid with sodium hydroxide, potassium chloride with silver nitrate, etc.

Gas evolution investigations - used as a Bubble Counter in e.g. rate of reaction of marble chips and hydrochloric acid, catalytic decomposition of hydrogen peroxide, yeast fermentation of sucrose, etc.

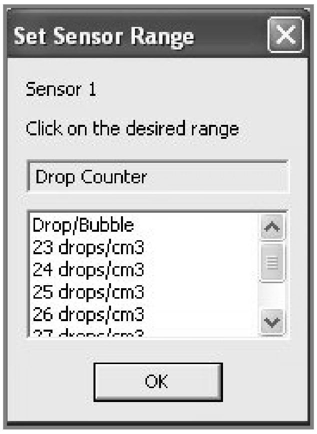
Connecting



- Hold the *Smart Q* Drop / Bubble Counter housing with the sensor description label showing. Connect one end of the sensor cable (supplied with the *EasySense* unit) into the shaped socket on the Sensor with the locating arrow on the cable facing upwards.
- Connect the other end of the sensor cable to the Input socket on the *EasySense* unit (with the locating arrow facing upwards). The red LED will light. The *EasySense* unit will detect that the Drop / Bubble Counter is connected.
- Select the range most suitable for your investigation.
  Press the button next to the LED indicator to reset the Drop / Bubble Counter to zero.

To set the range

The required range can be set by using the Sensor Configuration application in the Sensing Science program.



- Connect the *Smart Q* Drop / Bubble Counter to the *EasySense* unit and run the Sensor Configuration program.
- Select the number of the input that the sensor is connected to from the list.
- Click on the Set Range button. The current range will be highlighted.
- Select the required range and click on OK.

Exit the program. The sensor range setting will be retained until reselected.

With some *EasySense* units (i.e. those with LCD screens) it is possible to set the range from the unit. Please refer to the *EasySense* unit's user manual.

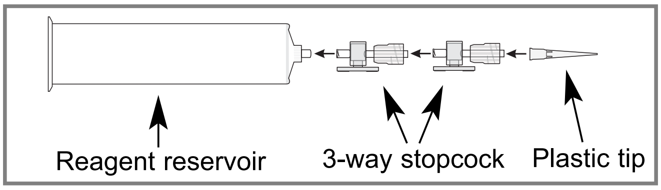
Using the Drop / Bubble Counter to count drops

Setting up the reagent reservoir and alignment adapter

Any type of dropping device can be used for your experiments. The plastic reagent reservoir and tip supplied with the Drop / Bubble Counter will provide drops within the preset calibration ranges. The reservoir has two stopcocks. One stopcock is used to set the rate of flow from the reservoir and therefore the drop rate. The other stopcock is used to turn the drops on and off. The reservoir is only used to hold the reagent so a volume scale has not been provided.

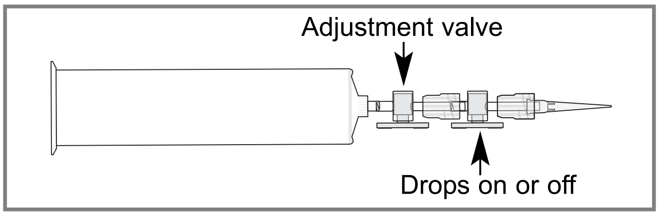
Assemble the plastic reagent reservoir

Screw a stopcock fitting onto the syringe body with a gentle half turn. Fit the second stopcock onto the first, then the tip. Turn both threaded collars to secure the fittings in place (twist back to release).

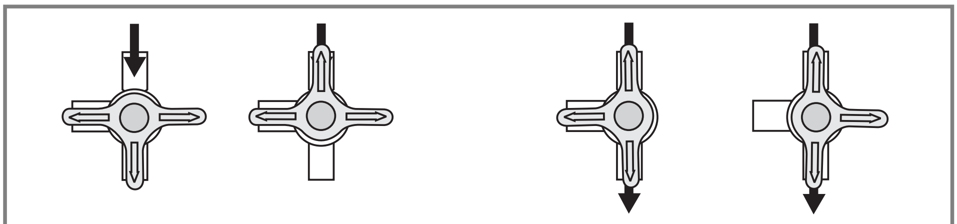


The combination of two three-way stopcocks is used to control the flow of fluid from the reservoir. The line of the blue handle indicates the ports of the stopcock that are linked and open.

Note: *Leave the white sealing blank fitted to the side port of the stopcock.*



- The top stopcock is used as an adjustment valve to set the rate of flow and therefore the drop rate from the reservoir.
- The lower stopcock is used in either an open or closed position to turn the drops on and off.



