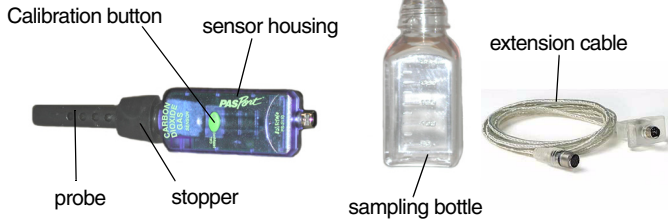




Carbon Dioxide

PS-2110



Sensor Specifications

Sensor Range:	0 to 300,000 ppm CO ₂ [†]
Resolution:	1 ppm
Accuracy:	0 ppm to 10,000 ppm: 100 ppm or 10% of value, whichever is greater 10,000 ppm to 50,000 ppm: 20% of value Over 50,000 ppm: qualitative only*
Repeatability:	±50 ppm or 5% of value, whichever is greater
Humidity/temp. range:	5% to 95% relative humidity, non-condensing, 20°C to 30°C**

[†]The CO₂ Gas Sensor was not intended for environmental compliance studies.

*In this range, the unit is only intended for qualitative measurements.

**The unit may be operated beyond this range, but the accuracy may be reduced.

Carbon Dioxide Quick Start

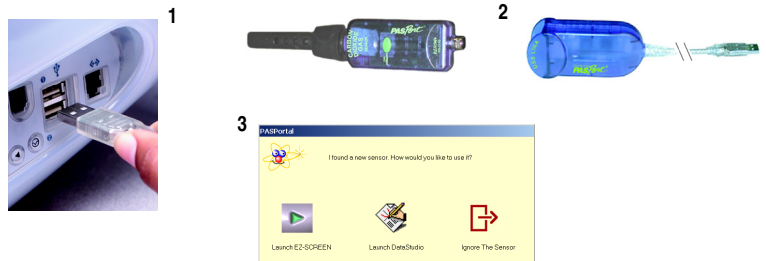
The PS-2110 Carbon Dioxide (CO₂) Gas Sensor measures carbon dioxide concentration (parts per million) in gases such as air. The CO₂ Gas Sensor was designed only for educational purposes.

Additional Equipment Needed

- PASPORT™ USB interface [e.g., USB Link (PS-2100), PS-2000 Xplorer, PS-2002 Xplorer GLX, or PS-2008 SPARK SLS] and a USB-compatible computer.
- EZscreen or DataStudio® Software (version 1.7.2 or later)

Equipment Setup

1. Connect the USB interface to a USB port on your computer or to a USB hub.
2. Connect the sensor to a USB interface, or connect the sensor to the PASPORT Sensor Extension Cable (included) and then connect the cable to the interface.
3. The software launches when it detects a PASPORT sensor. Select a choice from the PASPORTAL window.



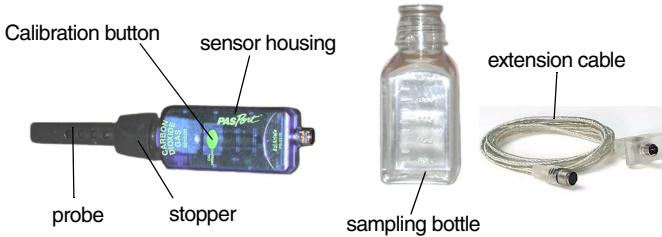
800-772-8700 • 916-786-3800 • techsupp@pasco.com • www.pasco.com

012-07757C



Carbon Dioxide Gas Sensor

PS-2110



Sensor Specifications

Sensor Range:	0 to 300,000 ppm CO ₂ [†]
Resolution:	1 ppm
Accuracy:	0 ppm to 10,000 ppm: 100 ppm or 10% of value, whichever is greater 10,000 ppm to 50,000 ppm: 20% of value Over 50,000 ppm: qualitative only*
Repeatability:	±50 ppm or 5% of value, whichever is greater
Humidity/temp. range:	5% to 95% relative humidity, non-condensing, 20°C to 30°C**

[†]The CO₂ Gas Sensor was not intended for environmental compliance studies.

