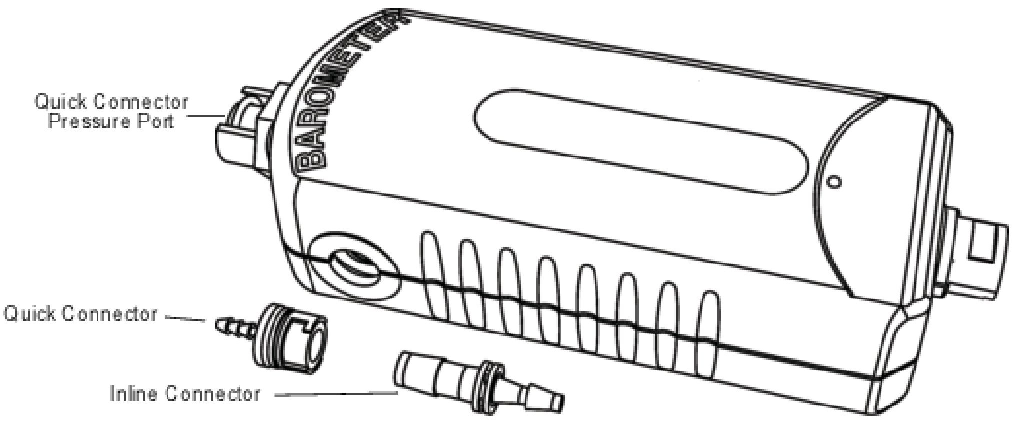
Barometer/Low Pressure Sensor



Included Items
Tubing, 60 cm (2 ft) - not shown
Connector, inline (4)
Connector, quick (4)

Required Items
PASCO Interface
PASCO Data Acquisition Software

Other Item*
PS-2500 PASPORT Extension Cable

Introduction

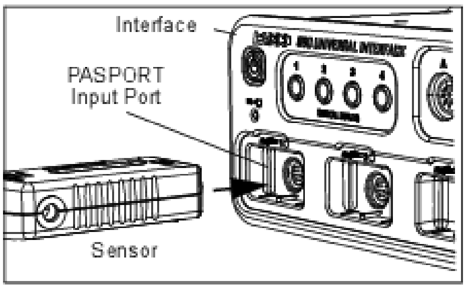
The PS-2113A Barometer/Low Pressure Sensor measures atmospheric pressure in inches of mercury (Hg), hectopascals (hPa), kilopascals (kPa), and millibars (mBar).

The sensor is designed to work with a PASPORT-compatible interface (such as the UI-5100 850 Universal Interface) and PASCO data acquisition software (such as PASCO Capstone). With the data acquisition software, the sensor can be used to measure the barometric pressure over a period of time, the difference in air pressure related to a change in altitude, or the change in pressure inside a plant due to transpiration.

The sensor includes plastic tubing, four inline connectors, and four quick connectors. The quick connector attaches to the pressure port on the front end of the sensor. The inline connector can be used to attach a piece of tubing to a one-hole stopper, for example.

Set-Up

- Plug the Barometer/Low Pressure Sensor into one of the PASPORT input ports of a PASCO interface.



NOTE: If more distance is needed between the sensor and the interface, plug the sensor into a PASPORT Extension Cable, and then plug the cable into the interface.

- Start the PASCO data acquisition software. Set up a data display in the software. Begin recording data.

Specifications

Item	Value
Range:	150 to 1150 hPa 150 to 1150 mBar 15 to 115 kPa 4.4 to 34 inches Hg
Accuracy:	±0.03 inches Hg
Resolution	0.001 inches Hg
Operating Temperature:	0 to 40 °C
Relative Humidity Range	5 to 95%, non-condensing*

**Condensation on the unit will negatively affect performance.*

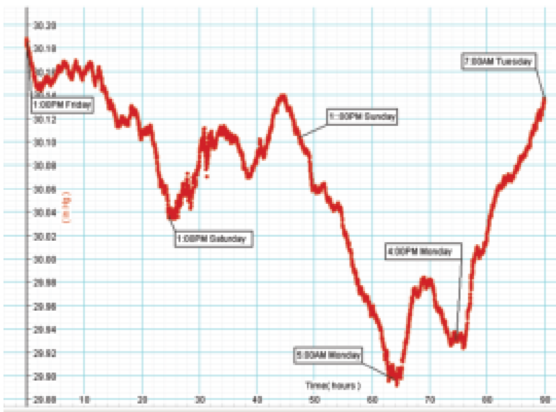
Suggested Activities

Measure Pressure Differences

Use the sensor to measure the difference in air pressure from the floor to the ceiling of the classroom.

