Smart Wireless pH Sensor

pH Sensor Pack (Bluetooth)
(Product No. 1110PK)

pH Adaptor (Bluetooth)
(Product No. 1110)

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

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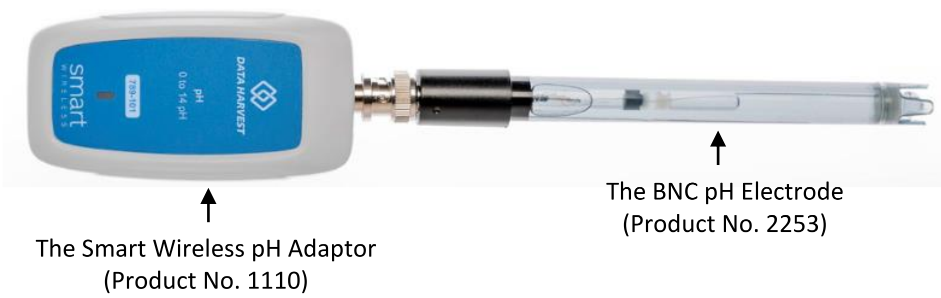
Introduction

The Smart Wireless pH sensor is both USB ad Bluetooth compatible and can wirelessly connect to mobile devices such tablets and mobile phones as well as desktop or laptop computers giving students the ability to run experiments independently without being tethered to a traditional data logger. See the EasySense2 user manual system requirements for further details.

The Smart Wireless pH sensor consists of a combination of the Smart Wireless pH adaptor (Product No. 1110) and a general-purpose pH electrode (Product No. 2253). The pH adaptor is supplied with a mini USB lead (1 m standard A to standard mini B).



The Smart Wireless pH sensor (Product No. 1110PK)

The Smart Wireless pH adaptor

Charge the pH adaptor fully before first use

Use the USB lead supplied to connect the pH adaptor either direct to a USB port on your computer* or to a USB mains charger that outputs 5 V at 500 mA or more. A full charge can take up to 4 hours.

*Or a powered USB hub. Your computer should be turned on and not in sleep or standby mode; or the battery may drain instead of charge.

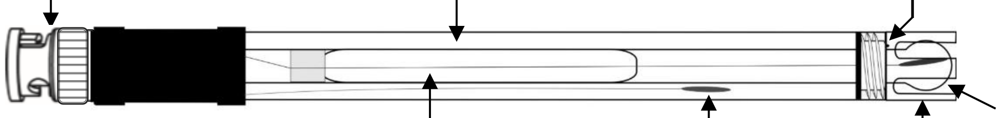
Status Light	Indicates
No light	Sensor is Off. Short press the On/Off switch
Blue flashing	Sensor On and Bluetooth advertising
White flashing	Charging via USB mains charger or USB port
Green flashing	Communication with the EasySense2 software (via USB or Bluetooth) has been established.
Orange flashing	Recording data

To switch the pH sensor off: Press and hold down the On/Off switch for about 2 seconds until the white light is lit solidly then release.

If not communicating with the EasySense2 software the sensor will puts itself to sleep after a period of about one hour of inactivity (blue LED flashing).

The pH electrode (BNC)

This is a general-purpose plastic bodied, single junction gel filled glass electrode, which is non-refillable.



IMPORTANT: Maintain the level of the 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 3.5 to 4 mol dm^{-3} KCl, see page 5

Connecting the Smart Wireless pH sensor to a computer

Bluetooth users:* *Do NOT pair devices *(if paired the sensor will not be available to the EasySense2 software). Computers or devices will need to support Bluetooth Low Energy (BLE), for further information refer to the instructions provided for the EasySense2 software.*

Install the EasySense2 software, if it is not already on your computer. For details of how to install and operate this app, please refer to the instructions provided for the EasySense2 software.

If connecting via USB:

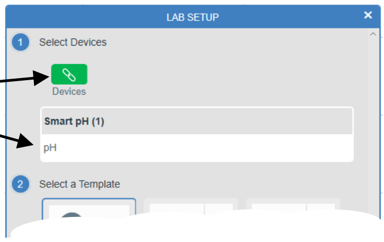
This sensor can be used like a traditional data logger connected via USB.

