

pH Adaptor & electrodes



pH Adaptor
(Product No. 3125)

Range: 0 – 14 pH
Resolution: 0.01 pH



pH Electrode (BNC cap)
(Product No. 2253)



pH Electrode (wired)
(Product No. 2251)

Not available from February 2020 onward



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Introduction

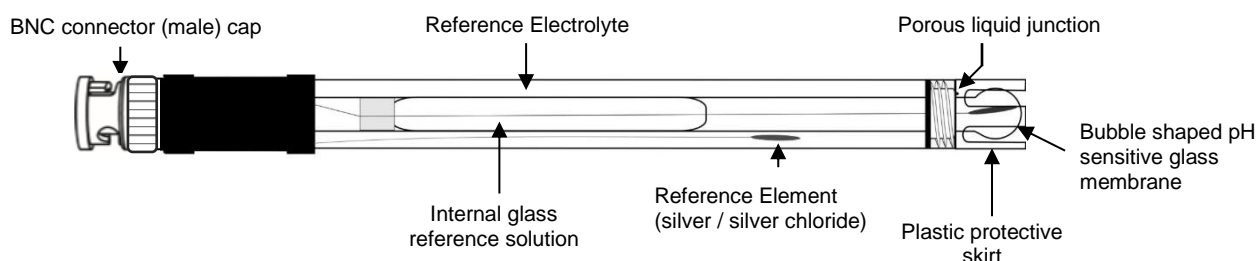
The *Smart Q* pH Sensor is a combination of a pH Adaptor (Product No. 3125) and a pH electrode. The general-purpose pH electrode supplied in the pH sensor pack (3125PK) is (Product No. 2253) which has a direct to BNC connector.

The *Smart Q* pH Adaptor enables the pH electrode to be connected to an **EASYSense** data logger. The data logger will detect that the pH Adaptor is connected and automatically load the stored calibration. This calibration can either be the pre-set default calibration or a user calibration (see page 4).

Note: The wired pH electrode (Product No. 2251) can similarly be used with this Adaptor but is no longer available to purchase.

The pH electrode

Plastic bodied, single junction gel filled glass electrodes, non-refillable. Working temperature range: 0 - 80°C.

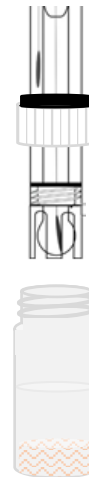


IMPORTANT: Maintain the level of storage solution, the pH sensitive glass membrane must be kept **wet**.

Please Note: Store the electrode tip in a 1:1 solution of pH 4 buffer and 4 mol dm⁻³ KCl (see page 7).

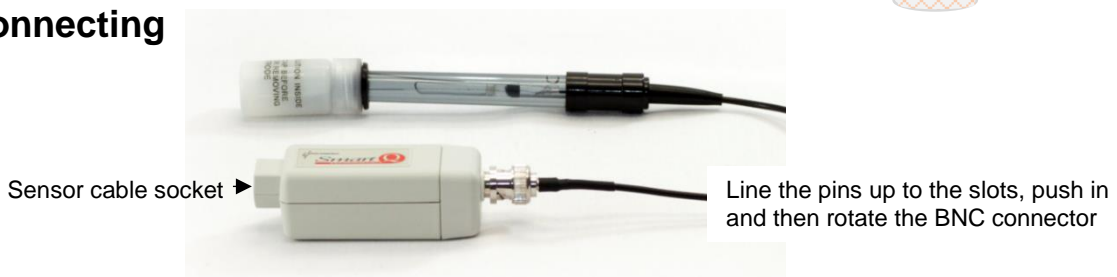
Electrode preparation

1. Remove the electrode from the storage solution bottle by unscrewing the cap **before** removing the electrode from the storage bottle.
2. Wash the lower section of the electrode (especially the glass membrane area) thoroughly with de-ionised or distilled water to remove any salt deposits from the exterior of the electrode.
3. Hold the electrode up to the light and check that the glass bulb tip of the electrode is full of electrolyte. If air bubbles are present they can be removed by shaking the electrode firmly in a downward motion (like a clinical thermometer).
4. Screw on the clear plastic protective skirt if it's not already attached.