*In this range, the unit is only intended for qualitative measurements.

**The unit may be operated beyond this range, but the accuracy may be reduced.

Carbon Dioxide Quick Start

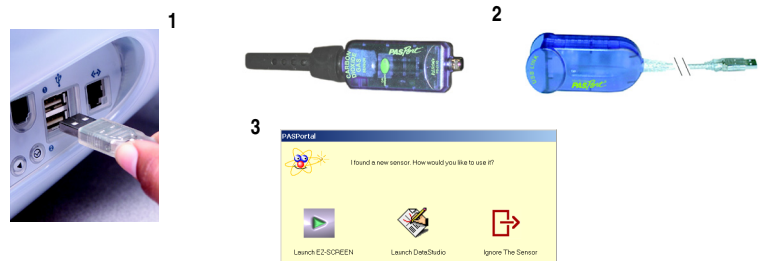
The PS-2110 Carbon Dioxide (CO₂) Gas Sensor measures carbon dioxide concentration (parts per million) in gases such as air. The CO₂ Gas Sensor was designed only for educational purposes.

Additional Equipment Needed

- PASPORT™ USB interface [e.g., USB Link (PS-2100), PS-2000 Xplorer, PS-2002 Xplorer GLX, or PS-2008 SPARK SLS] and a USB-compatible computer.
- EZscreen or DataStudio® Software (version 1.7.2 or later)

Equipment Setup

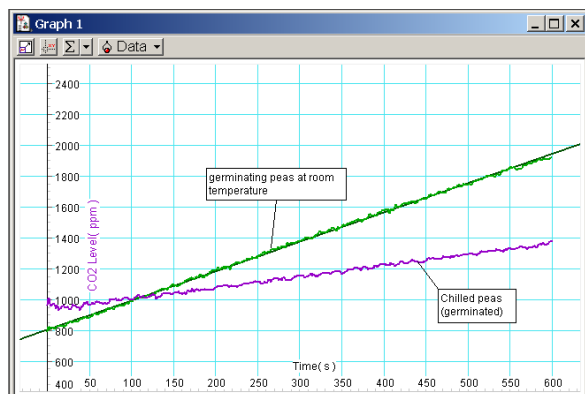
1. Connect the USB interface to a USB port on your computer or to a USB hub.
2. Connect the sensor to the USB interface, or connect the sensor to the PASPORT Sensor Extension Cable (included) and then connect the cable to the interface.
3. The software launches when it detects a PASPORT sensor. Select a choice from the PASPORTAL window.



800-772-8700 • 916-786-3800 • techsupp@pasco.com • www.pasco.com

012-07757C

Cellular Respiration of Peas



DataStudio/DS Lite

Procedure:

Open a display:

In the Displays list, double click on any display.

View the CO₂ reading:

In the Data list, click on the CO₂ (CO₂) icon and drag it to an open display.

Scale to fit the data:

Click the **Scale-to-Fit** (☒) button.

Change the sampling period or rate:

Click the **Setup** (≡ Setup) button to open the Setup window. Click on the **Maximize** button and scroll to the CO₂ sensor options. Select the down arrow and choose a time unit; use the **Plus** (⊕) and **Minus** (⊖) buttons to change the sampling rate.