Turn both stopcocks into the closed position. The reagent reservoir can now be clamped into place using the alignment adapter.

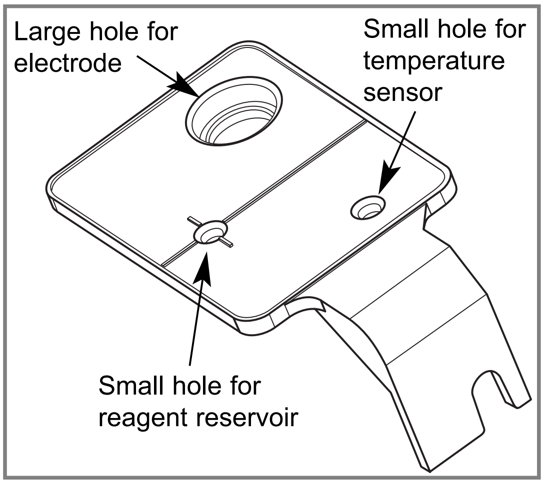
Using the alignment adapter

The alignment adapter has been provided to give an easy way of aligning drops through the light beam of the Drop / Bubble Counter.

The adapter has three holes in its flat plate.

1. The large hole will accept a pH or Conductivity electrode.
2. The small hole marked with ‘target’ lines is for the tip of the reagent reservoir or burette.
3. The other small hole is suitable for a Temperature Sensor (if used).

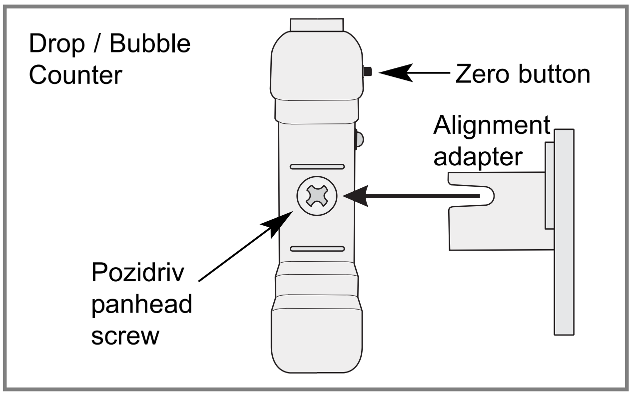
Note: *The holes in the adapter plate have been arranged to allow Sensors to be positioned in a 250 ml squat beaker without interfering with a stir bar.*



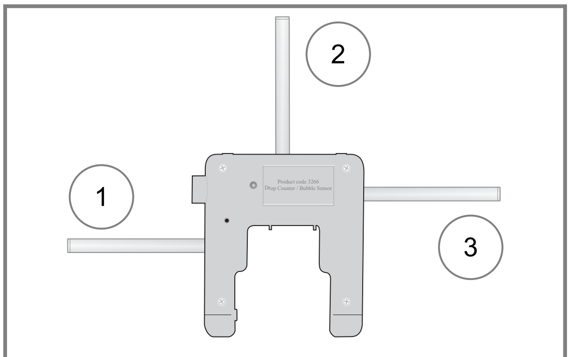
Attach the alignment adapter to the Drop / Bubble Counter:

- Part screw the Pozidriv pan-head screw supplied into the mounting thread between the two ridges in the centre of the Sensor.

- Slide the mounting arm of the adapter behind the screw head.
- Gently tighten the screw, do **not** over tighten.



Screw the support rod into the appropriate mounting thread (there is a choice of three positions) and clamp to a stand. Make sure the Sensor is level and the LED indicator is visible to the user.



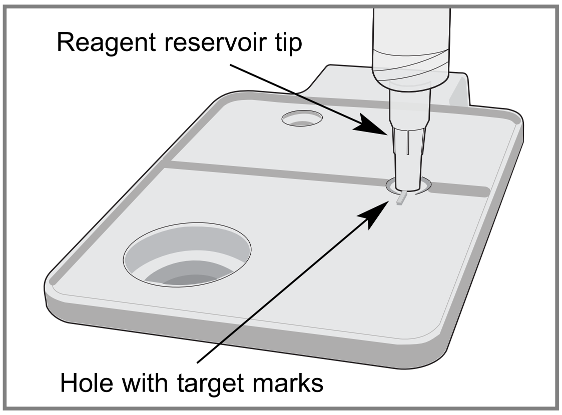
Support rod positions

Position the reagent reservoir in the alignment adapter

Locate the tip of the reagent reservoir into the hole that has 'target marks' around it. When correctly seated the tip will be visible below the adapter plate.