Unscrew the cap **before** removing the electrode

Connecting






- Push one end of the sensor cable (supplied with the **EASYSense** data logger) into the hooded socket on the adaptor with the locating arrow on the cable facing upwards.
 - Connect the other end of the sensor cable to an input socket on the data logger.
 - Connect the pH electrode to the pH Adaptor (line the pins up to the slots, push in and rotate the electrodes BNC connector until it locks into place).
- Note:** To disconnect, twist the BNC connector in the opposite direction and pull.
- The data logger will detect that the pH sensor is connected and display values using the currently selected range.


To set the range

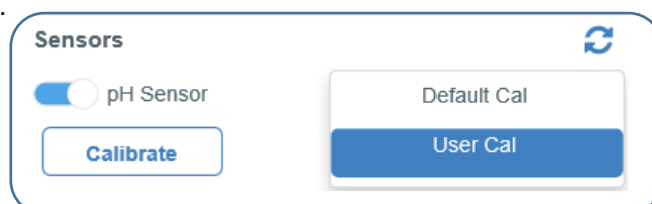
All *Smart Q* sensors are supplied calibrated. The stored calibration for the Sensor is the **Default Cal** range, which is suitable for most experiments. It is also possible for the user to adjust the calibration constants of an electrode for more accurate readings – this will be stored in the connected Adaptor as the '**User Cal**' range. See user calibration on page 4.

With some **EASYSense** data loggers it is possible to set the range from the data logger. Please refer to the data logger's user manual.


The range can be changed in the **EasySense2** software  from:

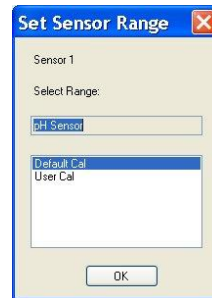
1. The Devices icon  top left of the screen or Lab Setup.
2. Setup (bottom left of screen)  , from the Sensors row select the edit symbol. 

Select the choice symbol  and a drop-down list of ranges will open. The range currently selected will be highlighted. Select the required range. This range setting will be retained until changed by the user.



To alter the range in the original **EasySense** software  :

1. Select a logging mode e.g. EasyLog from the Home screen.
2. Select the New recording wizard icon. 
3. Click on the sensor's name. A set sensor range window will open. Select the required range, then OK.
4. Select Finish to exit the wizard.



Or

1. Select Sensor Config from the Settings menu.
2. Select the pH sensor from the list and click on the Change Range button.
3. The current range will be highlighted. Select the required range and click on OK. Close Sensor Config.

Measurement procedure

1. Place the pH electrode in the sample to be tested, ensure the bulb is fully submerged.
2. Allow the electrode sufficient time to stabilise and then start taking readings.
3. Rinse the electrode between each measurement with either:
 - a portion of the next sample or
 - deionised or distilled water

Excess liquid can be removed by wiping the plastic body part of the electrode with soft lint free tissue - avoid contact with the bulb tip.

4. When you finished using the electrode, rinse with distilled water, slide the cap of the storage bottle onto the body of the electrode and then screw the cap onto the storage bottle making sure the tip of the electrode is immersed in the storage solution.

User calibration

The stored calibration for a pH Sensor is the **Default** calibration, which is set for operation at a temperature of 25°C.

If required the calibration constants of a pH electrode can be adjusted. The settings for an electrode will be stored in the Adaptor as the **User** calibration.

Note: Mark the pH electrode and adaptor combination so they are used as a pair.

Use standardised buffer solutions to adjust the sensor reading at either two or three points in its range. A slope adjustment is made using these points and will affect the whole range, between and beyond these points. The accuracy of the user calibration will depend upon the number of calibration points used and their spacing. Ideally the buffer solutions used should encompass the expected pH range and be as close as possible to the pH of the samples being measured.

A User calibration is best used when the:

- experiment requires a very accurate calibration
- electrode has aged to the point where its glass membrane has changed resistance
- samples to be measured are at a lower or higher temperature than 25°C. The buffer solutions used to set values must be at the same temperature as the samples in the experiment. Buffers values are temperature sensitive, enter a pH value for the buffer at that temperature.

