

Activity C10: Determine R, the Gas Constant (Pressure Sensor, Temperature Sensor)

Concept	<i>DataStudio</i>	<i>ScienceWorkshop (Mac)</i>	<i>ScienceWorkshop (Win)</i>
Gas laws	C10 Gas Constant.DS	C10 Determine R	C10_R.SWS

Equipment Needed	Qty	Equipment Needed	Qty
Pressure Sensor (CI-6532A)	1	Tongs	1
Temperature Sensor (CI-6505A)	1	Tubing, plastic (w/sensor)	1
Balance (SE-8723)	1	Protective gear	PS
Connector, rubber stopper (w/sensor)	1		
Flask, Erlenmeyer, 250 mL	1	Chemicals and Consumables	Qty
Graduated cylinder	1	Dry ice, solid*	1 g
Rubber stopper, two-hole	1	Glycerin	1 mL

(*SAFETY CAUTION! Do not handle dry ice with bare hands!)

What Do You Think?

The Ideal Gas Law describes the behavior of the pressure, volume and temperature of a ‘gas’ that has ideal properties. Can you use measurements of pressure, volume, and temperature for a ‘real’ gas to determine the value of the Gas Constant, **R**?



Take time to answer the ‘What Do You Think?’ question(s) in the Lab Report section.

Background

The Gas Constant relates the number of moles of a gas to the pressure, volume and absolute temperature of its surroundings.

The Ideal Gas Law states that pressure, volume, and temperature are related to the number of moles of gas as follows:

$$PV = nRT$$

where **P** is the pressure in atmospheres, **V** is the volume in liters, **n** is the number of moles of the gas, **R** is the gas constant and **T** is the absolute temperature.

If the equation is solved for R, the resulting relationship is:

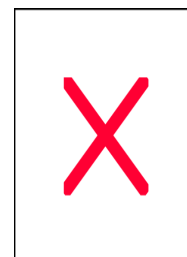
The units of the constant show its value. The accepted value for R is 0.082 atm • L / mole • K.

SAFETY REMINDERS

- Wear protective gear.
- Follow directions for using the equipment.
- Do not handle dry ice with bare hands.

For You To Do

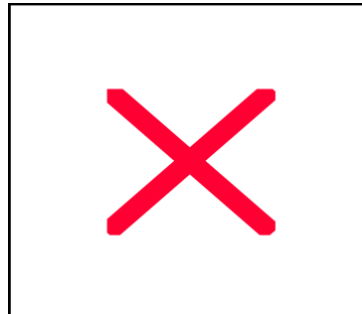
Use the Pressure and Temperature Sensors to measure the changes in pressure and temperature inside a container that has a small amount of ‘dry ice’ (frozen carbon dioxide). Use *DataStudio* or *ScienceWorkshop* to record and display the data. Determine the change in the mass of the dry



ice due to sublimation (phase change from solid to gas). Use your data to calculate a value for R, the Gas Constant, and compare your results to the accepted value.

PART I: Computer Setup

1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and turn on the computer.
2. Connect the DIN plug of the Temperature Sensor to Analog Channel A on the interface. Connect the DIN plug of the Pressure Sensor to Analog Channel B on the interface.
3. Open the file titled as shown;



<i>DataStudio</i>	<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
C10 Gas Constant.DS	C10 Determine R	C10_R.SWS

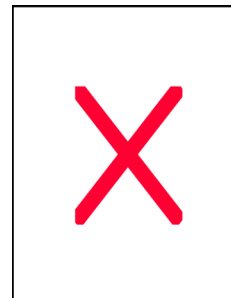
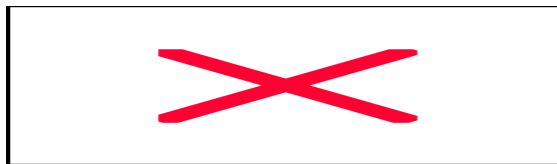
- The *DataStudio* file has a Graph display. Read the Workbook display for more information.
- The *ScienceWorkshop* document has a Graph display with a plot of the pressure versus time and a plot of temperature versus time.
- Data recording is set at ten measurements per second (10 Hz).

PART II: Sensor Calibration and Equipment Setup

You do not need to calibrate the sensors.

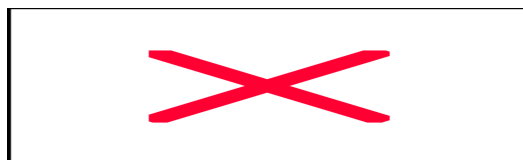
Set Up the Equipment

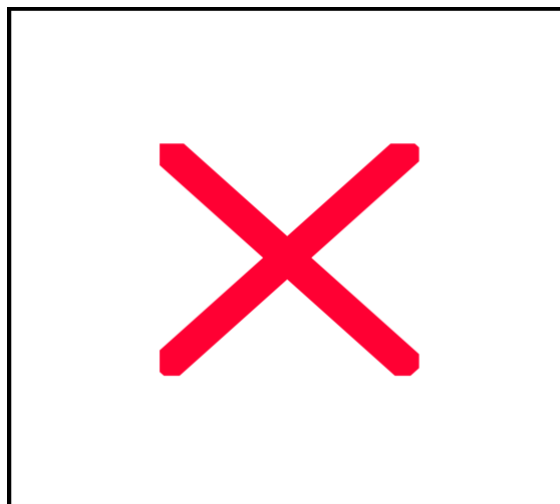
- For this part you will need the following: glycerin, quick-release coupling, connector, plastic tubing, two-hole rubber stopper, flask, Temperature Sensor, Pressure Sensor, dry ice, and balance (for measuring mass).
1. Put a drop of glycerin on the barb end of a quick release coupling. Put the end of the quick release coupling into one end of a piece of



plastic tubing (about 15 cm) that comes with the Pressure Sensor.

