Ideal gas laws

Apparatus

400 kPa absolute pressure sensor

Unhoused temperature sensor

60 cm³ (60 ml) Syringe (centred luer attachment) with collar to give 40ml compression,

Length of clear plastic tubing approx 3 mm inside diameter.

Pieces of pressure resistant silicon tube

3 way valve

T piece

Barbed male and female Luer lock connectors

Data recording setup.

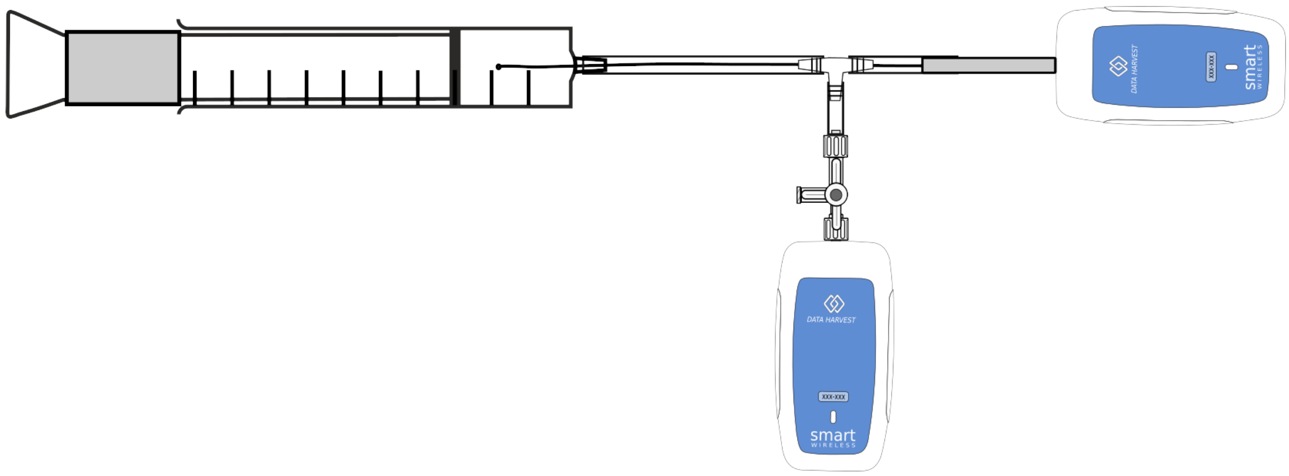
Single graph pane layout

Recording setup

Continuous

20 ms intersample period

Click start. Click stop



Introduction.

The apparatus lets us take measurements of temperature and pressure at the same time as the sample of gas is compressed.

The volume of a gas is dependant on the pressure and the temperature. The relationship between temperature, volume and pressure is described in the Ideal Gas Law.

You will produce a graph of the pressure and temperature changes as a volume of gas is compressed and then study the relationship between pressure and constant temperature and pressure and varying temperature.

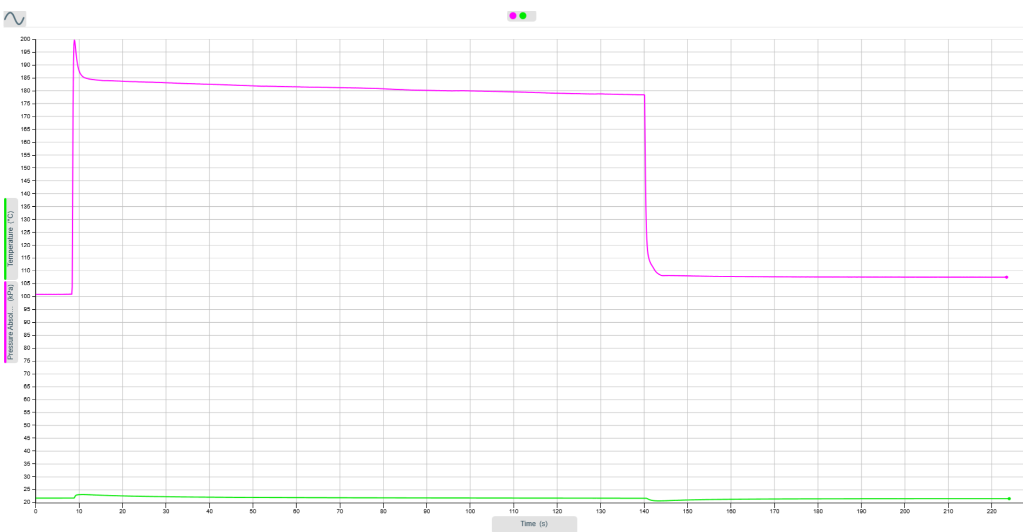
Method

1. Using the apparatus shown in the diagram connect the two sensors to the software.
2. Open the tap to allow you to draw air into the syringe to the 40 ml scale line on the syringe. Close the tap to seal off the apparatus from the room air.
3. You may have been given a collar to fit round the syringe plunger, this stops the plunger from damaging the temperature sensor on compression. It also allows you keep the compressed volume steady as you push against it