Values of pH buffers at various temperatures:

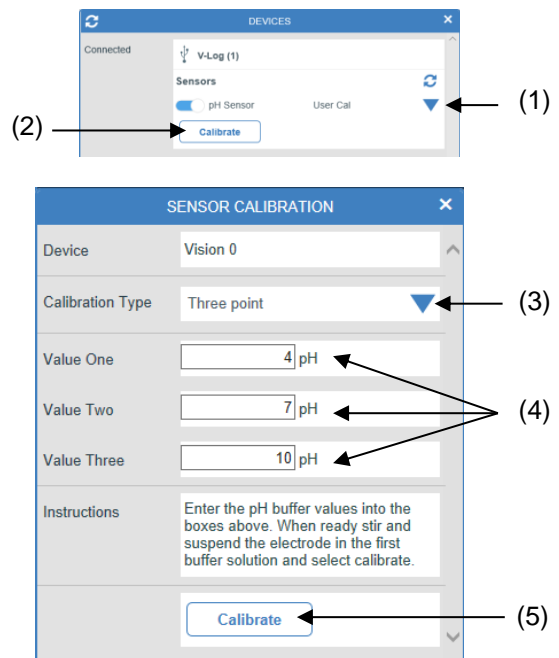
Temperature °C	pH 4.0 buffer	pH 7.0 buffer	pH 10.0 buffer*
0°	4.00	7.11	10.32
10°	4.00	7.06	10.18
20°	4.00	7.01	10.06
30°	4.02	6.98	9.97
40°	4.04	6.97	9.89
50°	4.06	6.97	9.83

*Please note that high pH buffers are less stable as they tend to absorb atmospheric CO₂ which lowers their pH. Only open the bottle of buffer to pour into a beaker, never leave the bottle open.

How to calibrate

EasySense2 software  users:

1. Change the sensor's range to **User Cal**.
2. Select the **Calibrate** button.
3. If only two samples of buffers are being used select the down arrow ▼ for Calibration Type, then Two point from the list.
4. Type in the **value of all the buffers** being used to set points into the appropriate boxes.
5. Rinse the electrode in distilled water. Wipe off the excess and suspend the electrode in the value one buffer solution, stir and select Calibrate.
6. After the 20 second count rinse the electrode in distilled water, wipe off excess, suspend in the value two buffer, stir and select Next.
7. After the next count down rinse the electrode in distilled water, wipe off excess and suspend in the value 3 buffer, stir and select Next.

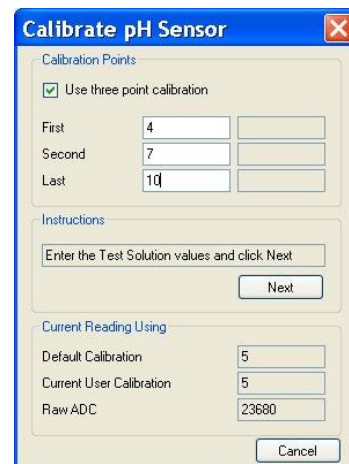


After the next count a message will say 'Your sensor has been calibrated'. Select Finish. Unplug and re-plug the pH sensor into the data logger.

Note: Mark the pH electrode and adaptor combination so they are used as a pair.

EasySense software  users:

- Start the EasySense program and select **Sensor Config** from the **Settings** menu.
- Select the pH Sensor from the list.
- Select **Change range** and alter the selected range to **User Cal**.
- Select **Calibrate Sensor**.
- If only two samples of buffers are available, click to deselect the tick in the Use Three point calibration box. Only the First and Last calibration points will then be available.



- Type in the **value of all the test solutions** (buffers) that will be used and click Next.
- Rinse the electrode in distilled water and place in the buffer with the lowest value e.g. pH 4 buffer. When the current reading stabilises, click on Next.
- Rinse the electrode in distilled water and place in the mid-range sample e.g. pH 7 buffer. When the current reading stabilises, click on Next.
- Rinse the electrode in distilled water and place in the highest value sample e.g. pH 10 buffer. When the current reading stabilises click on Next.
- A message to say 'The User range has been reprogrammed' will be displayed. Unplug and re-plug the pH Sensor from the **EASYSense** data logger and then reconnect.