Measure Barometric Pressure

Set up the sensor and the data acquisition software to record barometric pressure for a long period of time (24 to 48 hours). Compare the barometric pressure.



Barometric Pressure Over Three Days

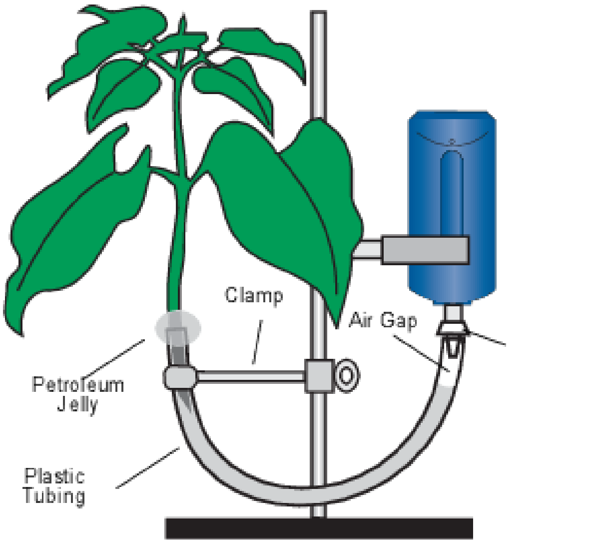
Plant Transpiration

Obtain a healthy plant seedling and soak its stem in a bowl of water. Make a 45° cut near the end of the stem.

Plant-Tube Joint: Fill a foot-long piece of the supplied tubing with water. To avoid air bubbles in the tube, submerge the tubing in the water bowl, and insert the seedling stem into the tube under water. Seal the joint with petroleum jelly.

Sensor-Tube Joint: Create a 2–3 cm air pocket at the other end of the tube. Using a quick connector, connect the tube to the sensor's pressure port. (WARNING: Do not allow fluid to enter the pressure port, as this will damage the sensor.)

Using a rod stand and two clamps, build the setup shown below. Keep the sensor's pressure port 5–7 cm higher than the plant's end of the tube.



Setup for Plant Transpiration

Click the Start button to record pressure data for at least 400 seconds.

Repeat data recording, but place a blowing fan next to the plant to simulate transpiration conditions on a windy day.

Compare the two graphs of pressure versus time.

Setup the Barometer/Low Pressure Sensor

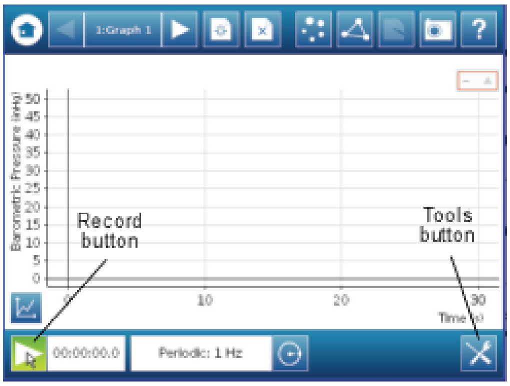
Using the PASCO Capstone Software

- In the PASCO Capstone software, click the "Hardware Setup" icon in the Tools palette to open the "Hardware Setup" panel. Confirm that the Barometer/Low Pressure Sensor icon appears with the interface's icon.
- Click the "Data Summary" icon in the Tools palette to open the "Data Summary" panel. The panel lists the sensor's measurements.
- To select the units of measure or make other changes to the measurement properties, select the parameter in the Sensor Data Summary panel, and then click the "Properties" icon (shaped like a gear) to open the Properties panel.

Using the SPARK Science Learning System

- Start the interface and plug the sensor into a port on the SPARK SLS.

- In the sensor parameter screen, tap 'Barometric Pressure' to highlight it, and then tap 'Show' to open a graph display.



- Tap the 'Start' button to start recording data.

NOTE: To change the parameter or units, tap the 'Tools' button in the graph display to open the 'Experiment Tools' menu, and tap 'Data Properties' to open the Data Properties screen. Tap 'Select Measurement...'.

local environmental laws and regulations to ensure that it will be recycled in a manner that protects human health and the environment. To find out where you can drop off your waste equipment for recycling, please contact your local waste recycle/disposal service, or the place where you purchased the product.