Step 1: Connect the pH sensor to the computer's USB port using the USB cable supplied. The computer will automatically detect a new device and install the drivers. The status light on the pH sensor will flash white to show its charging.

Step 2: Open the EasySense2 app.

Lab Setup will open showing the Smart pH sensor as connected (Devices icon green).

The status light on the pH adaptor will flash green to indicate a connection is established.

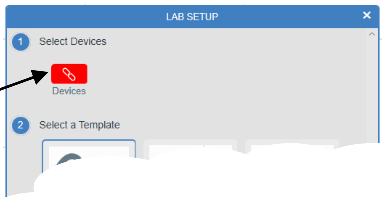


If connecting via Bluetooth:

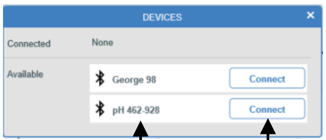
Step 1: Short press the switch to turn the pH adaptor on (blue LED will flash).

Step 2: Open the EasySense2 app.

Step 3: Lab Setup will open, select the red Devices icon.



Step 4: Select to connect to the pH sensor (the list will show the ID number printed on the sensor).



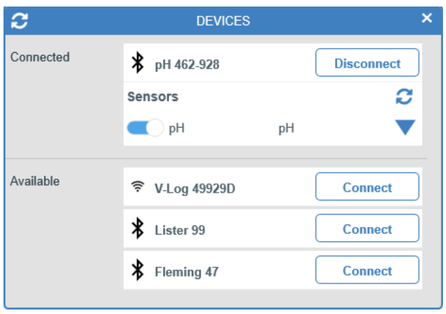
ID number

Connect

The Devices icon will alter to green and the status light on the pH adaptor will flash green to indicate a connection has been established.

Click or tap on ☒ to close the box.

When you have finished use of the pH sensor select Devices and Disconnect.



To add another data logger or smart wireless sensor

Only one USB device can be connected at the same time and it will be added automatically.

For Bluetooth or Wi-Fi devices select the Devices icon (top left of screen) then the Connect button for the device from the list of those available.

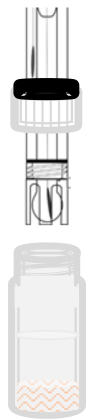
Troubleshooting

If the sensor loses Bluetooth connection and will not reconnect try

1. Closing and reopening the EasySense2 software.
2. Close the EasySense2 software. Switch the sensor Off and then On again (**To switch off**: Press and hold down the On/Off switch for about 2 seconds until the white light is lit solidly then release. **To switch back on:** Press the On/Off switch (blue LED will flash). Reopen the EasySense2 software.
3. If you are using a Bluetooth Smart USB Adaptor unplug the adaptor, plug back in again and try to reconnect.
4. Hard reset the sensor and then try to reconnect.

Electrode preparation

1. With the electrode vertical, unscrew the storage bottle's plastic cap **before** removing the electrode from the storage solution.
2. Wash the glass membrane and liquid junction area (the lower section of the electrode) 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 bulb at the tip of the electrode (glass membrane) 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.
5. Connect the pH electrode to the pH adaptor (line the pins up to the slots, push in and twist the electrodes BNC connector until it locks into place).



Unscrew the cap **before** removing the electrode

Note: *To disconnect, twist the BNC connector in the opposite direction and pull.*

Measurement procedure

1. Connect the pH sensor.
2. Rinse the electrode thoroughly in distilled water before use.
3. Place the pH electrode in the sample to be tested, ensure the bulb is fully submerged.
4. Allow the electrode sufficient time to stabilise and then start taking readings.
5. Rinse the electrode between each measurement with either:
   - a portion of the next sample or
   - deionised or distilled water
6. Dab or pat gently any excess water from the body of the electrode using a paper towel before placing in the next sample.