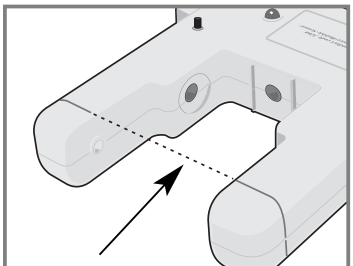
Use a clamp to support the body of the reservoir. Do not over tighten. Check the reservoir is vertical.

The drops produced will fall through and cut the light beam without further adjustment.



If the reagent reservoir and alignment adapter are not used

On the housing of the Drop / Bubble Counter there is an indented line above the emitter and receiver. The dropper should be aligned so that falling drops will cut through an imaginary line drawn between these indents. The LED on the Sensor will blink each time a drop interrupts the beam. Use the LED to help align the drops.



Note: *If a burette with a single stopcock is used then it is difficult to control the drop rate as the stopcock is also used to stop the flow of fluid. Some burettes have replaceable tips and it is possible to use a length of plastic tubing to link the tip to the burette. In this case a tubing clamp can be used to crimp the tubing and shut off the flow. A bung inserted into the top of a burette can be used as a 'stop' to prevent flow.*

Calculating the 'drop' range to use

The *Smart Q* Drop / Bubble Counter can be used to

1. Count the number of drops that pass through the Sensors light beam - go to page 2 and select the Drop / Bubble count range.
2. Display the data directly as a volume in cm^3 measurement by selecting one of the preset calibrated ranges - 23 drops/cm^3, 24 drops/cm^3, 25 drops/cm^3, 26 drops/cm^3, 27 drops/cm^3, 28 drops/cm^3 and 29 drops/cm^3. Go to page 2 and select the appropriate range.
3. Count the numbers of drops in a cm^3 for your set up (see page 7) and then select that value (e.g. 25 drops/cm^3) from the preset ranges (see page 2).
4. Count the number of drops (using the Drop / Bubble count range) and then convert this value into volume in cm^3. You will first need to calculate the number of drops in a cm^3 for your set up (see page 7), then use this value to convert the number of drops to cm^3 (see page 12).

The volume of a drop of fluid (and therefore the number of drops per cm^3) depends on a number of factors. These include the:

- Size and shape of the dropper end.
- Type of solution (its density, viscosity and surface tension).
- Flow rate of the liquid through the dropper end (the slower the dropping the smaller the drop).

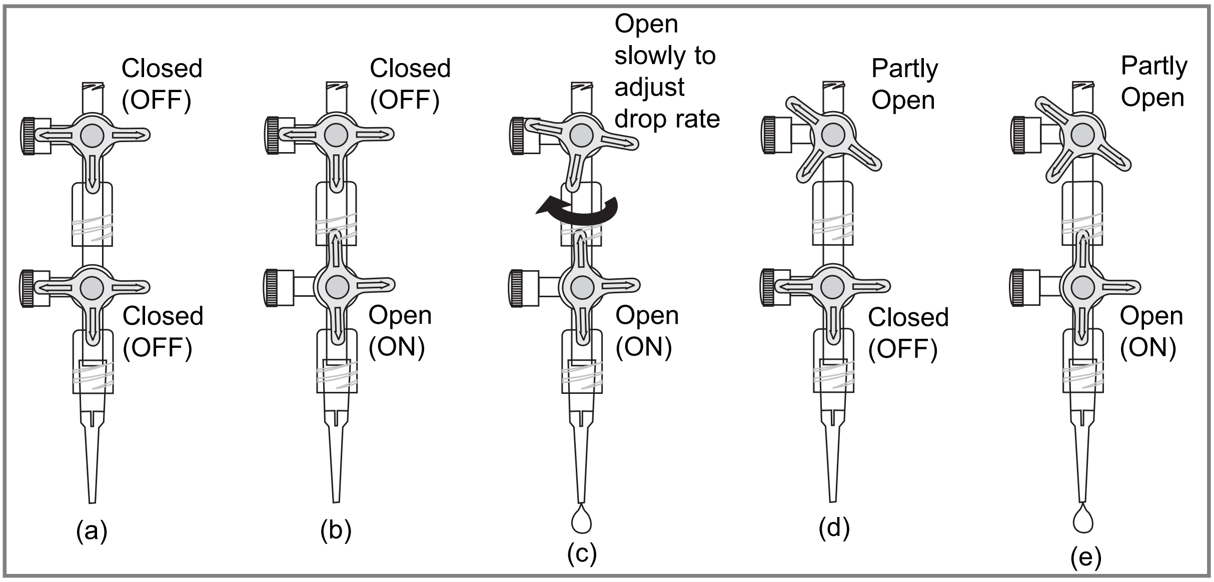
If accuracy is not critical and you are using the reagent reservoir and tip supplied with a low viscosity liquid (like water) and the flow rate set to: -

- Fast e.g. **10 plus** drops per second, use the **24** drops/cm^3 range.
- Medium e.g. between **5 – 10** drops per second, use the **25** drops/cm^3 range.
- Slow e.g. between **1.5 – 5** drops per second, use the **26** drops/cm^3 range.
- Very Slow e.g. **less than 1.5** drops per second, use the **27** drops/cm^3 range.