2. Put a drop of glycerin on the barb end of the connector. Push the barb end of the connector into the other end of the plastic tubing.
3. Fit the end of the connector into one of the holes in the rubber stopper.
4. Put a drop of glycerin into the other hole of the stopper and slide the Temperature Sensor through the hole.
5. Align the quick-release coupling on the end of the plastic tubing with the pressure port of the Pressure Sensor. Push the coupling onto the port, and then turn the coupling clockwise until it clicks (about one-eighth turn).

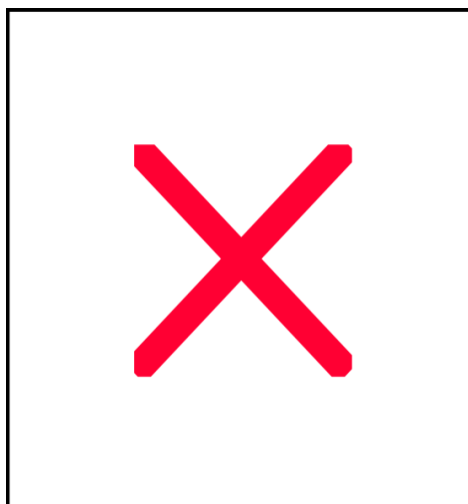


**PART III: Data Recording****Measure the Initial Mass**

1. Put a 1-g piece of dry ice into a flask. Carefully measure the mass of the flask plus dry ice. Record the mass in the Lab Report section.

Measure the Pressure and Temperature

2. Wait about 20 seconds and then start recording data. (Hint: Click 'Start' in *DataStudio* or click 'REC' in *ScienceWorkshop*.)
3. CAREFULLY force the rubber stopper with sensors attached into the top of the flask.



- CAUTION! The pressure inside the flask may become high enough to blow the rubber stopper out of the flask. Try to hold the stopper in place, but don't put your hands on the flask (because your hands might warm the flask too much).

- When the pressure has reached a maximum (or the rubber stopper blows off), stop recording data.
- If the rubber stopper is still in place, slowly open the flask to allow carbon dioxide to escape. Blow air into the bottle to clear the inside of carbon dioxide gas.



Measure the Final Mass

- Measure and record the final mass of the flask (with any remaining dry ice).
- After you have measured the flask and remaining dry ice, discard the dry ice according to instructions.

Measure the Volume

- Use the large graduated cylinder to add water to the flask to determine the actual volume of the gas in the flask. (Hint: Be sure to account for the space occupied by the bottom of the rubber stopper when it was in the flask.) Record the volume in the Lab Report section.
- Empty the bottle.

Analyzing the Data

- Use the built-in statistics in the Graph display to find the minimum pressure and the maximum pressure. (Hint: Click the 'Statistics menu' button () in *DataStudio* or the 'Statistics button' () in *ScienceWorkshop*.) Record the minimum and maximum pressure in the Lab Report section.
- Use the statistics in the Graph display to find the average temperature ("mean"). Record the value in the Lab Report section as the Average temperature of the gas.
- Use your data to calculate the pressure change in atmospheres, the temperature of the gas in Kelvin, the number of moles of carbon dioxide gas, and your experimental value for R.
- Compare your experimental value of R and the accepted value of R.

Record your results in the Lab Report section.

Lab Report - Activity C10: Determine R, the Gas Constant

What Do You Think?

The Ideal Gas Law describes the behavior of the pressure, volume and temperature of a ‘gas’ that has ideal properties. Can you use measurements of pressure, volume, and temperature for a ‘real’ gas to determine the value of the Gas Constant, **R**?

Data Table

Data	Measurement	Value
1	Mass of dry ice and bottle (before)	g
2	Starting pressure of gas	kPa
3	Maximum pressure of gas	kPa
4	Change in pressure due to gas	kPa
5	Change in pressure in atmospheres (Data 4 x 1 atmosphere/101 kPa)	atm
6.	Average temperature of the gas	C
7	Average temperature in K (Data 6 + 273)	K
8	Volume of gas (bottle)	mL
9	Volume of gas in Liters (Data 8 x 1 Liter/1000 mL)	L
10	Mass of dry ice and bottle (after)	g
11	Mass of dry ice used (Data 1 - Data 10)	g
12	Moles of carbon dioxide used (Data 11 x 1 mole/44 g)	moles
13	Calculated value of R (See below)	
14	% difference (See below)	%

The calculation for the Gas Constant is , or

The accepted value for the Gas Constant is .

Remember, percent difference is

Questions

1. How does your calculated value for R, the Gas Constant, compare to the accepted value?

2. What are possible sources of error or limitations in this experiment? For each one, try to decide what effect it might have on the experimental results.