The European Union WEEE (Waste Electronic and Electrical Equipment) symbol (to the right) and on the product or its packaging indicates that this product must not be disposed of in a standard waste container.

Oxygen Gas Sensor

Included Equipment

Sensor Amplifier

Oxygen Sensing Element (with deflector)

Rubber Stopper

Connecting Cable (3.5 millimeter)

Sampling Bottle

Required Equipment

PASPORT Interface

Introduction

The PS-2126A Oxygen Gas Sensor measures oxygen gas concentration in percent (%) and parts per million (ppm) oxygen. It can be used to study plant, animal, or cellular respiration; air quality; and the rate of oxygen (O_2) production in chemical reactions (see the experiment on page 2 for one example).

How it works:

The Oxygen Sensing Element is a galvanic fuel cell with a gas permeable membrane at one end. It is very similar to a battery. The fuel cell contains an electrolyte, anode and cathode. When oxygen enters the fuel cell through the membrane, a chemical reaction between the metallic cathode and anode and the electrolyte occurs. This chemical reaction produces a voltage and current that is present at the output jack at the other end of the Oxygen Sensing Element. The current produced is proportional to the concentration of oxygen present.

Oxygen Sensing Element Life:

Galvanic fuel cells have a limited lifetime which is determined by their age and their exposure to oxygen. This is similar to the life of a battery in a flashlight. If the flashlight frequently used, the battery life will not be as long as it would have been with limited usage. Similarly, the fuel cell's useful life is determined by its exposure to oxygen gas.

The fuel cell included with the PS-2126A has a useful life of 900,000 oxygen percent (O_2 %) hours.

An example: If the sensor is used in a 100% oxygen atmosphere, the life of the sensor may be calculated as 900,000 O_2 % hours divided by 100% oxygen which is 9,000 hours. This is about 1 year.

The life of the sensor in normal air (20.9% oxygen) is 900,000 O_2 % hours divided by 20.9% oxygen which is 43,062 hours. This is about 4.9 years.

The sensor is guaranteed for a minimum of 2 years from the date of manufacture. This is the absolute guarantee. If it is used in a 100% oxygen atmosphere its life will be shortened. If it is used in normal air, its life will be 4 to 5 years. There is reported evidence of this particular sensing element being in use for almost 10 years. In the end, the useful life of the sensing element is dependent on the manner in which it is used.

Setup

Connect the Oxygen Gas Sensor to your PASPORT interface.

To prepare the Oxygen Sensing Element for use:

1. Remove the Oxygen Sensing Element and deflector from the packaging.
2. Remove the pink tape from the Oxygen Sensing Element.
3. Carefully thread the deflector onto the Oxygen Sensing Element.
4. Slide the rubber stopper over the deflector.

5. Plug one end of the connecting cable into the Oxygen Sensing Element.

6. Plug the other end of the connecting cable into the Sensor Amplifier.

7. Connect the Sensor Amplifier to the PASCO interface.

8. Refer to the documentation that came with the PASCO interface and software for further instructions for data collection.

Collecting O_2 Samples

To collect an atmospheric sample, hold the bottle upright and open to the air. Insert the end of the sensing element into the bottle. Press the rubber stopper into the neck to seal the bottle.

To collect expired air or other gas samples, place the sensing element inside a plastic bag. Press any atmospheric air out of the bag. Use a tube to fill the bag with the gas sample. Hold, tie, or clamp the bag closed round the tube and sensing element cable to contain the gas sample and exclude atmospheric air.

When doing an experiment that requires a faster than usual response time, the response time of the sensor may be increased by removing the white deflector and stopper from the Oxygen Sensing Element. This shortens the path to the sensor's membrane allowing it to be populated more rapidly with the sample.

The purpose of the white deflector is to deflect air from an air stream into the sensing element and provide protection for the gas permeable membrane. It also holds the rubber stopper.

While the white deflector is removed from the sensing element, be careful not to place sharp objects near the membrane as puncturing the membrane could lead to damage to the sensing element and electrolyte leaking from the membrane.

Removal of the deflector is not required or recommended during typical operating conditions.

Warning: Do not allow the sensing element to contact liquids.