4. Click on start and gently compress the gas in the syringe then hold it after you have reduce the volume by about 10 ml. Study the graph and check the pressure is staying constant. This checks the apparatus for any leaks, unless the apparatus is airtight you will not collect valid data.
5. Stop data collection and allow the syringe plunger to return to normal. Open the valve to let you set the syringe volume for the practical work, try 40 ml for a first run.
6. Use new lab to clear out the leak test data and then set the software as shown in the data recording box at the beginning of this sheet.
7. When you are ready open the valve to set the start volume to 40 ml on the syringe scale and then close the valve to seal the apparatus.
8. Start the recording, let a few seconds of data collection to give the temperature, make a note of the value.
9. Now push the plunger of the syringe quickly onto the stop created by the collar around the plunger shaft. Hold the plunger firmly against the stop and watch the temperature values
10. The temperature will fall, you need to hold the plunger in place until the temperature has reached and stabilised around the start temperature, this can take between 30 and 120 seconds (dependent on the room temperature and the thermal properties of the apparatus). Be patient!
11. Once the temperature has gone back to the start temperature, release the plunger. Observe the temperature and keep recording until it has come back to the start value.
12. Stop the recording and save the data.
13. If necessary repeat.

Results and analysis.

Your collected data should look similar to the example shown.



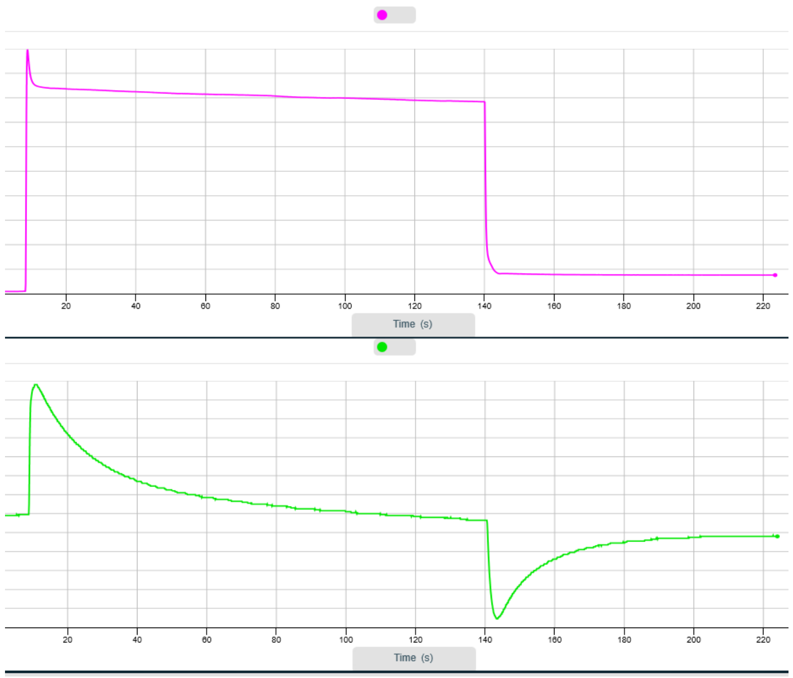
You will need to find and record the pressure and volume of the syringe at the same temperature with and without compression of the gas. The volume will be the initial volume of the syringe and the volume when the plunger is pushed to the stop. The pressure is the pressure before compression and when the temperature falls back to the start temperature with the gas still compressed.

	Volume (ml)	Pressure (kPa)
1		
2		

To analyse the graph and find the volume and pressure the data will need to be re-scaled.

First change the layout to give two panels stacked upon each other.

Next make sure only one set of data is shown on each panel and make sure the y axis is set to min max.



Example of data on two stacked panels with scale changed.

It will now be easy to use the values tools to find the data required.

The ideal gas law for a constant temperature reduces to $P_1V_1 = P_2V_2$, or,

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

Use your data to calculate the ratios P_1/P_2 and V_1/V_2. Are they equal? If not why not?

There is a small consistent error in the volume that can be accounted for, this is the air in the tubing and links to the sensors. The volume you record is only the calibrated volume of the syringe. You should be able to correct for this, if we create a new volume (the volume of all the tubing etc) called V_0 then our gas equation becomes

$$\frac{V_1 + V_0}{V_2 + V_0} = \frac{P_2}{P_1}$$

Solve the new equation for V_0 and then use your values to find V_0

Varying the Temperature.

1. Using your same data we can collect data to see what the effect of varying the temperature has.
2. Use the values tool to find a data point before you compressed the gas. It does not have to be different point from the previous part of the exercise. Record both the pressure and the temperature
3. Record the initial volume (before compression)(V_1), you now have a value for the volume in the tubing (V_o)so add this in as well.
4. Find on the graph the peak temperature (not the peak pressure, due to the differing thermal capacities and response times for the sensors pressure will peak before temperature) and record the pressure at the peak temperature and the peak temperature.
5. Record the volume of the compressed gas.

	Volume on syringe	V_o	Total volume	Pressure kPa	Temperature C^o	Temperature K^o
1						
2						

The Ideal Gas Law states that $\frac{P\,V}{T}$ Is a constant

Use your data to calculate the constant for your two sets of data.

Compare the constants calculated, are they about the same? Calculate the % difference between them

Questions.

1. When the syringe volume is compressed why does the pressure "double" and then fall back to a lower pressure?
2. When you hold the volume of the syringe at its new position why does the temperature fall back to room temperature but the pressure remains at a new higher level?
3. When you released the plunger why does the temperature fall to lower than the room temperature and then rise back to the room temperature?
4. If you observe the plunger position after releasing it, you will see it does not return fully to the original position, why? What stops it returning fully?