LAB L9.1 — GAS LAW: P–V AT CONSTANT T

THE QUESTION YOUR DATA WILL ANSWER

Day 3 introduced the model $PV = nRT$. Today your measurements test one of its predictions: **for a sealed sample of air held at one temperature, how does the pressure depend on the volume?**

This sheet is your lab record. Everything your group measures, plots, and argues goes on these four pages.

WARMUP Retrieval — three lines from Days 1–3

(a) Write the ideal gas law twice — once using moles n, once using molecule count N. Under each equation, name the constant with its value and units.

(b) The wall thermometer reads 17°C. Convert the reading to the scale every gas-law computation requires: $T = 17^{\circ}\mathrm{C} + 273 =$ ________ K

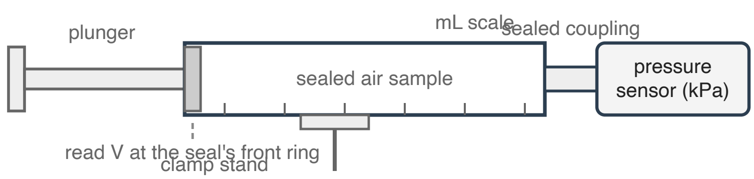
(c) A sealed syringe is compressed until the trapped air fills half of the trapped air's starting volume. Circle one: the number of air molecules inside the syringe **increases / decreases / stays the same**.
What feature of the apparatus makes your circled answer true?

____

Safety — pinch points. The clamp's jaws and the gap between the plunger flange and the barrel mouth can pinch skin: grip the barrel, not the mouth. If your group loads the plunger with stacked masses, keep the stack low and centered so the stack cannot topple onto fingers.

EQUIPMENT AND CONSTRAINTS — YOUR DESIGN WORKS INSIDE THESE

- The syringe is **sealed at the tip** (capped coupling to the pressure sensor): no air enters or leaves during a run.
- Vary the volume reading from **18.0 mL down to 9.0 mL**; collect at least **6 (V, P) pairs** spanning the full range.
- The sensor reports the **absolute pressure** of the trapped air, in kPa. The volume scale reads to **±0.5 mL**, at the plunger seal's front ring.
- Compress **slowly**, then pause about **10 s** before recording each pressure.
- Record the room temperature: the trapped air returns to room temperature whenever you pause long enough.



The apparatus. A capped syringe loaded by stacked masses is the no-sensor variant — same sealed sample, same analysis.

DESIGN YOUR MEASUREMENT

D1 Name the Variables — and the Action That Controls Each

(a) The quantity your group deliberately changes (independent variable): ___________________________

(b) The quantity your group measures in response (dependent variable): ___________________________

(c) For $PV = nRT$ to predict a clean P–V relationship, two quantities must stay constant during the whole run. Name each one, and name the *specific action in your procedure* that keeps that quantity constant.

Held-constant quantity	Action in the procedure that holds the quantity constant

D2 Write the Procedure

In 3–5 numbered steps, write the procedure your group will follow: the volume readings you will visit, the order you will visit the readings in, and what every group member does at each reading. Decide which one volume reading your group will re-measure at the end as a repeat check.

COLLECT THE DATA

DATA Lab Record — Sealed Air Sample

Room temperature: __________ °C $\rightarrow$ $T =$ __________ °C $+ 273 =$ __________ K

Trial	V reading (mL)	P reading (kPa)	1/V (mL^{-1}) — *Analysis*	P·V (kPa·mL) — *Analysis*
1				
2				
3				
4				
5				
6				
7 (repeat)				

Watch while you work: the pause matters. If a pressure reading keeps drifting after you stop the plunger, note which direction the reading drifts: ____________________________________