Calibration

The sensor is factory calibrated. However, for greater accuracy, you can follow these steps to calibrate the sensor:

1. With the sensor connected to a powered PASPORT interface, place the sensing element in the empty sampling bottle. Outside air has an O_2 concentration 20.9%.

2. Press the **CAL (20.9%)** button on the sensor and hold it for 3 seconds. The green light will flash on and off for 4 seconds, indicating that calibration is in progress.

3. After 4 seconds, the reading will stabilize at 20.9%. When calibration is complete, the light will stop flashing.

Note: If the green light flashes rapidly after calibration, the sensing element may be expired and it may need replacement.

Experiment: Oxygen Production from Liver Catalase

Equipment required: *Oxygen Gas Sensor with sampling bottle, beef or chicken liver, hydrogen peroxide, pipette, mortar and pestle, ice bath, boiling water, and safety goggles.*

Safety*: Always wear safety goggles when performing this experiment. Do not allow excessive pressure to develop in the sampling bottle.*

1. Place the liver in an open container and allow it to warm to room temperature.

2. (Optional) Calibrate the Oxygen Gas Sensor (see above).

3. Grind the liver to a mushy consistency.

4. Place 10 mL of hydrogen peroxide into the clean, dry sampling bottle.

Note: Perform step 5 through 7 carefully and quickly.

5. With a pipette, extract 1 mL of blood/homogenate from the ground liver and release it into the sampling bottle.

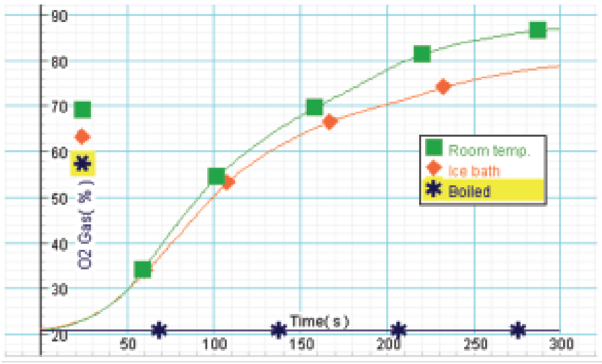
6. Insert the end of the sensing element into the bottle. Press the rubber stopper into the neck of the bottle just enough to close the bottle, but not too tightly

7. Start data collection on the computer or interface.

8. After about 300 seconds, stop data collection.

9. Clean and dry the sampling bottle. Repeat steps 4 through 8 with cold liver homogenate that has been chilled in an ice bath. Repeat again with liver homogenate that has been boiled in water.

10. Compare your results from the three runs.



Sensing Element Maintenance

Storage:

The Oxygen Sensing Element may be stored in its package until its first use.

It is recommended that the sensing element be stored with the threaded nose piece in the downward position. This insures that the electrolyte remains in contact with the membrane for extended periods of storage. Sensor life may be extended by storing the sensing element in a refrigerator at 40°F to 50°F (4°C to 10°C). Do not freeze the sensor or sensing element.

Specifications

Range	0 to 100% O_2 concentration 0 to 1000000 parts per million (ppm)
Resolution	0.025% oxygen
Repeatability	±0.5% oxygen
Accuracy	±1% O_2 at constant temperature and pressure; ±5% O_2 over operating temperature range
Operating temperature	0 to 40 °C
Relative humidity range	0 to 100%, non-condensing
Sensing element useful life	4+ years
Sensing element warranty period	24 months

Instruction Sheet

pH Sensor

Included Parts

1. pH amplifier
2. pH electrode
3. Storage bottle containing storage solution

Additional Part Required

- PASPORT interface or datalogger

Related Parts

- Replacement electrode (PASCO part 699-195)
- Flat-surface electrode (PS-2182)
- pH buffer set (SC-2321)

Quick Start

1. Connect the amplifier to your PASPORT interface.
2. Connect the pH electrode to the amplifier.
3. If you are using a computer, connect the PASPORT interface to it and start DataStudio.
4. Remove the storage bottle from the electrode.
5. Rinse the electrode with distilled water.
6. Immerse the end of the electrode in the solution to be measured.
7. Press or click the start button to begin recording data.