When used with a pH or Conductivity Sensor, the flow rate needs to be very slow (less than 1.5 drops per second) to allow the Sensor time to settle to a new reading after addition of the titrant.

To calculate the number of drops in a cm^3
You will need to use an accurate reading measuring cylinder, syringe barrel or volumetric flask (10 mls or less).

1. Set up the reagent reservoir in the alignment adapter of the *Smart Q* Drop / Bubble Counter. Close both stopcocks (a) and fill the reservoir with the type of solution being used.



2. The first step is to adjust the flow rate. Place a beaker under the stopcock to catch the drops. Fully open the lower stopcock (b). Slowly turn the top stopcock round (c) until it begins to produce drops and then finely adjust the drop rate. When the correct flow rate of drops is achieved close the lower stopcock (d) to stop the flow. Now the ‘flow rate’ is set, do not adjust the top stopcock – leave in this position. Use the lower stopcock to turn the drops on and off (e).

   Note: *Do not set the flow rate too fast, the drops will merge to form a continuous stream and will not be counted as individuals.*

3. Top up the reservoir. Place the accurate measuring container e.g. volumetric flask under the dropping tip. Open the lower stopcock **fully** and count the number of drops required to fill up to the volume mark on the measuring container. You can use the Drop / Bubble Counter to count the total number of drops (set to the Drop / Bubble Count range). Make sure you zero the Sensor before each run. Close the lower stopcock to stop the drops.

Notes:

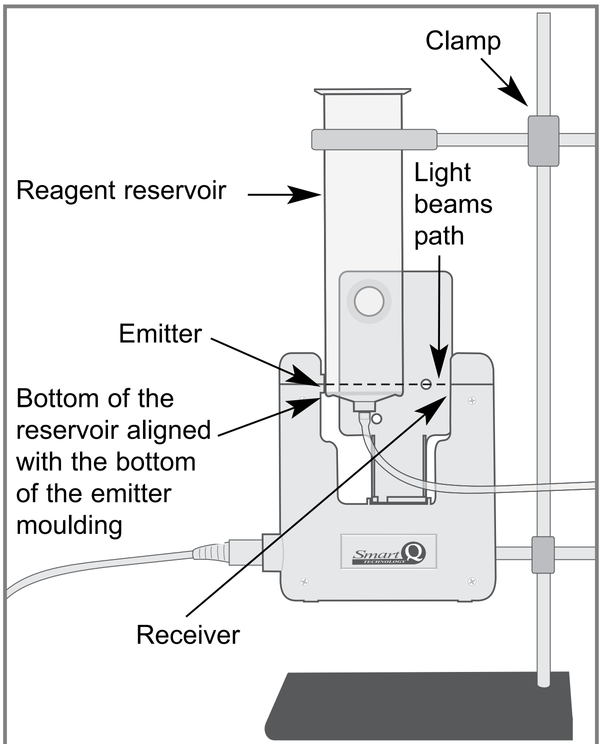
- *Make sure the lower stopcock is turned fully to the open position or the rate of flow (and therefore the number of drops per cm³) will be affected.*
- *If EasySense is connected to the computer, you can use the Graph program to help you count. Zero the Sensor. Use a start condition e.g. 'Trigger when Sensor 1 (Drop / Bubble) is greater than 1 count', click on start (on the computer), open the lower stopcock and the recording will start automatically when I drop has passed. When the exact volume has been collected, close the stopcock and click on stop (on the computer). Gradient from the Analysis menu can be used to calculate the flow rate. Select Overlay from the Display Wizard in the Display menu, zero the Sensor and click on start to repeat.*

4. Divide the number of drops by the volume (in cm^3) to get the drops per cm^3 value e.g. 272 drops fill a capacity of 10 mls = 27.2 drops/cm^3. Top up the reservoir and repeat three times to get an average value.

Using the Drop / Bubble Counter to count bubbles

The *Smart Q* Drop / Bubble Counter can be used to detect a bubble formed in a column of water. The column of water is positioned between the Sensors receiver and emitter so it blocks the light beam. When a bubble rises the light level is momentarily changed and the bubble is counted. Use the Drop / Bubble count range to show the total number light beam interruptions (caused by a bubble passing through the light beam) since the Sensor was set to zero. Bubbles cannot be calibrated for volume but can be used to measure the change of gas production over time.