The User calibration values will be stored in the Adaptor and will be retained until reconfigured by the user.

Note: Mark the pH electrode and adaptor combination so they are used as a pair.

Practical information

- These electrodes are **non-refillable**.
- Check the condition of the storage solution on a regular basis.
- Keep the pH sensitive membrane **wet** at all times. For the ion exchange process to occur properly, the glass needs to be hydrated. Check and maintain the level of storage solution. See page 7.
- If the electrode should inadvertently become dry, place in the storage solution for several hours in an attempt to recondition the glass.
- Care should be taken to avoid handling the pH sensitive glass membrane. Any damage to the surface, such as abrasion, may cause inaccuracies and result in a slow response time.
- Stirring of a sample will achieve a faster electrode response, but the glass bulb tip is very thin and requires care to prevent accidental damage. Broken glass bulbs are not covered by warranty.
- Distilled or deionised water contains little or no ions so produce a poor response and unstable inaccurate readings.
- pH electrodes have a finite lifespan due to their inherent properties. How long a pH electrode will last will depend on how it is cared for and the solutions it is used to measure. Even if the electrode is not used, it will still age.
- Always use freshly prepared pH buffers. When not in use, pH buffers should be stored in sealed containers. High pH buffers are less stable as they tend to absorb atmospheric CO₂ which lowers their pH. Only open the bottle of buffer to pour it into a beaker, never leave the bottle open.
- Buffers and sample solution should be at the same temperature when measuring pH. The resistance of glass electrodes partially depends on temperature. The lower the temperature, the higher the resistance. It will take more time for the reading to stabilise if temperatures are cold.
- To allow the *Smart Q* pH Adaptor to be used with any suitable pH electrodes with a BNC connector, automatic temperature compensation has not been built in.
- The electrical connections, terminations, etc., must be kept clean and dry. Failure to do so will result in a loss of insulation that will produce inaccurate results or total failure.
- If other electrochemical type Sensors (**Oxygen** and **Conductivity**) are put in the same solution at the same time and connected to the same **EASYSense** data logger, they

may interfere with each other's signals. Keep the Sensors as far apart as possible - the distance required will depend on the conductivity of the solution. If there is still a problem, try connecting the Sensors to different data loggers or take readings using one Sensor at a time.

Conditions to avoid:

- **Never** store the electrode in **deionised or distilled water**, as this will cause the migration of the electrode's fill solution.
- To maximise electrode life, avoid pH/ temperature extremes whenever possible. High temperature, strong acids or caustics (greater than 1.0 mol dm^{-3}) shorten electrode life. If used at high temperatures, the electrodes life is drastically reduced. The higher the range of temperature, the shorter the life of the electrode e.g. typical electrode life when used at ambient temperature is 1 – 3 years, if used at 80°C this will be reduced to less than 4 months.
- Never expose to temperatures below -12°C , freezing will damage the electrode.
- Coatings on the glass or junction surfaces e.g. proteins, will prevent proper operation (see maintenance on page 8). Avoid frequent or prolonged periods of use in these solutions.
- The plastic body of the sensor may be damaged by organic solvents such as acetone, chloroform, methanol, toluene and xylene.

Electrode storage

Maintain the level of pH electrode storage solution, the pH sensitive membrane must be kept **wet**.

Store the electrode in equal volumes of pH 4.0 buffer and 4 mol dm^{-3} Potassium Chloride (KCl) solutions (1:1 v/v).

Recipe: Add 29 g of KCl to 100 cm^3 of distilled water. Add 100 cm^3 of a pH 4 buffer solution.

Check the condition of the storage solution on a regular basis.

Never store the electrode in **deionised or distilled water** - this will cause migration of the electrode's fill solution.

