

TAP 601- 5: Changes in temperature, changes in pressure

Common behaviour

Gases are remarkable because they are all so similar. Solids vary considerably because they are tightly bound, and the details of the bonding between the particles affect the properties of the material. Gases are not tightly bound, so are much simpler. Increasing either the mass or speed (or both) of the particles that make up the gas is likely to result in more violent collisions, so increasing the pressure of the gas. It is best to do one thing at a time, so as to keep the story simple, so keep the mass of the particles, and the number of particles, constant.

Increasing the temperature increases the speed of the particles, so expect this change to increase the pressure. Here you are asked to find as exact a relationship as you can between temperature and pressure.

You will need

- ✓ beaker, 400 cm³
- ✓ pressure sensor
- ✓ thermometer
- ✓ gas sample

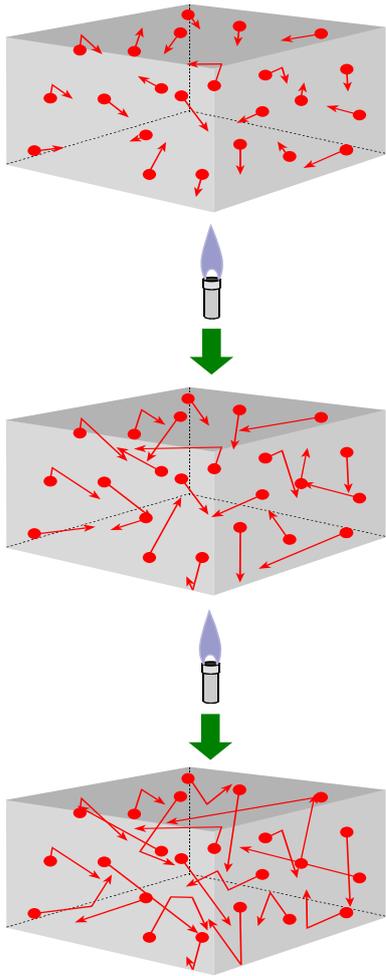


Safety

Strong heating of glass is always hazardous, so protect your eyes, and, in the second example, use a safety screen.

