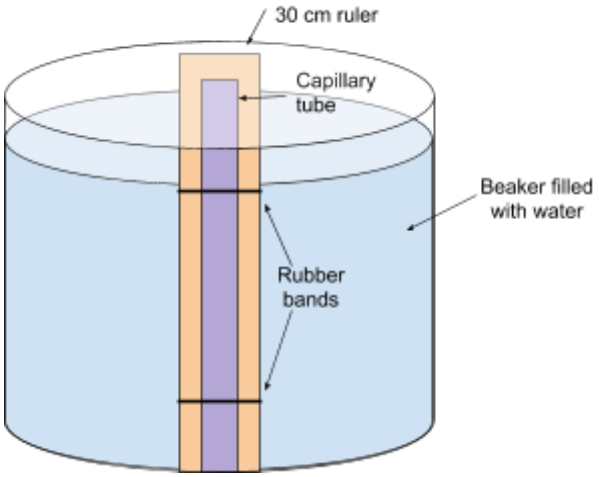
OCR A Physics A-Level

PAG 8.3

Estimating the work done by a gas as its temperature increases

Equipment

- Thermometer
- Large beaker
- Kettle
- Capillary tube sealed at one end, containing a sample of air trapped by a small amount of sulphuric acid (at atmospheric pressure)
- 30 cm ruler
- Elastic bands
- Cold water/ice
- Vernier calipers



Method

1. Measure the internal diameter of the capillary tube using vernier calipers.
2. Attach the 30 cm ruler to the capillary tubes using 2 elastic bands so that the 0 cm mark is at the very start of the length of the air sample.
3. Boil water using the kettle, leaving it to cool slightly before pouring it into the large beaker.
4. Place the capillary tube (attached to the ruler) into the beaker, with the open end facing upwards.
5. Measure the temperature of the water using the thermometer, making sure to stir the water with the thermometer beforehand, and record this value.
6. Measure the length of the air sample without removing the capillary tube from the beaker.
7. Decrease the temperature of the water by 5 °C by adding a small amount of cold water/ice to the beaker, and again measure the temperature and length of the air sample.
8. Repeat the above step until the water reaches room temperature.

Calculations

- Calculate the cross-sectional area of the capillary tube, using the following equation:

$$A = \frac{\pi d^2}{4}$$

- Calculate the volume of the air sample at each length by multiplying each length by the cross-sectional area.
- Plot a graph of volume against temperature and draw a line of best fit.
- Your line of best fit should be a straight line, meaning that volume and temperature are directly proportional.
- The air inside the capillary tube is allowed to expand freely within the tube meaning it is under atmospheric pressure. As the pressure of the air sample is constant, you can use the following equation to calculate the work done:

$$Work\ done = p\Delta V$$

Where p in this case is atmospheric pressure (101 kPa) and ΔV is the change in volume.

- As temperature and volume are directly proportional (as shown by your graph), you can see that as temperature increases, the work done on the gas also increases.

Safety

- Sulphuric acid is corrosive therefore may cause irritation to skin and damage to eyes so safety goggles must be worn and the capillary tube must be handled carefully.
- Boiling water may cause burns so care should be taken when handling it.