Absolute Zero Sphere

TD-8595

Equipment List

Included Equipment
Absolute Zero Sphere (TD-9595)
Coupling, Non-valved for 1/8 inch tubing (not shown)

Additional Equipment Required
A PASCO Interface and Data Collection Software (see the PASCO catalog or www.pasco.com)
Steam Generator (TD-8556) or Hot Plate (SE-8767)
PASPORT Pressure/Temperature Sensor (PS-2146)*
OR
PASCO Wireless Pressure Sensor (PS-3203)* **OR** PASPORT Absolute Pressure Sensor (PS-2107)*
AND
PASPORT Temperature Sensor (PS-2125)*
Ice (approximately 2 cups)

*PASPORT sensors require a PASPORT interface or the PS-3200 Wireless AirLink. A Fast Response Temperature Probe is molded into the Absolute Zero Sphere. The apparatus produces pressure data and temperature data and It needs a sensor that can measure both pressure and temperature, such as the PASPORT Pressure/Temperature Sensor (PS-2146), or a separate pressure sensor and a temperature sensor. The PS-3203 PASCO Wireless Pressure Sensor connects wirelessly through Bluetooth and does not need a separate interface. (NOTE: The CI-6532A Absolute Pressure Sensor can be used but requires the PS-2158 Analog Adapter in order to connect to a PASCO interface.)

Introduction

The Absolute Zero Sphere consists of a Fast Response Temperature Probe and plastic tubing (with pressure connector) mounted into a hollow copper sphere. When the sphere is submerged in a water bath and connected to a temperature sensor, pressure sensor, and a computer interface, the PASCO software records and displays the temperature and pressure.

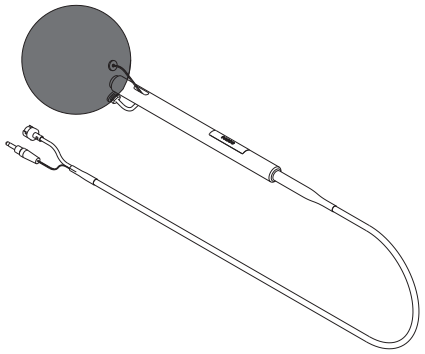


Figure 1: Absolute Zero Sphere

The Fast Response Temperature Probe plugs into any PASPORT Temperature Sensor box, allowing the Absolute Zero Sphere to be used with PASCO's PASPORT interfaces.

The Absolute Zero Sphere is used to experimentally determine the temperature of absolute zero (in degrees Celsius). Absolute zero, by definition, is the point at which a gas exerts zero pressure. With a computer, the Absolute Zero Sphere can help students to observe the relationship between temperature and pressure and use DataStudio to mathematically extrapolate to find absolute zero.

Theory:

For an ideal gas, the absolute pressure is directly proportional to the absolute temperature of the gas.

$$T = \left(\frac{V}{nR}\right)P$$

Thus a plot of temperature vs. pressure will result in a straight line.

$$y = (slope)x + b$$

$$T = \left(\frac{V}{nR}\right)P + 0$$

The slope of the line depends on the amount of gas in the thermometer, but regardless of the amount of gas, the intercept of the line with the temperature axis should be at absolute zero. If we instead plot the temperature in degrees Celsius, the intercept will not be zero, but rather the temperature of absolute zero in degrees Celsius.

Equipment Setup

1. Plug the Fast Response Temperature Probe plug into a PASPORT Temperature Sensor box.
2. Connect the Temperature Sensor box to an interface.
3. Connect the Absolute Zero Sphere Pressure Connector to the Quick-release Port on a Pressure Sensor.

- NOTE: Using the PASCO Wireless Pressure Sensor (PS-3203) requires an adapter. See Appendix A for details.

4. Connect the Pressure Sensor to an interface.
5. Set up the experiment in the PASCO data collection software. Open a Graph display and set it to plot temperature versus pressure. Use manual sampling with no keyboard input. (For detailed software setup instructions, see the online help for the PASCO software.)
6. Submerge the sphere into a bucket of ice water.
7. In the software, begin collecting data.

Suggested Experiments

Experiment I: Determining Absolute Zero while Keeping the Number of Gas Moles (n) Constant.