Electrode specifications

Sealed silver / silver chloride gel filled electrode

Measuring range	0.00 to 14.00 pH
Working temperature range	0 to 80°C
Sensitive glass	ASI 8
E°	$0 \pm 20 \text{ mV}$
Slope (pH 4.00 – 6.86)	>95%
Junction Resistance	<1 kohms
Tube diameter	12 to 13 mm

Maintenance

The glass bulb can become coated with any compound that has an affinity for glass.

After any cleaning procedure, soak the electrode in its storage solution for at least 30 minutes before use.

General cleaning procedure: - Soak the electrode in 0.1 mol dm^{-3} Hydrochloric acid (HCl) for 10 minutes. Rinse thoroughly with distilled water. Soak in its storage solution for at least 2 hours before use.

Inorganic coatings: - Soak in either 0.1 mol dm⁻³ Tetrasodium E.D.T.A acid solution or 1% Decon 90 solution for 1 – 2 hours.

Oil, Grease: - Carefully wash the electrode under warm tap water using a non-filming dish washing detergent. Do not use automatic or electric dish washing detergents. Rinse thoroughly with fresh tap water followed by a three rinses of distilled water. Soak the electrode in its storage solution for at least 30 minutes before use.

Protein & Fatty Materials: - Either gently wipe the bulb with a tissue soaked in propanol or soak in 1% pepsin in 0.1 mol dm⁻³ HCl for at least 10 minutes. Rinse thoroughly with distilled.

Highly resistant deposits: - Clean with H₂O₂ or sodium hyperchlorite.

Bacterial cultures: - Chemically sterilize with ethylene oxide, soak a cloth to wipe the entire body.

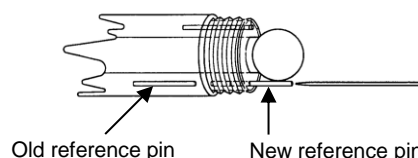
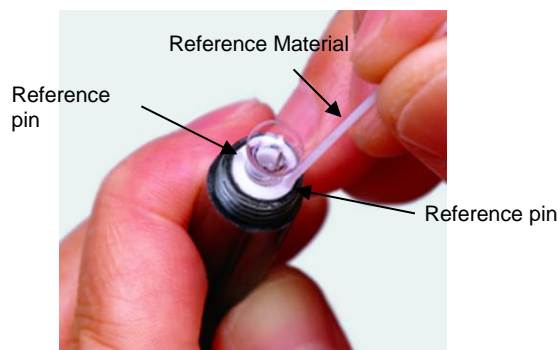
CAUTION - Do not use strong solvents such as halogenated hydrocarbons, petroleum ether, etc. for cleaning.

If the bottle of electrode storage solution develops mould, empty the contents, fill with a bleach solution (about 1 part bleach to 4 parts water) and leave to soak for about 10 minutes. Rinse thoroughly with warm water. Refill with a fresh solution of the pH 4.0 buffer: 4 mol dm⁻³ Potassium Chloride (KCl) storage solution.

Reference pin replacement instructions for the 2251 electrode

If the pH electrode fails to respond to cleaning, and the electrode response becomes slow or begins to drift, then the reference pins can be replaced.

- Use clean scissor or a craft knife to cut two 12 mm (½") lengths of reference material from the spare reference pin material provided with the electrode.
- Unscrew the threaded guard that protects the glass bulb.
- Hold the electrode and identify the two reference pins that are located on either side of the pH bulb.
- Use the toothpick provided (or a similar tool) and push each of the reference pins part way out of the reference assembly and into the reference reservoir.
- Using clean tweezers, insert the new reference pins into each of the holes in the reference assembly. The old reference pins will be forced out of the reference assembly and will remain in the reference reservoir. This is normal and will not affect electrode performance.
- Ensure the new reference pins stick out about 3 mm (⅛") from the surface of the reference. If the pins protrude to far from the reference assembly, the electrode may not operate properly.
- Reinstall the threaded guard onto the end of the electrode.
- Rinse the electrode with distilled water. It will now be ready for use.



Hints:

1. Prepare the new reference pins and have them available before you start.
2. Use clean tools, washed thoroughly with distilled water.
3. Flat style toothpicks work better than the round style.