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 **3.5 - 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.*

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

Practical information

- This general purpose electrode is **non**-refillable
- 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.
- 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 membrane tip is very thin and requires care to prevent accidental damage. Broken glass bulbs are not covered by warranty.
- Some magnetic stirrers can generate sufficient heat to change the temperature of the test solution. If this is the case place a piece of insulation material such as polystyrene under the beaker.
- The working temperature of the pH electrode is 0 to 80˚C. The operating range of the adaptor is 0 to 40˚C and 0 to 95% RH (non-condensing). Do not subject to extreme heat or cold.
- The pH adaptor is not waterproof. It may be cleaned using a damp cloth. Do not immerse in water or detergent
- Do not place the pH adaptor in an environment in which high humidity levels are possible as this may result in damage or malfunction
- If the sensor has been left in the cold, let it warm to near room temperature before waking it from sleep.
- Do not expose to direct sunlight for extended periods of time.
- 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 CO_2 which lowers their pH. During calibration 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 pH adaptor to be used with any suitable pH electrodes with a BNC connector, automatic temperature compensation has not been built in.
- This sensor can also be used with alternative probes, such as Ion Selective Electrodes (ISE) and the Oxidation Reduction Potent (ORP) Probes using the mV range.

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 9). Avoid frequent or prolonged periods of use in these solutions.

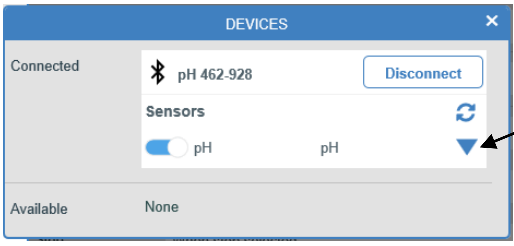
To set the range

The stored calibration for the sensor is the **pH** range, which is suitable for most experiments. It is also possible for the user to adjust the calibration constants of an electrode – this will be stored in the connected Adaptor as the **User pH** range, see page 8.

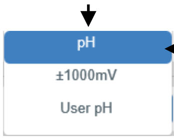
To alter the range in the EasySense2 software:

1) Either select the Devices icon  or the Setup icon (bottom left of screen), line 1: Sensors and select the edit symbol.

Edit symbol

2) 

Tap or click the down arrow and select the wanted range from the list.



Current range highlighted

The range setting will be retained until changed by the user.

The sensor ranges

pH range

This range is the pre-set default calibration that is suitable for most investigations. The calibration is set for operation at a temperature of 25˚C.

±1000 mV

This range gives the reading in mV and can be used in experiments on calibrating a pH sensor using buffer solutions of known pH values. See page 14.

An ideal would be that the potential is zero mV when the pH is 7 but in a real pH system this is rarely so, it is normally between -20 mV and +20 mV.

This range can also be used with ion-selective electrodes (ISE) and oxidation reduction probe (ORP). All ISE's work in the same manner as a pH electrode, in fact the pH electrode is really an H+ ISE. Ions have either a positive charge or a negative charge. The ISE measures the electrical energy created by the presence of the charged particles. An Ion Selective membrane controls the flow of the ions to the electrode; it is this membrane that makes the electrode particular to an ionic species. The production of a calibration curve is required to convert the mV reading to ppm or Log ion concentration reading. Refer to the manufacturer's guide for the ion-selective electrodes (ISE) and oxidation reduction probes (ORP) for details of dilutions for calibration and mV slope values.

User calibration

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 pH** calibration.

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

Standardised buffer solutions are used 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.

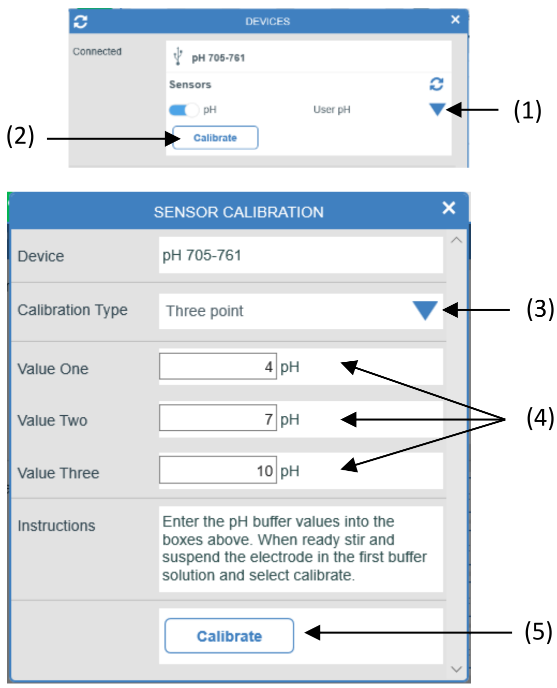
Values of pH buffers a various temperatures:

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 CO_2 which lowers their pH. Only open the bottle of buffer to pour into a beaker, never leave the bottle open.