Test your set up before beginning the experiment. It is critical that the column of fluid is positioned so that when bubbles rise they will change the light level. Bubble counting is not an exact science. Bubbles have an inconsistent format and can move through the fluid in an erratic manner; they need to rise separately from the same origin to be counted.



Note: *The reservoir is positioned up against the emitter.*

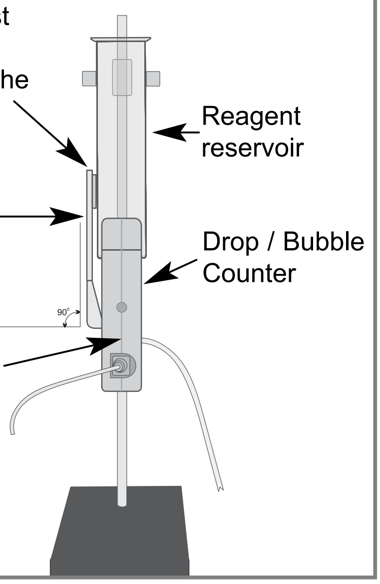
1. Set the range of the Drop / Bubble Counter to Drop / Bubble count, see page 2.
2. Set up the vessel of fluid for the bubbles to rise through.

   The reagent reservoir can be used as a vessel for counting bubbles.
   Only one stopcock should be attached, which is used to isolate the reservoir.

Connect a length of PVC tubing (3mm inside diameter) from the reservoir to a stopcock attached to the delivery tube on the apparatus. Turn the stopcock to a closed position.

Note: *If the stopcock is attached direct to the reservoir the process of opening and closing the cock can make the path of the bubbles move out of the light beams path.*

Clamp the Drop / Bubble Counter vertically. Clamp the reservoir and position in the gap between the receiver and emitter so that the reservoir is touching the emitter's moulding.



Adjust the Sensor or reservoir vertically so the moulding ring at the bottom of the reservoir barrel is level with the lower edge of the emitter moulding.

Adjust the reservoir laterally so the reservoir is just touching the moulding of the large hole in the alignment plate. In this position bubbles rising should pass through the light path between the receiver and emitter.

Note: *You may need to make fine lateral adjustments of the reservoir.*

Check the reservoir is vertical and parallel to the Sensor.

Note: *Try to keep the experimental apparatus higher than the water level in the reagent reservoir to prevent backflow of water into the experimental apparatus.*

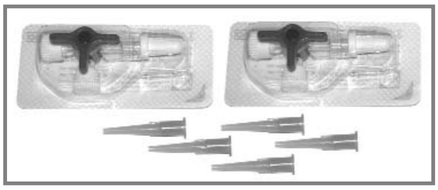
3. Pour approximately 10 cm^3 of water into the reservoir.
4. Test to make sure that bubbles will pass through the light beam as they rise through the water.

Note: *This can be done by using a syringe full of air connected to the end of the plastic tubing. Turn the stopcock to allow the air from the syringe to pass into the reservoir. Gentle push the syringe plunger to produce a stream of bubbles - check that the bubbles cause the red LED indicator to blink.*

5. Press the zero reset button on the Drop / Bubble Counter.
6. Run the experiment (remember to turn the stopcock to an open position).

Practical information

- A replacement parts pack for the Drop Counter reservoir is available from Data Harvest, which contains 2 x 3-way stopcocks and 5 plastic tips - use Product No 3271.



- A small 'reset to zero' button is situated on the Sensor close to the indicator LED. Press the button to zero the count.
- The *Smart Q* Drop / Bubble Counter works by recording interruptions of a beam of infrared energy. The receiver can be sensitive to high levels of ambient infrared light or heat. Shield the Sensor from bright light e.g. sunlight, which can produce a false OFF result by providing an extra source of light that prevents the receiver from detecting when the light beam has been interrupted. Work in an area away from direct light, or rotate through 180^0 so the external light source is directed towards the emitter.
- Any calculations made for drops per cm^3 will only be valid for the same dropper with the same type of solution and flow rate.
- If the flow rate is too fast the drops will merge to form a continuous stream. The flow rate should be set so that each drop passes thorough the Sensor before the succeeding drop.
- With a titration use a very slow drop rate (e.g. with a maximum speed of 1.5 drops a second) so the drops can add too and mix thoroughly with the reactant, allowing the pH electrode time to respond.
- If you use a burette you will need to devise a method of stopping the flow from the burette without altering the drop rate. If the burette has a replaceable tip, use a length of plastic tubing to link the tip to the burette. A tube clamp can be used to crimp the plastic tubing and shut off the flow. A bung inserted into the top of a burette will also prevent flow and can be used as a 'flow stop'. During test we found a standard 50 ml burette produced 23 or 24 drops per cm^3 (depending on flow rate).
- The chemical 'rule of thumb' for low viscosity liquids is 20 drops per cm^3 from a standard eyedropper or pipette.
- If the height from the dropping point to the beaker / flask is too great then the contact of the drops with the liquid may create splashes.
- For gas creating experiments that produce large volumes of gas such as marble chips and acid we suggest using a 250 ml conical flask. For small volumes of gas such as catalase investigations, a boiling tube is more appropriate.
- Volume measurements are calculated by using the 'drops per cm^3' data so there is no need for the reagent reservoir to have a volume scale.