4. Exercise caution when installing new reference pins. The pH bulb is thin glass and is easily scratched or damaged. Broken glass bulbs are not covered by warranty.
5. Do not allow KCl gel to run out of the electrode reservoir.
6. The pins will remain inside the reference reservoir. This is normal. Do not attempt to remove them; this does not affect electrode performance.

Theory of pH measurement

pH is a unit of measure which describes the degree of acidity or alkalinity of a solution and is usually written as:

$$\text{pH} = -\log [\text{H}^+]$$

Where 'p' is the mathematical symbol of the negative logarithm and $[\text{H}^+]$ is the concentration of Hydrogen ions.

pH levels generally range from 0 to 14. A pH value of 7 is described as neutral - the point at which the activities of hydrogen and hydroxide in solution are equal. When the pH value is less than 7, the activity of hydrogen ion is greater than that of the hydroxide ion and the solution is described as acidic. Conversely, as the hydroxide ion activity is increased the solution becomes alkaline (or basic) and the pH value is greater than 7.

The pH electrode is actually a combination of a two half-cells (electrodes) within a single body

- Internal pH Half Cell, the measuring electrode, whose voltage varies proportionately to the hydrogen activity of the solution, and a
- Reference Cell, the reference electrode, which provides a stable and constant reference voltage and completes the electrical circuit.

The pH Half Cell consists of a thin membrane of hydrogen ion sensitive glass blown on the end of a high resistance glass tube. Within this tube is an internal reference system, which remains constant.

The Reference cell uses a similar system, but without using a hydrogen sensitive glass. It is housed concentrically between the outer body of the electrode and the glass half-cell. It is comprised of a reference element (silver/silver chloride) and an electrolyte solution that seeps through a porous liquid junction (a small filter) to make the necessary electrical connection with the sample (the external liquid).

The pH Adaptor measures the difference between the pH Half cell and the Reference cell in millivolts DC. This millivolt reading is displayed in pH units.

The electrode signal varies with the pH according to the Nernst Equation:

$$E = E^{\circ} + \frac{2.3 RT}{nF} \cdot \log [\text{H}^+]$$

Where:

- E = Measured electrode potential
- E° = Standard potential of the system (constant)
- R = gas law constant (8.314 J/K Mol)
- T = absolute temperature in °K (°C +273)
- F = Faraday constant (9.648 x 10⁴)
- n = valence factor (n = 1 in the case of hydrogen)

At 25°C the theoretical slope is $\frac{2.3 \times 8.314 \times \text{K}}{96,486} = 59 \text{ mV/ per pH unit.}$

Temperature can affect the pH value in three ways:

1. The pH of the sample can change due to the hydrogen ion activity in the solution being temperature dependent. This factor is usually ignored because accurate pH measurement will be desired at that particular temperature.
2. Temperature will affect the glass membranes impedance.

3. Changes in temperature of a solution will vary the millivolt output of the electrode in accordance with the Nernst equation. Whether or not temperature compensation is needed will depend on the level of accuracy required.

pH error chart

°C	2	3	4	5	6	7	8	9	10	11	12
15	-0.15	-0.12	-0.09	-0.06	-0.03	0	+0.03	+0.06	+0.09	+0.12	+0.15
25	0	0	0	0	0	0	0	0	0	0	0
35	+0.15	+0.12	+0.09	+0.06	+0.03	0	-0.03	-0.06	-0.09	-0.12	-0.15
45	+0.30	+0.24	+0.18	+0.12	+0.06	0	-0.06	-0.12	-0.18	-0.24	-0.30
55	+0.45	+0.36	+0.27	+0.18	+0.09	0	-0.09	-0.18	-0.27	-0.36	-0.45

Trouble shooting

Wild readings, check for air bubbles in the electrode tip.

Response time and stability are affected by the condition of the electrodes glass membrane, reference junction and reference solution. Restoration to acceptable levels can often be accomplished by cleaning the electrode's glass surface.

Sluggish response, erratic readings, or a reading that will not change can indicate electrode demise.