How to calibrate

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 symbol ▼ 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, 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.
8. After the next count a message will say 'Your sensor has been calibrated ……' Select Finish.

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

Specifications

pH Adaptor

Sensor ranges: 3

Connectivity: USB or Bluetooth

Fastest logging speed: 50 samples per second [20 ms]

Firmware upgradeable

USB communication to PC: Full speed compliant

Power specifications: 5 V at 500 mA

Battery: rechargeable internal lithium-ion 3.7 V, 1300 mAh

Operating range: 0 - 40˚C and 0 to 95% RH (non-condensing)

Memory: Last log, up to 10,000 samples

Weight of pH adaptor only: approx. 85 g

External dimensions of pH adaptor only: approx. height 33 mm x width 50 mm x length 103 mm

Bluetooth

- Bluetooth 4.2 low energy radio, single mode compliant
- Transmit (TX) power: 0 dBm
- Receiver (RX) sensitivity: - 90 dBm
- Usable transmission range: up to 10 m in open air
- Frequency Range: 2.402 to 2.480 GHz operation

pH Electrode

Range 1: pH, 0.00 to 14.00 pH. Resolution: 0.01 pH

Range 2: ±1000 mV, Resolution: 1 mV

Range 3: User pH, 0.00 to 14.00 pH. Resolution: 0.01 pH

E° 0±20 mV (25˚C)

Slope (pH 4.00 – 6.86) >95%

Electrode Diameter: 12 to 13 mm

Electrode working temperature: 0 to 80˚C

Batteries

The Smart Wireless pH sensor is fitted with a rechargeable lithium-ion battery. Whenever the pH sensor is connected to the USB port on the computer or to a USB mains charger (output 5 V at 500 mA or more), it will automatically re-charge the battery (LED status flashing white).

The adaptor will stay awake for 60 mins when Bluetooth advertising (LED status flashing blue).

Once connected to the EasySense2 software (LED status flashing green) the adaptor will stay awake until the battery loses charge.

To switch Off: Press and hold down the On/Off switch for about 2 seconds until the white light is lit solidly then release.

Lithium-ion batteries are 'memory-free' and prefer a partial rather than a full discharge. Constant partial discharges with frequent recharges will not cause any harm. Frequent full discharges should be avoided whenever possible. Ideally the sensor should be stored at about 40% or more charge.

The speed at which a lithium-ion battery will age is governed by both its storage temperature (preferably less than 40˚C) and state-of-charge. Eventually the battery will no longer deliver the stored energy and will need to be replaced. A fully charged battery that loses its charge quickly will demonstrate the need for replacement. When this happens, contact Data Harvest.

Updating the Firmware

Occasionally Data Harvest may release updated firmware which will contain improvements or new features. Updates will be made available from the product specific page on the Data Harvest website.

Hard Reset

If the Smart Wireless pH sensor fails to respond to the computer carry out a hard reset.

- If necessary attach the pH sensor to power.
- Press and hold down the On/Off button for at least 8 seconds until the status LED gives a flash of blue light then release.

If the sensor still fails to respond contact Product Support at Data Harvest.

Please provide details of:

- The computer platform it is being used with and the EasySense2 software's version number.
- A description of the problem being encountered

If possible, telephone from a location where you can operate the sensor with the computer.

Electrode 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 between 10 to 30 minutes. Rinse thoroughly with distilled water. Soak in its storage solution for at least 2 hours before use.

The pores of the reference junction may become clogged, if so heat to 50˚C in 3 to 4 mol dm^{-3} Potassium Chloride (KCl) or pH 4 buffer solution for 1 hour, then allow to cool to room temperature in the same solution. Rinse with distilled water and soak in its storage solution for at least 30 minutes 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 or stain removing pre wash pre-treatment. Do not use automatic or electric dish washing detergents. On overnight soak may be needed if build-up is heavy. 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} hydrochloric acid (HCl) for at least 10 minutes or soak the pH electrode in contact lens enzymatic cleaner solution overnight. Rinse thoroughly with distilled.