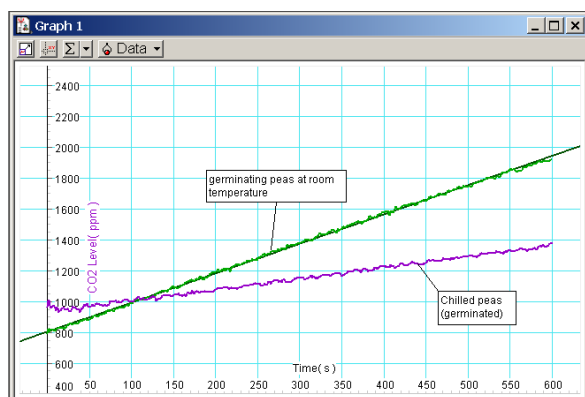
Carbon Dioxide Activity

Cellular Respiration of Peas

Equipment required: 1/4 cup of pea seeds, piece of dark cloth, PS-2110 CO₂ Gas Sensor with bottle and stopper, PASPORT Interface, DataStudio or EZscreen Software, PS-2125 Temperature Sensor (optional)

1. Connect the Carbon Dioxide Gas Sensor to a PASPORT Interface.
2. Put the dry pea seeds into the bottle supplied with the sensor. Insert the probe with stopper and sensor into the bottle.
3. In your data collection software or **Xplorer**, click the **Start** button to take a reading of the concentration of carbon dioxide gas in the bottle. Record data for about 10 minutes; this is the baseline reading before germination.
4. Disconnect the USB Link or **Xplorer** from the sensor/bottle assembly.
5. Moisten the peas with a few teaspoons of water. Place a dark cloth over the bottle, and allow the peas to germinate in the bottle overnight.
6. Following germination, reconnect the sensor to the interface and click the **Start** button. Monitor the CO₂ gas reading for about 10 minutes. (**CAUTION:** Do not allow the probe or sensor assembly to get wet at any time!)
7. Compare the rate of carbon dioxide generation before and after germination. Explain your results. What is causing the change in carbon dioxide concentration?
8. (Optional): Repeat step 6 with the bottle placed in water baths of different temperatures. (Note: If you have a PS-2125 Temperature Sensor or thermometer available, you can monitor both the CO₂ and temperature every 5 minutes for 20 minutes.)

Cellular Respiration of Peas



DataStudio/DS Lite

Procedure:

Open a display:

In the Displays list, double click on any display.

View the CO₂ reading:

In the Data list, click on the CO₂ (CO₂) icon and drag it to an open display.

Scale to fit the data:

Click the **Scale-to-Fit** (☒) button.

Change the sampling period or rate:

Click the **Setup** (≡ Setup) button to open the Setup window. Click on the **Maximize** button and scroll to the CO₂ sensor options. Select the down arrow and choose a time unit; use the **Plus** (⊕) and **Minus** (⊖) buttons to change the sampling rate.

Carbon Dioxide Activity

Cellular Respiration of Peas

Equipment required: 1/4 cup of pea seeds, piece of dark cloth, PS-2110 CO₂ Gas Sensor with bottle and stopper, PASPORT interface, DataStudio or EZscreen Software, PS-2125 Temperature Sensor (optional)

1. Connect the Carbon Dioxide Gas Sensor to a PASPORT Interface.
2. Put the dry pea seeds into the bottle supplied with the sensor. Insert the probe with stopper and sensor into the bottle.
3. In your data collection software or **Xplorer**, click the **Start** button to take a reading of the concentration of carbon dioxide gas in the bottle. Record data for about 10 minutes; this is the baseline reading before germination.
4. Disconnect the USB Link or **Xplorer** from the sensor/bottle assembly.
5. Moisten the peas with a few teaspoons of water. Place a dark cloth over the bottle, and allow the peas to germinate in the bottle overnight.
6. Following germination, reconnect the sensor to the interface and click the **Start** button. Monitor the CO₂ gas reading for about 10 minutes. (**CAUTION:** Do not allow the probe or sensor assembly to get wet at any time!)
7. Compare the rate of carbon dioxide generation before and after germination. Explain your results. What is causing the change in carbon dioxide concentration?
8. (Optional): Repeat step 6 with the bottle placed in water baths of different temperatures. (Note: If you have a PS-2125 Temperature Sensor or thermometer available, you can monitor both the CO₂ and temperature every 5 minutes for 20 minutes.)