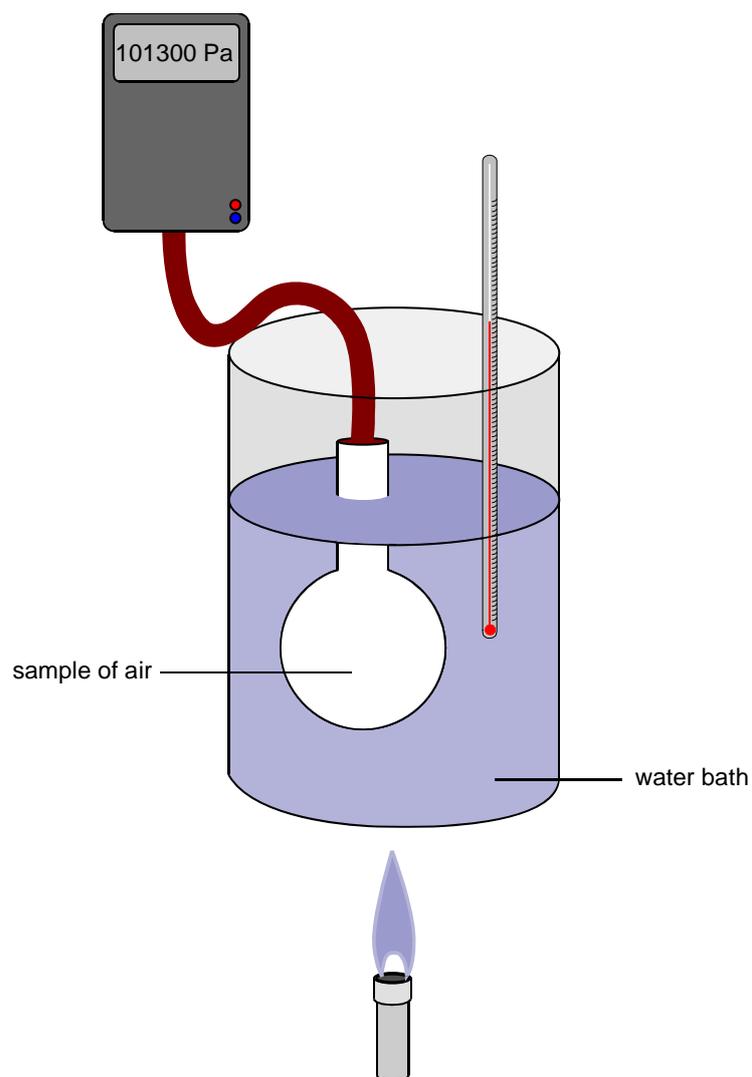
Thinking about the measurements

You need to measure how the temperature of a fixed number of particles affects the pressure. In a school laboratory you may be constrained by the range of temperatures you can reach (remembering that all of the fixed mass of gas must be at one temperature), or the resolution of the pressure meter over this range of temperatures.



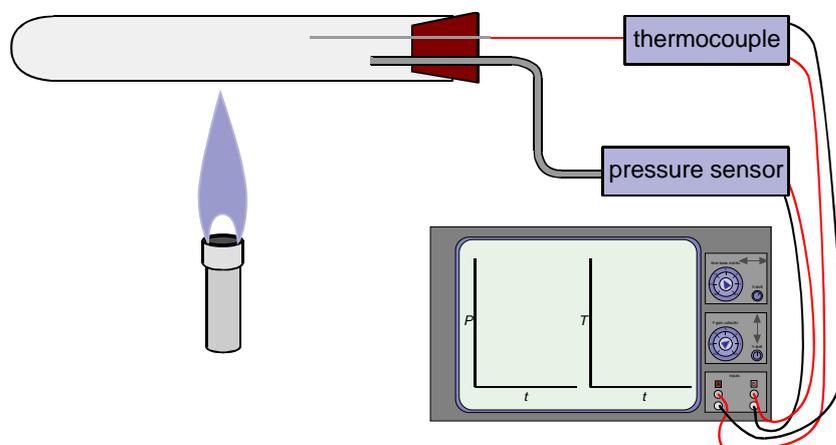
Two solutions to this problem are given below.

A traditional solution



1. Take readings of pressure for the widest range of temperatures that you can manage (0–100 °C?). This is only likely to give a small range of pressures (think about the range of temperatures the gas could exist at). Plot a graph as you go.
2. Look for a pattern in the results and then plot a presentation graph, showing the pattern clearly.
3. Are there any regions of the graph that do not fit your pattern as well? Can you account for these deviations in ways that relate back to the state of the gas at that point – or other likely weaknesses in the experimental arrangement?

A more sophisticated solution



1. Strongly warm the air in a Bunsen flame. Remove the boiling tube from the flame and start capturing data, perhaps for 10 minutes.
2. Once you have checked that your plots of pressure / time and temperature / time are sensible, try plotting pressure / temperature. Look for a clear relationship.
3. Any of your plots may have revealed regions where the readings are not sensible, and you may be able to relate this to the particulars of the experiment that you have just carried out. Once you have eliminated these, produce some presentation-quality graphs.

You have

1. Measured how the pressure of a gas changes with its temperature.
2. Thought carefully about why the experiment is set up in a particular way.
3. Produced a set of presentation-quality graphs describing the relationships you found.

Safety

The most likely failure is the bung being blown out. The second most likely is the boiling tube breaking. A safety screen or screens should be placed to protect the experimenter from both modes of failure.

Practical advice

In this activity it is important that students do not simply collect data and then plot a graph. They also need to be encouraged to appreciate a little of the ingenuity that has resulted in the apparatus being put together in the way that it has. It is also important that students imagine the gas molecules at work, increasing the pressure by blindly colliding with the container walls more and more often as the temperature rises. Producing a datalogged version of this experiment is not so hard. You need to ensure that the seal on the boiling tube is good, as gaining or losing molecules will be fatal. The tube will get hot, so hold it near the bung. Another possible source of error is that not the entire sample of gas is at the same temperature – so place the temperature sensor carefully.

External reference

This activity is taken from Advancing Physics chapter 13, 30E