Highly resistant deposits: - Clean with H_2O_2 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.

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:

$$pH = -\log [H^+]$$

Where 'p' is the mathematical symbol of the negative logarithm and $[H^+]$ 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:

$$E = E^{o} + \frac{2.303\,RT}{nF} \cdot \log [H^+]$$

Where:

E = Measured electrode potential

E^{o} = Standard potential of the system (constant)

R = gas law constant (8.314 J mol^{-1} K^{-1})

T = absolute temperature in ˚K (˚C + 273)
F = Faraday constant (96,485.33 C mol^{-1})
n = valence factor (n = 1 in the case of hydrogen)

At 25˚C the theoretical slope is $\frac{2.303 \times 8.314 \times (25 + 273.15)}{96,485.33} = \frac{5,708.995}{96,485.33}$ = 59.1695 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.

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 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.

If the sensors are being used in a solution that has a high conductance e.g. seawater 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).

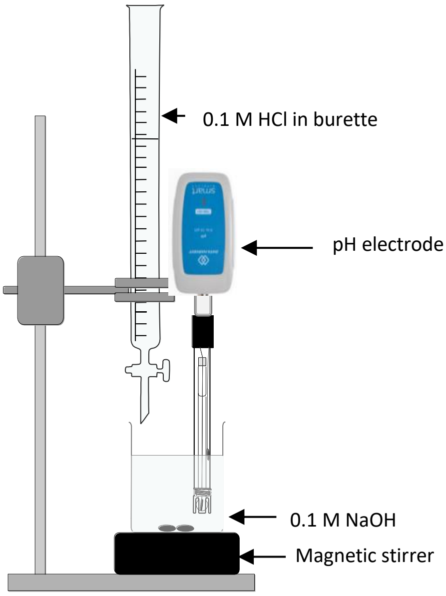
Investigations

- *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.

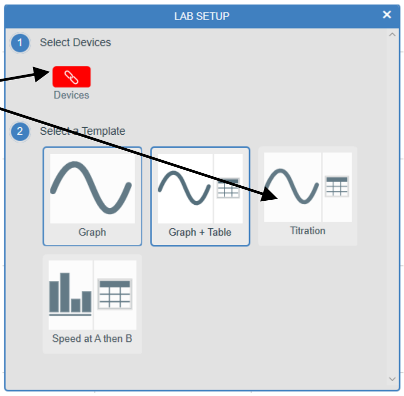
Sodium hydroxide
0.5 to 2% (Solutions 0.05 to 0.5 mol dm^{-3})
Xi; R36/38
Wear pvc gloves and eye protection.
Sodium hydroxide solution is dangerous to eyes
Refer to Hazard Sheets for First Aid Measures



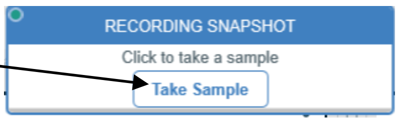
1. Assemble the apparatus as shown.
2. Carefully fill the burette with 0.1 mol dm^{-3} hydrochloric acid. Place a beaker under the reservoir and open the stopcock to allow a small amount of HCl to pass through. Pour the HCl from the beaker back into the burette.
3. Add 25 cm^{3*} of 0.1 mol dm^{-3} sodium 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.
5. Open EasySense2 and select the **Smart pH sensor** as the device and the **Titration** template from Lab Setup.

   Note: Lab Setup can be accessed on opening or via File -> New Lab.

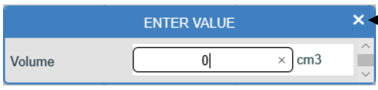


6. Tap or click below the X axis and select Volume.
7. Tap or click on **Start** to begin.
8. Tap or click on **Take Sample** to record the first pH value with no acid added.