Collecting CO₂ Samples

Use the supplied sampling bottle to collect air samples, such as an atmospheric sample or the CO₂ gas produced from germinating seeds. **[Note:** Do not try to remove the probe (sensing tube). The probe is not removable.]

To collect an atmospheric sample: When collecting air, keep the bottle upright and the neck open (without the stopper). Wait long enough to allow atmospheric air to fill the bottle. Insert the probe with stopper into the top neck of the bottle. Ensure the stopper fits snugly into the neck of the bottle before taking a reading.

To collect expired air or other gas samples: Collect the sample in a plastic bag and clamp the bag. To take a reading, unclamp the bag and immediately place the plastic bag over the probe and stopper. In some cases, a valve, tubing with stopcock, or chamber may be necessary to prevent atmospheric gas from entering the bag and mixing with the collected sample.



Figure 1

CO₂ Sensor Calibration

Calibration of the PS-2110 Carbon Dioxide Gas Sensor is not required for most activities, as the sensor is factory calibrated. Over time, the sensor's characteristics may change. To restore the sensor to its factory-calibrated state, perform the calibration in typical outside air conditions (around 400-450 ppm CO₂).

Perform a single point calibration:

1. Go outside and collect a sample of fresh air (400 to 450 ppm CO₂).
2. Insert the probe with stopper and sensor assembly into the upright sampling bottle. Be sure the stopper fits snugly into the neck of the bottle (See Figure 1).
3. Bring the sensor/bottle assembly inside and connect it to an **Xplorer**, USB Link, or other PASPORT interface.
4. In DataStudio (or EZscreen or **Xplorer**), observe the carbon dioxide reading. Wait at least 90 seconds for the reading to stabilize.
5. Press the **Calibrate** button on the sensor and *hold* for 3 seconds. The green light will stay on to indicate calibration has begun.
6. Wait approximately one minute. When the green light flashes again, calibration is finished.
7. To verify the calibration, observe the sensor's reading in DataStudio (or EZscreen or **Xplorer**). The reading should be stable at approximately 400 ppm (± 50 ppm).
8. If the sensor's reading drifts or seems too high or low, recalibrate.

Collecting CO₂ Samples

Use the supplied sampling bottle to collect air samples, such as an atmospheric sample or the CO₂ gas produced from germinating seeds. **[Note:** Do not try to remove the probe (sensing tube). The probe is not removable.]

To collect an atmospheric sample: When collecting air, keep the bottle upright and the neck open (without the stopper). Wait long enough to allow atmospheric air to fill the bottle. Insert the probe with stopper into the top neck of the bottle. Ensure the stopper fits snugly into the neck of the bottle before taking a reading.

To collect expired air or other gas samples: Collect the sample in a plastic bag and clamp the bag. To take a reading, unclamp the bag and immediately place the plastic bag over the probe and stopper. In some cases, a valve, tubing with stopcock, or chamber may be necessary to prevent atmospheric gas from entering the bag and mixing with the collected sample.



Figure 1

CO₂ Sensor Calibration

Calibration of the PS-2110 Carbon Dioxide Gas Sensor is not required for most activities, as the sensor is factory calibrated. Over time, the sensor's characteristics may change. To restore the sensor to its factory-calibrated state, perform the calibration in typical outside air conditions (around 400-450 ppm CO₂).

Perform a single point calibration:

1. Go outside and collect a sample of fresh air (400 to 450 ppm CO₂).
2. Insert the probe with stopper and sensor assembly into the upright sampling bottle. Be sure the stopper fits snugly into the neck of the bottle (See Figure 1).
3. Bring the sensor/bottle assembly inside and connect it to an **Xplorer**, USB Link, or other PASPORT interface.
4. In DataStudio (or EZscreen or **Xplorer**), observe the carbon dioxide reading. Wait at least 90 seconds for the reading to stabilize.
5. Press the **Calibrate** button on the sensor and *hold* for 3 seconds. The green light will stay on to indicate calibration has begun.
6. Wait approximately one minute. When the green light flashes again, calibration is finished.
7. To verify the calibration, observe the sensor's reading in DataStudio (or EZscreen or **Xplorer**). The reading should be stable at approximately 400 ppm (± 50 ppm).
8. If the sensor's reading drifts or seems too high or low, recalibrate.