SI units: Volume is a measurement of the space occupied by a body. The SI unit of volume is the cubic metre (m^3). The volume of a liquid is calculated from the space it takes up in its containing vessel. The internal volume of the containing vessel is called its capacity. The SI unit of capacity is the litre (l) equal to $10^{-3}m^3$ ($1ml = 1cm^3$).

Specifications

Infrared source: Peak at 880 nm

Maximum number of drops / bubble counted = 10 000
Total volume = 120 cm^3

Investigations

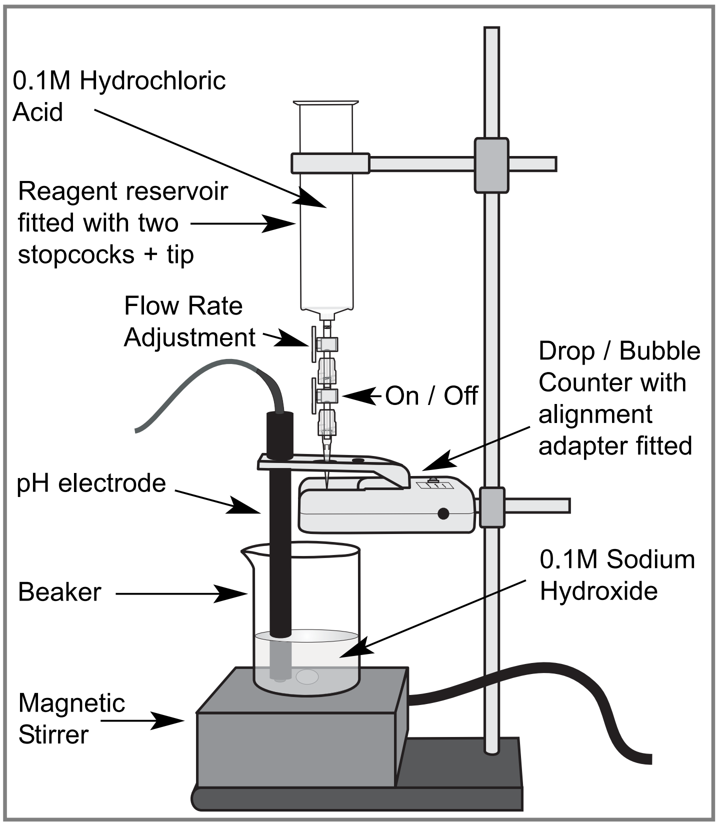
Titration of a strong acid vs. a strong alkali

Timespan or an X vs.Y plot?
Two methods used to collect data for a titration are:

1. An X vs.Y plot with the pH Sensor along the Y-axis and Volume from the Drop / Bubble Counter along the X-axis.
2. Plotting against time using a selected timespan.

With an X vs.Y graph you can display the change in pH as the volume of titrant increases, but only two sets of data can be displayed on the graph at the same time. If you intend to use Function Wizard to calculate first derivative (which will be an extra set of data) it is best to plot against time. The first derivative ‘peak’ can be used to identify the volume and pH at end point. The display can be altered using the Display Wizard to show a Sensor along the X-axis if required.

1. Set up the apparatus as shown in the diagram. Set the required range of the *Smart Q* Drop / Bubble Counter i.e. Drop / Bubble count or Volume in cm^3 (e.g. 27 drops/cm^3).
2. Fill the reagent reservoir with 0.1M HCl. Place a beaker under the reservoir and open both stopcocks to allow a small amount of HCl to pass through. Adjust the flow rate using the top stopcock, leave in that position and close the lower stopcock.
3. Pour the HCl from the beaker back into the reagent reservoir.
4. Pour 20cm^3 of 0.1M NaOH into a 250 ml beaker and place under the reservoir.



