OCR A Physics A-Level

PAG 8.1

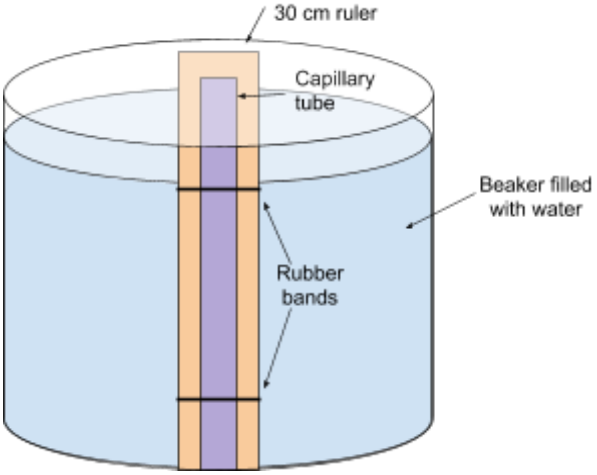
Estimate a value for absolute zero from gas pressure and volume

Absolute zero (-273°C), also known as 0 Kelvin, is the lowest possible temperature, and is the temperature at which particles have no kinetic energy and the volume and pressure of a gas are zero.

Volume

Equipment

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



Method

1. 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.
2. Boil water using the kettle, leaving it to cool slightly before pouring it into the large beaker.
3. Place the capillary tube (attached to the ruler) into the beaker, with the open end facing upwards.
4. Measure the temperature of the water using the thermometer, making sure to stir the water with the thermometer beforehand, and record this value.
5. Measure the length of the air sample without removing the capillary tube from the beaker.
6. 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.
7. Repeat the above step until the water reaches room temperature.

Calculations

- Draw a graph of length against temperature and draw a line of best fit.
- The line of best fit will have the equation y = mx+c (as it is a straight line), where y is the length (l) and x is the temperature (θ):

$$l = m\theta + c$$

- m is the gradient of the line of best fit which can be calculated by finding the change in l over the change in θ, over a large interval.
- c is the y-intercept of the graph which can be calculated by using two points from the line of best fit and substituting them into the equation of the line of best fit (above).

- At absolute zero the volume of the air sample will be 0, therefore its length (l) will also be zero. Substitute this result (and your known values of m and c) into the equation of the line of best fit to calculate absolute zero.

$$\text{Absolute zero} = -c/m$$

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.

Pressure

Equipment

- Thermometer
- Bourdon gauge
- Flask
- Beaker large enough to fully contain the flask
- Bung with connective tubing which attaches to the bourdon gauge
- Kettle
- Cold water/ice

Method

1. Place the bung into the neck of the flask making sure that it sits in the flask tightly so that it does not fall out. Attach the connective tubing to the bourdon gauge, again making sure it fits the gauge tightly.
2. Place the flask into the large beaker.
3. Boil water using the kettle, leaving it to cool slightly before pouring it into the large beaker until it reaches the bung in the flask.
4. Measure the temperature of the water using the thermometer, making sure to stir the water with the thermometer beforehand, and record this value.
5. Record the value of pressure on the bourdon gauge.
6. 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 pressure of the air in the flask.
7. Repeat the above step until the water reaches room temperature.

Calculations

- Draw a graph of pressure against temperature and draw a line of best fit.
- The line of best fit will have the equation y = mx+c (as it is a straight line), where y is the pressure (p) and x is the temperature (θ):

$$p = m\theta + c$$

- m is the gradient of the line of best fit which can be calculated by finding the change in p over the change in θ, over a large interval.
- c is the y-intercept of the graph which can be calculated by using two points from the line of best fit and substituting them into the equation of the line of best fit (above).

- At absolute zero the pressure of the air sample will be 0. You can substitute this result (and your known values of m and c) into the equation of the line of best fit to calculate absolute zero.

$$\text{Absolute zero} = -c/m$$

Safety

- Boiling water may cause burns so care should be taken when handling it.
- Take care when using glassware. If a breakage occurs avoid touching any shards of glass with bare skin, and inform a teacher.