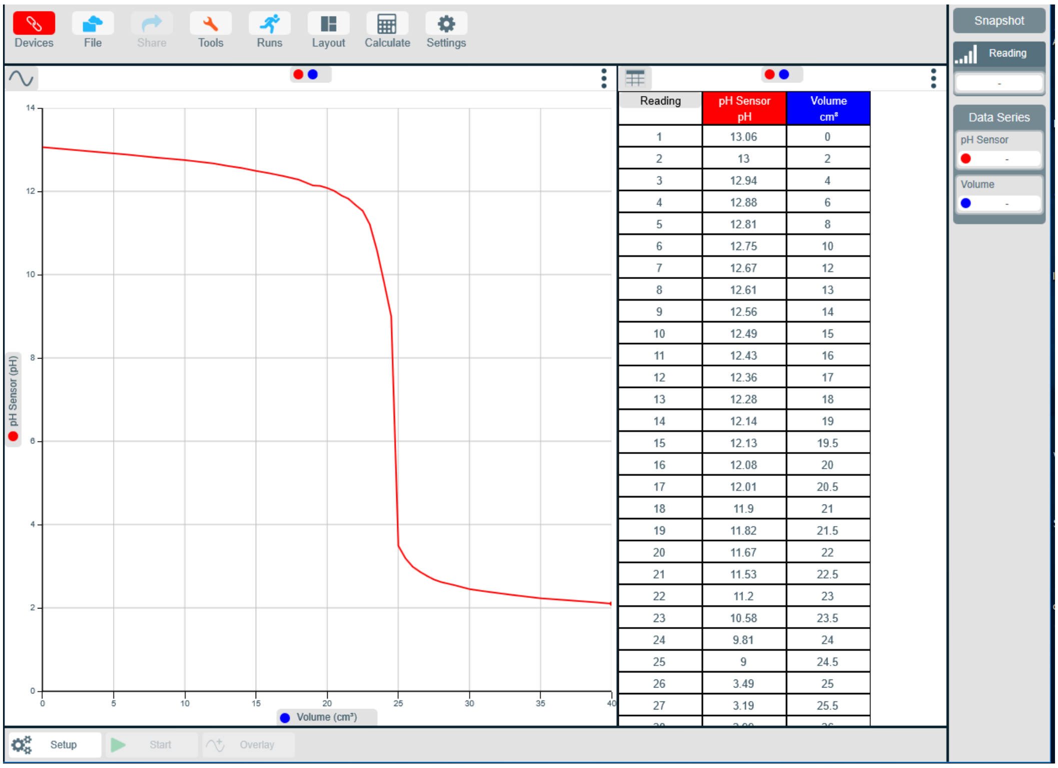


9. Type 0 into the ‘enter value’ box and close.

   Note: Enter the TOTAL volume of acid added so far.



10. Turn the tap on the burette to add a measured amount e.g. 2 cm^3. Let the solutions mix and take a sample. Enter the volume of acid added e.g. 2.
11. Vary the amount of acid added as required.
12. Tap or click on the **Stop** icon to finish recording.



In this titration 2 cm^3 was added for the first 6 readings then the amount of acid added was reduced to 1 cm, then after 19 cm^3 (closer to the expected end-point) it was reduced to 0.5 cm^3

How to create a mV to pH calibration graph

Buffers. You will need a minimum of two buffers, preferably three or more e.g. 4, 7 and 10.

If you are only using two then its best if one is a ‘neutral’ buffer with a pH of 7, and the second is near to the expected pH of the samples you will be testing. For example buffers with a higher pH (10) are best for measuring bases, whereas buffers with a low pH (4) are best for measuring acidic samples.

Once you have chosen your buffers allow them all to reach the same temperature. Pour your buffers into individual beakers for calibration. Check the temperature of the room and label the value of each buffer with its pH value at that temperature.

For example: Values of pH buffers a various temperatures:

Temperature ˚C	pH 4.0 buffer	pH 7.0 buffer	pH 10.0 buffer
10˚	4.00	7.05	10.10
20˚	4.00	7.00	10.00
25˚	4.01	6.99	9.945
30˚	4.01	6.98	9.90