Equipment required:	
Absolute Zero Sphere (TD-8595)	One bucket of hot water, one bucket of cold water, ice
Absolute Pressure Sensor (PS-3203 or PS-2107)	PASCO Data Collection Software and Interface
Temperature Sensor (PS-2125)	Steam Generator (TD-8556) or Hot Plate (SE-8767)

Procedure:

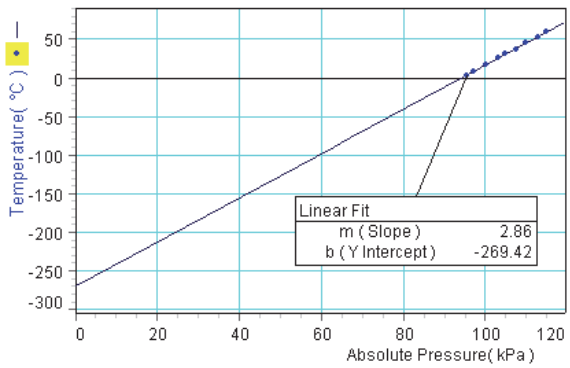
1. Start with the water as hot as possible.
2. Connect the hose fitting from the Absolute Zero Sphere to the Pressure Sensor. Connect the stereo plug from the apparatus to the Temperature Sensor.
3. Set up the experiment in the PASCO data collection software. Open a Graph display and set it to plot Temperature versus Pressure. Use manual sampling with no keyboard input. (For detailed software setup instructions, see the online help for the PASCO software.)
4. Set up a Digits display to show Temperature.
5. Begin recording data.
6. Place the sphere of the apparatus in the water bath, and keep the sphere completely submerged.

Figure 1-1: Experiment Set up

7. Watch the Digits display of temperature. When the display stops changing, click the **Keep** (or **Manual**) button. Do **not** stop recording.
8. Cool the water bath by adding cold water or some ice cubes. When the container becomes too full, dump out some of the water, but always have enough water to keep the apparatus completely submerged. Cool the bath by about 10°C. When the Digits display stops changing, “keep” the data again.
9. Repeat the steps: add ice to the water bath, wait for the temperature to stabilize, and “keep” the data. for temperatures down as low as you can go, and then end the data recording.
10. In the Graph display, use the “curve fit” function and select a linear curve fit. The y-intercept is your value for absolute zero.

Sample Data (Experiment 1)

Graph of Data Fit



Experiment II: Varying the Number of Moles of Gas (n)

Equipment required:	
Absolute Zero Sphere (TD-8595)	One bucket each of hot water, cold water, room temperature water, ice,
Pressure Sensor (PS-3203 or PS-2107)	PASCO Data Collection Software and Interface
Temperature Sensor (PS-2125)	Steam Generator (TD-8556) or Hot Plate (SE-8767)

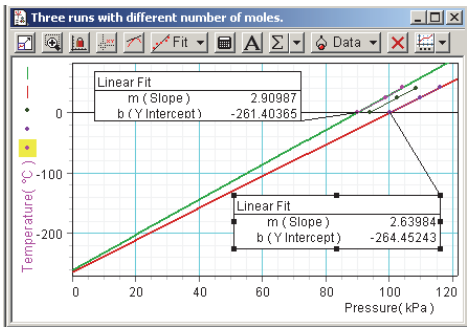
Experiment Procedure:

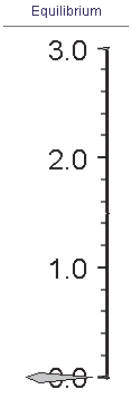
Figure 2-1: Experiment Setup

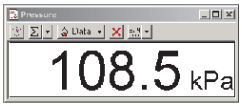
1. Prepare three different temperature water baths: A hot-water bath, room temperature bath, and a cold-water bath. Keep the hot-water bath as hot as possible, using a steam generator or hot plate, if available. Use ice for the cold water bath, if available. The room temperature bath needs to be somewhere in the temperature range between the other two baths.
2. Connect the Fast Response Temperature Probe plug from the Absolute Zero Sphere to the Temperature Sensor, but leave the pressure hose fitting disconnected.
3. Set up the experiment in the PASCO data collection software. Open a Graph display and set it to plot Temperature versus Pressure. Use manual sampling with no keyboard input. (For detailed software setup instructions, see the online help for the PASCO software.)
4. Set up a Digits display to show Temperature.
5. Place the sphere of the apparatus in the ice-water bath, and connect the hose fitting to the Pressure Sensor. Keep the sphere completely submerged, start recording data, and watch the Digits display of temperature.
6. When the temperature stops changing (in the hundredths place), click the **Keep** (or **Manual**) button. Do **not** stop recording.
7. Place the sphere in the room temperature bath and repeat the data collecting procedure.
8. Place the sphere in the hot-water bath and repeat the data collecting procedure one more time.
9. End data recording. Save this data to disk.
10. Use the “curve fit” function and select a linear curve fit. The y-intercept is your value for absolute zero.
11. Repeat the above procedure using a *different amount of gas (n)* in the sphere. This time, start with the room temperature bath. Disconnect the hose fitting from the Pressure Sensor. Place the sphere in the bath and then reconnect the fitting. Take readings for all three baths as before. Plot this data on the same graph, use the “curve fit” function and select a linear curve fit. You will now have two lines with different slopes, but about the same intercept.
12. Repeat the above procedure again, starting this time with the hot-water bath. Take the readings in the other two baths, and plot this data on the same graph.
13. Average your three values, estimate the uncertainty, and round your answer to the appropriate number of significant figures. Compare the average of your three values for absolute zero with the accepted value of -273°C.
14. Measure the volume of the sphere. Using the slope of each of the lines, determine the number of moles of gas in the container for each of the three runs.