Interference may occur between electrochemical sensors (**pH**, **Oxygen**, and **Conductivity**) if they are placed in the same solution at the same time and connected to the same data logger. This is because these sensors make an electrical connection to the solution; therefore an electrical path exists between the sensors through the solution. Maximise the distance between the Sensors to minimise the effect, the distance required will depend on the conductivity of the solution.

If the Sensors are being used in a solution that has a high conductance e.g. seawater, either

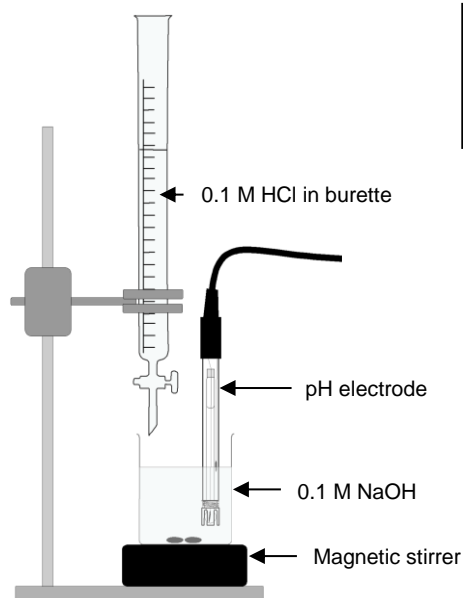
- Connect the Sensors to different **EASYSense** data loggers or
- Take readings from the Sensors individually. (Place one Sensor in the solution, take a reading, and remove from the solution. Place the other Sensor in the solution, take a reading and remove).

Investigations

- *Acid - base titration*
- *Monitoring photosynthesis*
- *Respiration*
- *Fermentation*
- *Activity of enzyme*
- *Studies of household acids & bases*
- *Monitoring pH change during chemical reaction*

Neutralisation of a strong base (sodium hydroxide) by a strong acid (hydrochloric acid)

This experiment uses the pH Sensor to monitor the pH as 0.1 mol dm^{-3} hydrochloric acid is added to a beaker containing 0.1 mol dm^{-3} sodium hydroxide.



Sodium hydroxide
 0.5 to 2% (Solutions 0.05 to 0.5 mol dm^{-3})
 Xi; R36/38
 Wear pvc gloves and eye protection.
 Sodium hydroxide solution is dangerous to eyes
 Refer to Hazard Sheets for First Aid Measures

1. Assemble the apparatus as shown.
2. Carefully fill the burette with 0.1 mol dm^{-3} hydrochloric acid. Place a beaker under the reservoir and open the stopcock to allow a small amount of HCl to pass through. Pour the HCl from the beaker back into the burette.
3. Add 25 cm^3 of 0.1 mol dm^{-3} sodium hydroxide to the beaker and make sure the end of the pH electrode is covered.
Note: The volume of alkali may need to be increased, the solution should cover the bulb end of the pH electrode. Do **not remove the electrodes protective skirt - the end is made from permeable glass, which is fragile and easily damaged*
4. Place a magnetic stir bar in the beaker and turn on the stirrer. Check the stir bar rotates freely and does not make contact with the electrode.