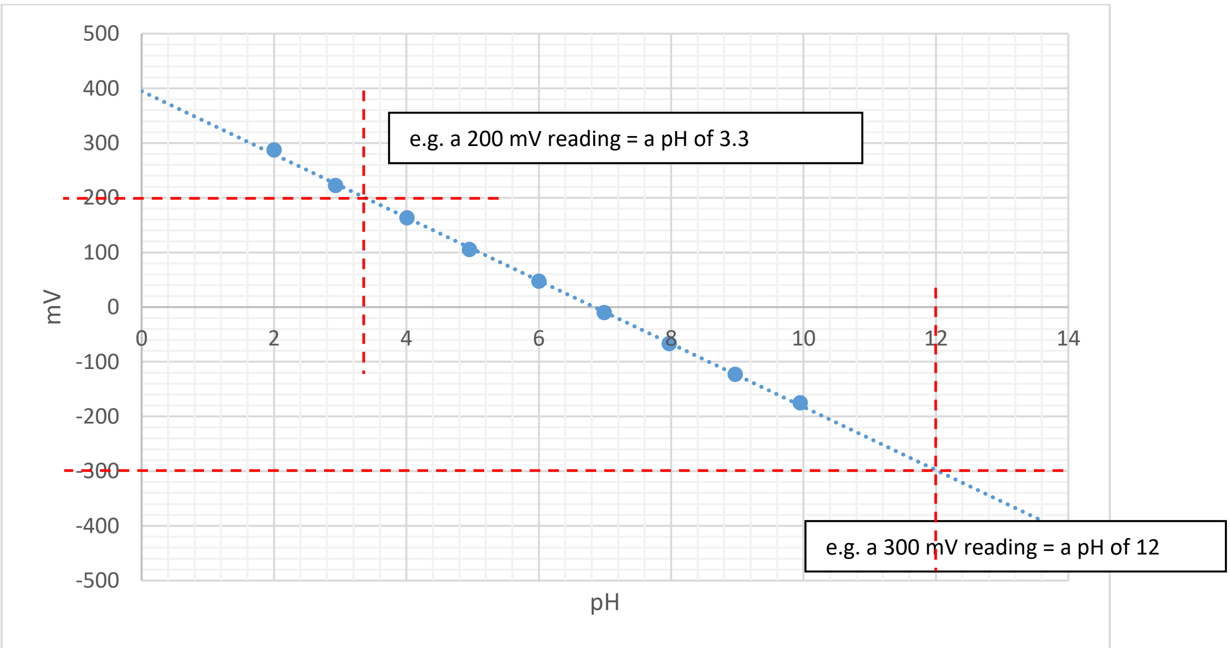
- Connect the pH sensor to the computer, open the EasySense2 software and check the range of the pH sensor is set to ±1000 mV.
- In Setup check the mode is Continuous, select a Numeric chart and Start logging.

- Rinse the electrode with distilled water. Dab or pat gently any excess water from the body of the electrode using a paper towel.
- Place the pH electrode in the beaker of the first buffer solution, allow the reading to stabilise and write down the mV reading and the pH value of the buffer in a results table.
- Rinse the electrode with distilled water. Dab or pat gently any excess water from the body of the electrode using a paper towel.
- Place the pH electrode in the beaker of the second buffer solution, allow the reading to stabilise and write down the mV reading and the pH value of the buffer.
- Repeat for all buffers supplied.
- Draw a graph with the pH buffer value on the X axis (from 0 to 14) vs. mV reading on the Y axis. Draw a best fit line.

  This graph can be used to find the pH value for the mV reading from the sensor.

For example we used 9 different buffers:

pH of buffers	2	2.93	4.01	4.95	6.0	6.99	7.97	8.97	9.95
mV reading	287	222	163	105	47	-10	-67	-123	-175



To calculate the pH electrode slope percentage

The ratio of the measured potentials to the difference of pH gives the slope of the straight line.

$$\text{Slope S} = \frac{E_2 - E_1}{pH_2 - pH_1} \quad [\text{mV/pH}]$$

For example: pH buffer pH 4 and pH 7 are used. For buffer pH 4 the potential is 163 mV and in buffer pH 7 its -10 mV.

$$\text{Slope S} = \frac{163 - (-10)}{7 - 4} = \frac{173}{3} = 58\ [\text{mV/pH}]$$

At 25˚C the theoretical slope is 59.17 mV/ per pH unit. To calculate the pH electrode slope percentage divide the mV potential being generated per pH unit by the theoretical number and multiply by 100

$$\frac{58}{59.17} \times 100 = 98\%\ \text{slope}$$

Generally a slope between 90 to 105% is acceptable.

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.

FCC Details

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.