CO₂ Gas Sensor Operation

1. Connect the Carbon Dioxide Gas Sensor to an **Xplorer**, USB Link, or other PASPORT interface.
2. Insert the probe in the air sample. Allow 90 seconds for the sensor to warm-up with the probe equilibrated at 20°C to 30°C.
3. In your data collection software (i.e. DataStudio or EZscreen) or **Xplorer**, click the **Start** button to take a measurement.



CAUTION: The Carbon Dioxide Gas Sensor was not designed for use in liquids, dusty or windy environments, or in direct sunlight. Do not place the Carbon Dioxide Sensor in liquid samples, such as water or beverages. Immersing the Carbon Dioxide Sensor in liquids will permanently damage the sensor. Using the Carbon Dioxide Sensor in dusty or windy environments or in direct sunlight may cause anomalous readings. Always store the sensor in the plastic zip-lock bag to minimize sensor reading distortion from dust, dirt, etc.



CAUTION: When the Carbon Dioxide Gas Sensor is used with the **Xplorer** datalogger, the **Xplorer's** battery life is limited to around 60 minutes with full battery power. For prolonged CO₂ monitoring (greater than 55 minutes) and/or to maximize battery life, connect the **Xplorer** to a computer or **Xplorer** Power Adapter (PS-2530). When using **Xplorer** on battery power, do not reduce the sample rate to less than 1 sample/30 seconds in order to prevent **Xplorer** from going into "sleep" mode.

Suggested Activities

- Plant Respiration vs. Photosynthesis
- Cellular respiration
- Animal respiration
- Air quality evaluations
- Sublimation of solid CO₂
- Rate of CO₂ generation in reactions
- Decomposition of organic materials in soils
- Measurement of carbon dioxide concentration from various sources, such as from a greenhouse, expired air before and after exercise, automobile exhaust emissions, or various locations in a city.

CO₂ Gas Sensor Operation

1. Connect the Carbon Dioxide Gas Sensor to an **Xplorer**, USB Link, or other PASPORT interface.
2. Insert the probe in the air sample. Allow 90 seconds for the sensor to warm-up with the probe equilibrated at 20°C to 30°C.
3. In your data collection software (i.e. DataStudio or EZscreen) or **Xplorer**, click the **Start** button to take a measurement.



CAUTION: The Carbon Dioxide Gas Sensor was not designed for use in liquids, dusty or windy environments, or in direct sunlight. Do not place the Carbon Dioxide Sensor in liquid samples, such as water or beverages. Immersing the Carbon Dioxide Sensor in liquids will permanently damage the sensor. Using the Carbon Dioxide Sensor in dusty or windy environments or in direct sunlight may cause anomalous readings. Always store the sensor in the plastic zip-lock bag to minimize sensor reading distortion from dust, dirt, etc.



CAUTION: When the Carbon Dioxide Gas Sensor is used with the **Xplorer** datalogger, the **Xplorer's** battery life is limited to around 60 minutes with full battery power. For prolonged CO₂ monitoring (greater than 55 minutes) and/or to maximize battery life, connect the **Xplorer** to a computer or **Xplorer** Power Adapter (PS-2530). When using **Xplorer** on battery power, do not reduce the sample rate to less than 1 sample/30 seconds in order to prevent **Xplorer** from going into "sleep" mode.

Suggested Activities

- Plant Respiration vs. Photosynthesis
- Cellular respiration
- Animal respiration
- Air quality evaluations
- Sublimation of solid CO₂
- Rate of CO₂ generation in reactions
- Decomposition of organic materials in soils
- Measurement of carbon dioxide concentration from various sources, such as from a greenhouse, expired air before and after exercise, automobile exhaust emissions, or various locations in a city.