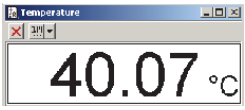
Sample Data (Exp.2) - Three Runs with Different Molar Amounts

Graph of Data









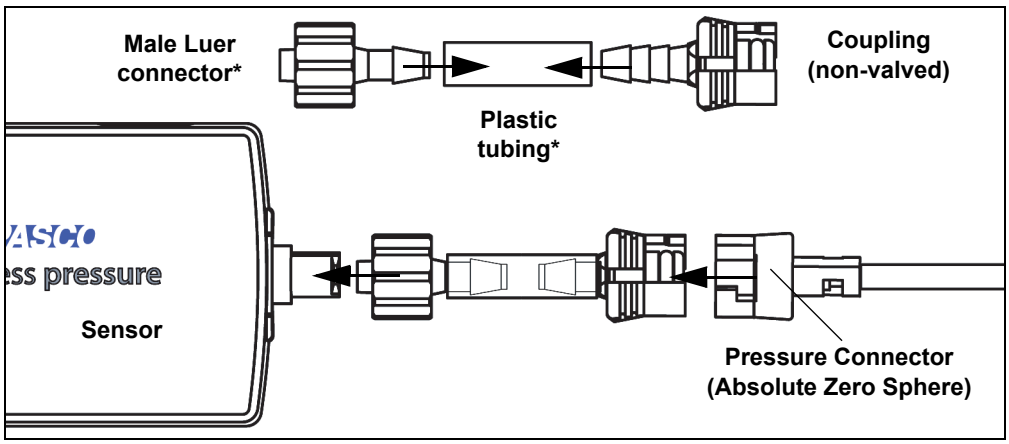
Specifications

Component	Description
Sphere:	Material: copper with hollow center Radius: 2 inches Volume: 32.66 inches Surface area: 50.24 inches
Temperature Probe (Fast Response):	Thermistor is 10,000 ohms at 25°C, Range: -35 to 135°C, -31 to 279°F, 238 to 408 K Resolution: ±0.01°C Accuracy: ±0.5°C
Tubing:	Polyurethane, 3 feet in length
Stereo plug:	3.5 mm male plug

Appendix A: Adapter for PS-3203 Wireless Pressure Sensor

Other Luer-compatible Device

Use the included Coupling (non-valved for 1/8 inch tubing) make an adapter for use with the PS-3203 Wireless Pressure Sensor. The Wireless Pressure Sensor includes a male luer connector and a length of plastic tubing. Cut a short piece (2 - 3 cm) of the plastic tubing. Use a very small amount of glycerin to lubricate the barb end of the male luer connector and the barb end of the coupling included with the Absolute Zero Sphere. Push the barb end of the male luer connector into one end of the plastic tubing and the barb end of the coupling into the other end.



Connect the male luer connector end of the adapter to the Wireless Pressure Sensor. Connect the Pressure Connector of the Absolute Zero Sphere to the coupling end of the adapter. Slightly twist the Pressure Connector clockwise to lock it in place. (Twist the Pressure Connector counter-clockwise to unlock it.)

Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: +1 916 462 8384 (worldwide)
8700-772-8700 (U.S.)

Web: www.pasco.com

Email: support@pasco.com

The manual maybe updated periodically. For the latest revision, visit the PASCO Web site at

www.pasco.com/manuals

and enter the product number, TD-8595, in the text window.

Replacement Parts

For information about possible replacement parts, contact Technical Support:

Product End of Life Disposal Instructions:
This electronic product is subject to disposal and recycling regulations that vary by country and region. It is your responsibility to recycle your electronic equipment per your 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.