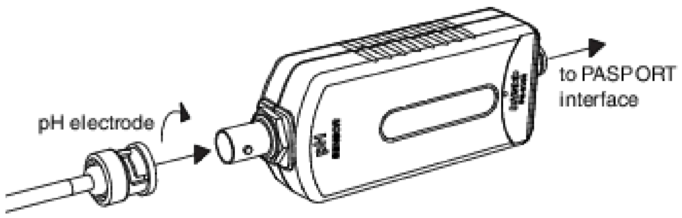
Introduction

The pH Sensor measures the pH of a solution. The measurement is recorded and displayed by the connected computer or datalogger. The pH Sensor is well-suited for continuous recording and discrete measurements.

Set-up

Connecting the Parts

1. Plug the sensor's PASPORT connector into any port of a PASPORT interface or datalogger.
2. Push the connector at the end of the electrode cable onto the sensor's electrode connector. Twist the connector to lock it in place.



Connecting the electrode and interface

3. If you are using a computer, connect the PASPORT interface to it and start DataStudio.

Removing the Storage Bottle

Removing the bottle

1. Hold the electrode vertically so that the solution will not spill out of the bottle.
2. Unscrew and remove bottle. Keep the storage solution for later use.
3. Push the bottle cap up the electrode shaft to keep it out of the way.

Collecting Data

1. Rinse the electrode with distilled water.
2. Immerse the end of the electrode in the solution to be measured. The bulb-shaped glass membrane should be entirely immersed.
3. Press or click the start button to begin recording data.
4. Wait for the reading to stabilize.
5. Rinse the electrode again before placing it in another solution.

Calibration

Calibration is not always necessary, especially if you are interesting in measuring a change in pH rather than absolute pH values. For accurate measurements, first calibrate the sensor. You will need two different buffer solutions (pH 4 and pH 7 in this example) and distilled water. The solutions should be at the same temperature as the solutions that you will measure later.

The calibration procedure varies depending on which software or datalogger you are using. For more specific instructions, see the documentation for your software or datalogger.

1. Open the calibration window or screen. (In DataStudio, click **Setup**; then click **Calibrate Sensors**.)
2. Select the "2 Point" calibration type.
3. Rinse the electrode with distilled water.
4. Place the electrode in pH 4 buffer solution. Wait for the reading to stabilize.
5. Click or select **Read** for the first calibration point.
6. Remove the electrode from the solution and rinse it with distilled water.
7. Place the electrode in pH 7 buffer solution. Wait for the reading to stabilize.
8. Click or select **Read** for the second calibration point.

Electrode Maintenance

Electrode Storage

For a storage period of a few weeks or less, rinse the electrode with distilled water and place it in the storage bottle filled with storage solution. To make storage solution, combine equal parts 4 M potassium chloride (KCl) and pH 4 buffer solution, with a few drops of pH buffer preservative (buffer preservative is optional).

You may keep the electrode in the storage solution indefinitely, but for long term storage, PASCO recommends storing the electrode dry. After dry storage, the electrode must be restored (see below) to rehydrate the glass membrane.

Restoring the Electrode

Follow this procedure to improve the response of a slow electrode or to rehydrate the membrane after dry storage.

1. Clean the membrane using one or more of these methods:
   - If the electrode is contaminated with proteins, soak the electrode in a solution of 1% pepsin in 0.1 Molar hydrochloric acid (HCl).
   - If the electrode is contaminated with inorganic deposits, rinse the electrode with 0.1 M ethylene dinitric tetra-acidic acid (EDTA) tetrasodium solution.
   - If the electrode is contaminated with oil or grease, wash the electrode in a mild detergent or solvent known to be effective for the particular film.
   - If the electrode is not responding quickly, soak the electrode alternately in 12 M NaOH (sodium hydroxide) and 1 M HCl (hydrogen chloride). Leave it in each solution for one minute. Rinse completely between soakings and end with HCl.
2. Soak the electrode in 0.1 M hydrochloric acid (HCl) for 15 minutes.
3. Soak the electrode in a pH 7 buffer solution for 30 minutes.

If the restoring procedure fails to improve the response of the electrode, replace the electrode.

Replacement and Alternative Electrodes

- For a replacement electrode, purchase PASCO part 699-195.
- A flat-surface electrode, part PS-2182, is also available.
- The pH Sensor is compatible with other combination pH electrodes that have BNC connectors.

Specifications

pH Amplifier	
Maximum sampling rate	50 samples/s
pH Range	0 to 14 (probe dependent)
Accuracy	±0.1 after calibration
Resolution	0.005
Repeatability	0.02
pH Electrode	
Type	Gel-filled Ag-AgCl combination electrode
Connector	BNC