Note: *The volume of the alkali may need to be adjusted to account for the format of the glassware. The solution needs to cover the bulb end of the pH electrode (up to the top of the arches in its protective skirt). Do* ***not*** *remove the electrodes protective skirt - the end is made from permeable glass, which is fragile and easily damaged.*

5. Insert the pH electrode through the large hole in the alignment plate.
6. Place a magnetic stir bar in the beaker and turn on the stirrer. Check the stir bar is free to rotate and that it is rotating slowly and evenly.
7. Press the button on the Drop / Bubble Counter to set the counter back to zero.
8. Open the Graph application from the Sensing Science Laboratory program.
9. Click on the **New recording wizard** and select the recording method as Timespan with 5 minutes and Continuous ticked, Finish.
10. Click on **Start** and then open the lower stopcock to let the hydrochloric acid drip into the alkali.

    Note: *Top up the reagent reservoir if necessary.*
11. When you are satisfied that the titration has proceeded past the equivalence point close the lower stopcock and click on **Stop** to finish logging data**.**
12. Save the data.

The recording method used was against time so the data will be displayed as volume and pH vs. time graph. To alter the display to a pH against Volume graph, select Display Wizard from the Display menu and select the X-axis as Sensor. If necessary click to the left of the axis to alter the data channel displayed so that pH is on the Y-axis and Drop /Bubble count or Volume is on the X-axis.

Converting the Drop count range to volume

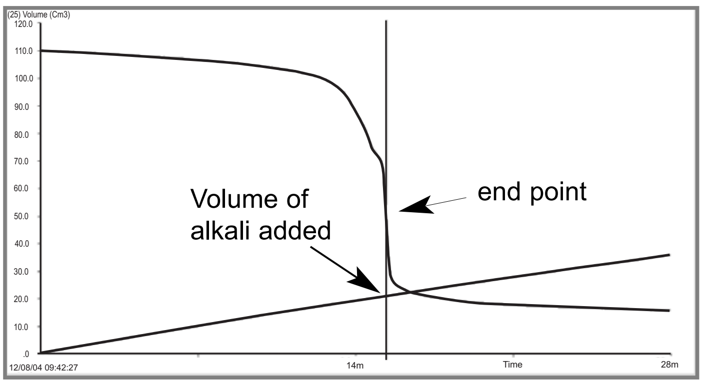
If the Drop / Bubble count range was used then it is possible to convert this value into a volume. You will first need to calculate the number of drops in a cm^3 (see page 7).

- Select **Function Wizard** from the **Tools** menu.
- Select the formula as **(a-x)/b**.
- Make **x** = Drop / Bubble count **a** = 0 **b** = the number of drops in a cm^3 e.g. 27.
- Type in a new name e.g. Volume and alter the units to cm3.
- Change the max to a more suitable number.
- Click on Apply and then OK.

Analysing the data

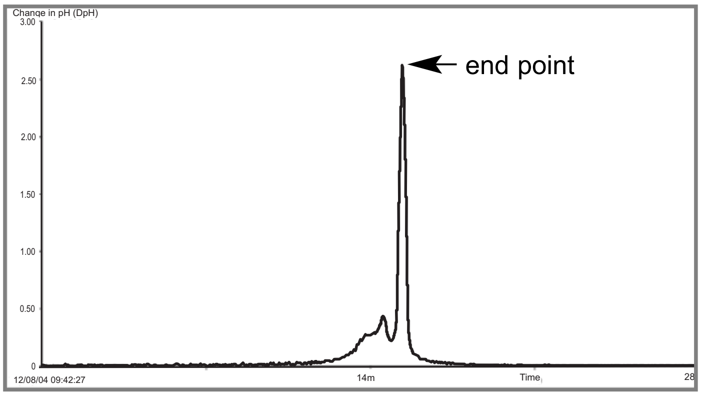
A volume vs. pH graph will produce a classic "S" shaped titration curve.

Use Values to find the end point, which occurs at the point of maximum deflection.



Using a derivative to find the end point

The **a dx/dt** function can be applied to the pH data to produce a "first derivative" curve. The point of the sharp peak produced will represent the end point of the titration.

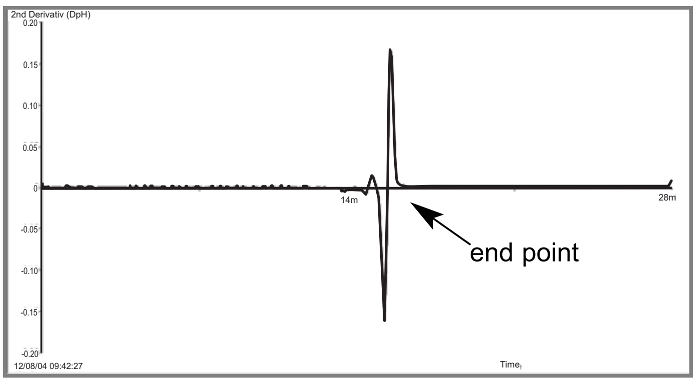


Select **Function Wizard** from the **Tools** menu.

