

TAP 603 -1: Warming up a gas by speeding up its particles

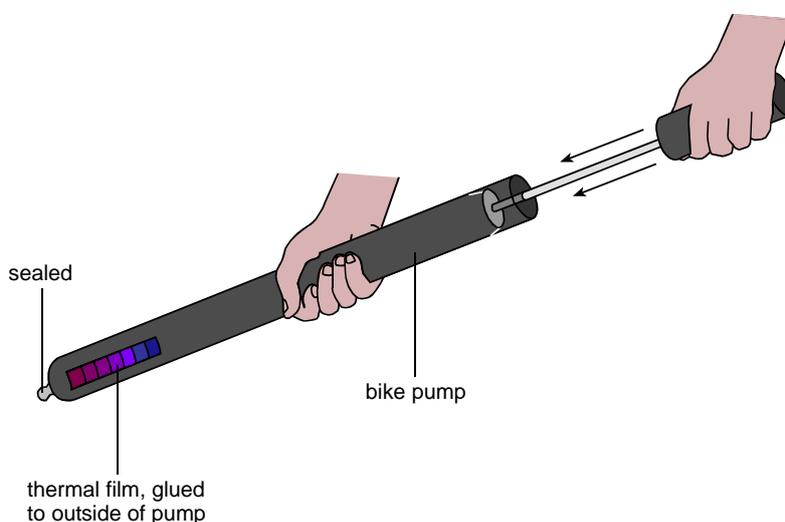
Arranging the molecules

Molecules move at random; by altering their environment you can get them to do useful things.

If you squash up a gas, pushing molecules into a restricted space, their average kinetic energy increases. You have to push the gas into shape, thus knocking into the molecules, which increases their speed.

You will need

- ✓ aluminium bodied bike pump with valve sealed / washer in normal position
- ✓ thermal film



What to do

1. Fully extend the pump and block the hole at the bottom with a close-fitting bolt and PTFE tape. Attach the thermal film to the sides of the cylinder near the bolt.
2. Make sure that the bicycle pump is cool. The temperature should be at the bottom of the range to which the thermal film will respond.
3. Fully extend the pump and squash the air up rather suddenly with one good push. Leave the piston at the position of maximum compression.
4. Watch for the temperature rise of the cylinder, as shown by the thermal film attached to it.

Practical advice

This is another simple experiment that can be explained using the kinetic theory of gases. Ask students to explain what an increase in temperature of a gas tells us about the particles of the gas. Follow this up by asking for explanations of the increased particle speed. It may take some time before the class is happy that collisions with the approaching piston increase the velocities of the gas particles. (Consider the momentum changes of an air particle as it rebounds from the approaching piston.)

Imagine the molecules engaged in violent collisions with the piston as it is closed rapidly. These collisions increase the average energy of the molecules, since they have more momentum (on average) when they leave the piston than when they arrive.

Technician's notes

An aluminium-bodied bicycle pump is essential, as is a well-oiled piston. The valve end can be sealed with an appropriately threaded bolt, plumbers PTFE tape, grease and a nylon washer. The thermal film should be fixed to the end furthest from the handle, where the warmed gas will reside, once it is compressed. For a similar reason it is advisable to move the handgrip on the barrel of the pump to the top third of the pump, as close to the plunger handle as is comfortable, to avoid thermal contamination from the users hands.

Thermochromic film is available from Middlesex University teaching resources <http://www.mutr.co.uk/> as "thermocolor sheet".

Alternative approaches

Repetitive bending of a paperclip, or stretching a rubber band, leads to tangible heating. Rubbing on a sheet of thermal film produces a more spectacular, but less tangible, demonstration of the transfer of mechanical energy to thermal energy. Cooling can be done by rupturing a CO₂ drinks cylinder, or by allowing the contents of a camping gas cylinder to vent (take care!), provided that you note that at least some of the cooling in this case comes from pulling the molecules apart.

External reference

This activity is taken from <http://www.practicalphysics.org/> which is an adaptation of Advancing Physics chapter 13, 230P