

Gas laws, kinetic theory and thermal energy

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

If a gas is cooled at constant volume, its pressure falls steadily. In this lab you measure the pressure of trapped air at six temperatures between 0 °C and 100 °C and extrapolate the line back to find where the pressure would reach zero.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB B.1-B.3

Aim

To measure how the pressure of a fixed volume of air changes with temperature, and to use a straight-line graph to estimate absolute zero.

Equipment

- sealed round-bottom flask (250 mL) with a rubber bung and short rigid tube
- pressure gauge or sensor (0–200 kPa) connected by the tube
- thermometer (–10 to 110 °C)
- large beaker or tub for the water bath
- kettle, ice, stirrer, retort stand and clamp

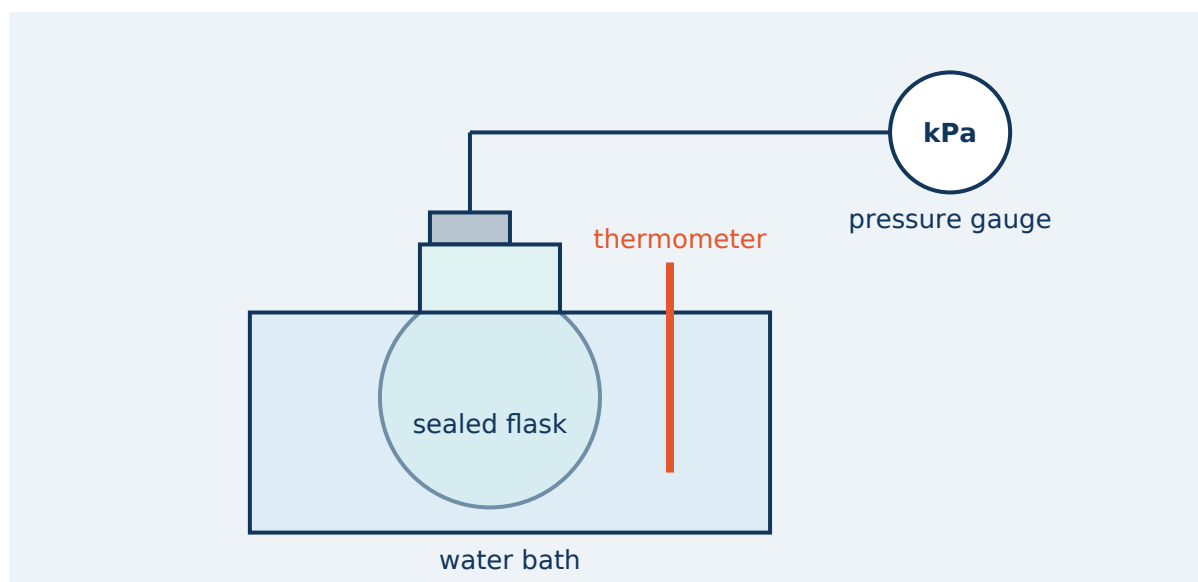
Safety

Safety

Wear goggles. Hot water scalds, so pour it with care and keep the kettle away from the edge of the bench. Do not heat the flask directly and never exceed 100 °C, because the bung could be pushed out.

Method

1. Clamp the sealed flask so that all of the glass bulb is below the water level in the bath.
2. Fill the bath with crushed ice and water, stir and wait until the thermometer reads 0 °C.
3. Wait one minute, then record the gauge reading as p for 0 °C.
4. Add hot water to reach about 20 °C, stir for one minute and record the temperature and pressure.
5. Repeat for about 40 °C, 60 °C, 80 °C and 100 °C, always stirring first and reading both instruments at the same moment.
6. Plot p (vertical axis) against θ in degrees Celsius.



Set-up: the flask and the tube to the gauge are sealed, and the whole bulb is under the water.

Results

Sample measurements from one group:

Temperature θ ($^{\circ}\text{C}$)	Pressure p (kPa)
0	94.0
20	100.6
40	107.9
60	114.4
80	121.9
100	128.2

Analysis questions

Question 1 Plotting the graph

Plot p against θ for the sample data. Describe the shape and state what it suggests about the relation between p and θ .

Question 2 Gradient

Use the points (0 $^{\circ}\text{C}$, 94.0 kPa) and (100 $^{\circ}\text{C}$, 128.2 kPa) to calculate the gradient of the line.

Question 3 Estimating absolute zero

Use the line of best fit to find the temperature at which the pressure would reach zero. Use a gradient of 0.34 kPa/ $^{\circ}\text{C}$ and an intercept of 94.0 kPa.

Question 4 Comparing with the accepted value

Calculate the percentage difference between your estimate and $-273\text{ }^{\circ}\text{C}$.

Question 5 Why kelvin is better

Explain why p is proportional to T in kelvin but not to θ in degrees Celsius.

Question 6 Sources of error

Give two reasons why the measured pressures may differ from the ideal line.

Question 7 Uncertainty in temperature

The thermometer is read to $\pm 1\text{ }^{\circ}\text{C}$. Calculate the percentage uncertainty in the $20\text{ }^{\circ}\text{C}$ reading and say whether it matters more at low or high temperatures.

Question 8 Improving the method

Suggest two improvements that would make the estimate of absolute zero more reliable.