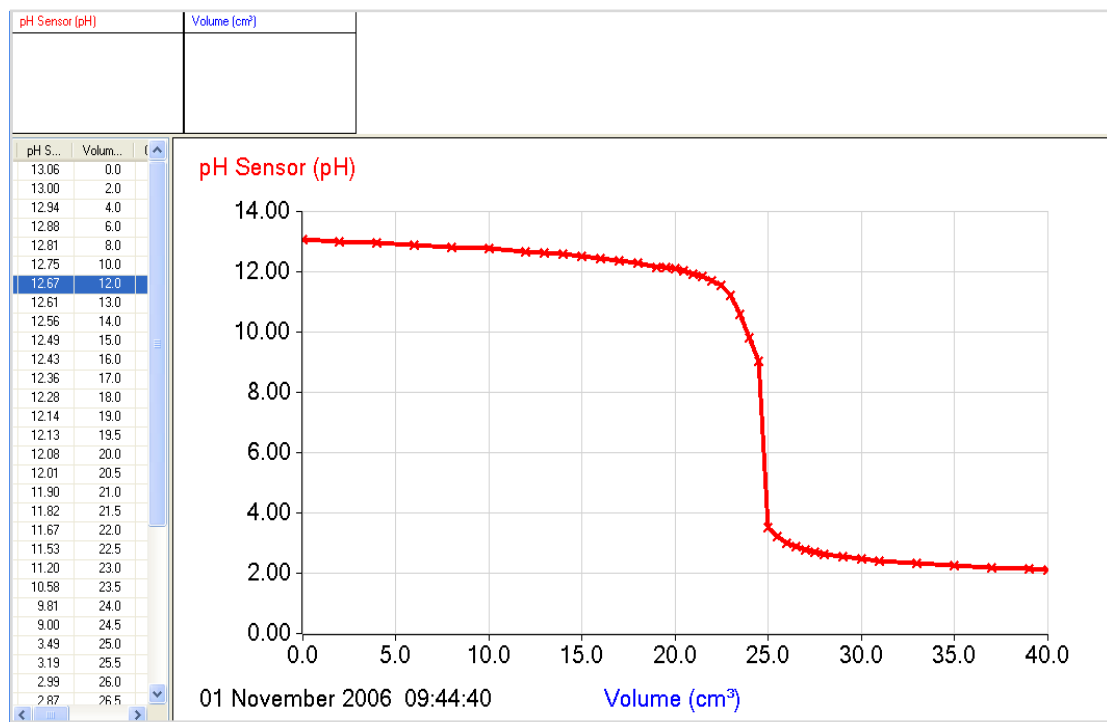
EasySense2 users:

5. Open the EasySense2 software and select **Titration** from Lab Setup or File, New Lab.
6. Select **Start** to begin. Select Take Sample and type 0 in the enter value for Volume box, then Save sample to record the first pH value with no acid added.
7. Turn the tap on the burette to add a measured amount e.g. 2 cm^3 . Let the solutions mix and then click on Take sample and enter the volume of acid added so far.
8. Repeat the above until the pH value falls and levels out. The amount of acid added can be varied as required.
9. Select **Stop** to finish recording.

EasySense users:

5. Open the EasySense software and select **SnapShot** from the Home page.
6. Select **Pre-log Function** from the **Tools** menu.

7. Select a **Preset** function, with Titration from the first drop-down list and then **Asks for the Volume added** from the second list, Next and then Finish.
8. From the **Options** icon select **X-Axis** and select **Channel**. OK. If necessary, click below the X-axis so that 'Volume' is displayed.
9. Click on the **Start** icon to begin. Click in the graph area to record the first pH value with no acid added. Type 0 into the 'enter value box', OK.
10. Turn the tap on the burette to add a measured amount e.g. 2 cm³. Let the solutions mix and then click in the graph area to record the pH value. Enter the volume of acid added so far.
11. Repeat the above until the pH value falls and levels out. The amount of acid added can be varied as required.
12. Select the **Stop** icon to finish recording.



In this graph the quantity of acid added started at 2 cm³ between each reading, after 12 cm³ this was reduced to 1cm³, and then down again to 0.5 cm³ after 19 cm³ had been added.

Buffers

Buffers are solutions that have constant pH values and the ability to resist changes in that pH value.

To make up your own solutions:

pH	Add	of	to	of
4.0	2 cm ³	0.1 mol dm ⁻³ HCl	1000 cm ³	0.1 mol dm ⁻³ potassium hydrogen phthalate
7.0	582 cm ³	0.1 mol dm ⁻³ NaOH	1000 cm ³	0.1 mol dm ⁻³ potassium dihydrogen phosphate
10.0	214 cm ³	0.1 mol dm ⁻³ NaOH	1000 cm ³	0.05 mol dm ⁻³ sodium bicarbonate

Limited warranty

For information about the terms of the product warranty, see the Data Harvest website at: <https://data-harvest.co.uk/warranty>.

Damage to the pH sensitive glass bulb is **not** covered by warranty.

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 Ltd is fully compliant with WEEE legislation and is 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.