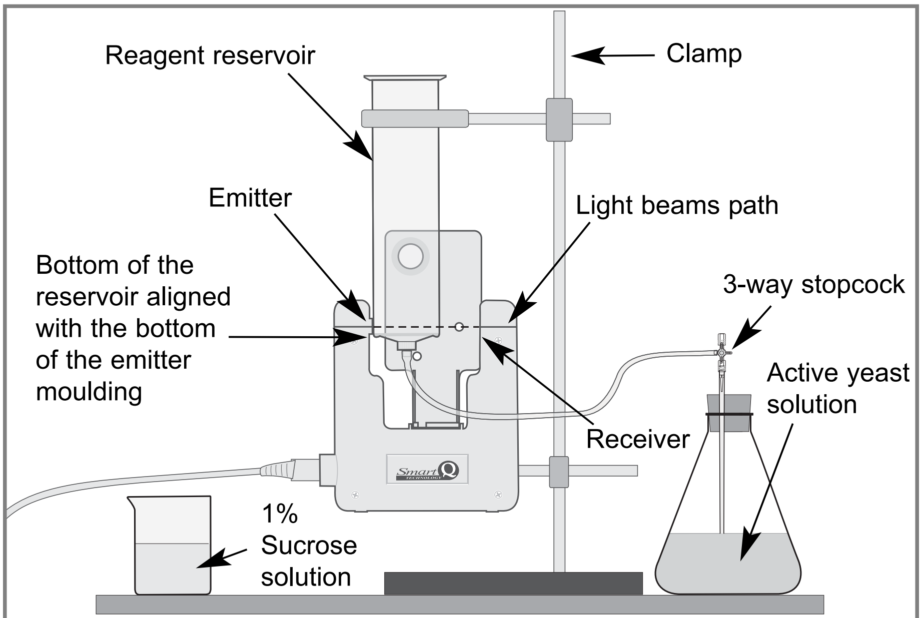
- Select the formula as **a dx/dt.**
- Make **x** = pH Sensor.
  a = -1
- Alter the number of decimals to 4.
- Type in a new name e.g. Rate change.
- Change the max to a more suitable number e.g.1.
- Click on Apply and then OK.

Zoom in and use **Values** from the Analysis menu to find the point of the peak.

The peak is created by the connection of the highest value to the next highest value. It is possible that there would have been a higher value before readings started to fall. Check by using the 'second derivative'. Apply the **a dxt/dt** function to the first derivative curve. This will produce a graph with a sharp "positive" spike followed immediately by a sharp "negative" spike. The intersect of the line that joins the two spikes across zero will give the end point.



The rate of gas production in an active yeast fermentation of sucrose



Note: *The Reservoir is positioned up against the emitter.*

1. Set up the apparatus as shown in the diagram above. Test to make sure bubbles rising up in the reservoir will be detected.
2. Place 40cm^3 of active yeast solution (a 0.1% W/V should produce an active enough suspension) into the conical flask.
3. Open the Graph application from the Sensing Science Laboratory program. Click on the **New recording wizard** and select the recording method as Real time, with an initial timespan of 1 minute and Continuous ticked.
4. Add 20cm^3 of a 1% sucrose solution (w/v) to the flask.
5. Place the bung in the neck of the flask. Allow any bubbles created by the displacement of air in the pvc tube to be released. Press the reset button on the Sensor to set the count to zero.
6. Click on **Start** to commence logging.

The time it takes for this investigation to complete is variable. The age of the yeast and the temperature of the solutions will have a large effect. The investigation can easily be extended to see the effect of different sugar substrates on rate as part of an investigation into respiration / glycolysis. The effect of heat on metabolism can be studied if a temperature controlled water bath is accessible.

Warranty

All Data Harvest Sensors are warranted to be free from defects in materials and workmanship for a period of 12 months from the date of purchase provided they have been used in accordance with any instructions, under normal laboratory conditions. This warranty does not apply if the Sensor has been damaged by accident or misuse.

In the event of a fault developing within the 12-month period, the Sensor must be returned to Data Harvest for repair or replacement at no expense to the user other than postal charges.

Note: *Data Harvest products are designed for* ***educational*** *use and are not intended for use in industrial, medical or commercial applications.*

WEEE (**W**aste **E**lectrical and **E**lectronic **E**quipment) Legislation.
Data Harvest Group Limited are fully compliant with WEEE legislation and are pleased to provide a disposal service for any of our products when their life expires. Simply return them to us clearly identified as 'life expired' and we will dispose of them for you.