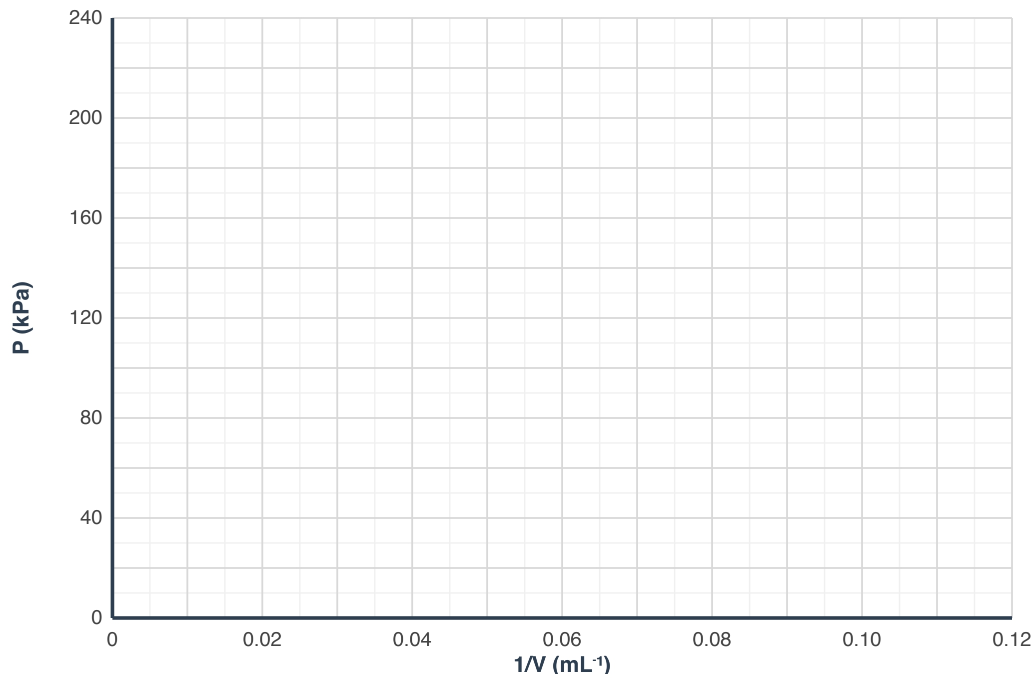
ANALYSIS I — STRAIGHTEN THE CURVE

WHY PLOT P AGAINST 1/V

At constant T and sealed n, the model $PV = nRT$ rearranges to $P = (nRT) \cdot \frac{1}{V}$. Plotted as P versus $1/V$, the model predicts a **straight line through the origin with slope** nRT. A curve is hard to judge by eye; a straight line is the model's fingerprint — and the slope of that line is a measurement.

A1 Fill, Plot, and Fit

Compute the **1/V column** of your data table (3 significant figures, in mL^{-1}). Plot each (1/V, P) pair on the grid below. Then draw **one straight best-fit line with a ruler** — a single line through the middle of the point cloud, *not* a dot-to-dot chain.



A2 Measure the Slope — Units Included

Mark two points **on your best-fit line** (not data points), far apart. Read each point's coordinates off the axes:

Point 1: ($1/V$ = __________ mL^{-1} , P = __________ kPa)   Point 2: ($1/V$ = __________ mL^{-1} , P = __________ kPa)

$$\text{slope} = \frac{\Delta P}{\Delta(1/V)} = \frac{(\_\_\_\_\_\_\_\_\_\ \mathrm{kPa})}{(\_\_\_\_\_\_\_\_\_\ \mathrm{mL}^{-1})} = \_\_\_\_\_\_\_\_\_\ \text{kPa·mL}$$

Convert to SI — the slope is an energy: $1\ \mathrm{kPa{\cdot}mL} = (10^3\ \mathrm{Pa})(10^{-6}\ \mathrm{m}^3) = 10^{-3}\ \mathrm{J}$, so slope = __________ J

ANALYSIS II — WHAT THE NUMBERS SAY

A3 From Slope to Amount of Gas

The model says your slope equals nRT. Use the slope (in J) and the room temperature (in K) from your record. Carry units through both computations. $R = 8.31\ \mathrm{J/(mol{\cdot}K)}$; $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$.

$$n = \frac{\text{slope}}{RT} = \frac{(\_\_\_\_\_\_\_\_\ \mathrm{J})}{(8.31\ \frac{\mathrm{J}}{\mathrm{mol{\cdot}K}})(\_\_\_\_\_\_\_\_\ \mathrm{K})} = \_\_\_\_\_\_\_\_\_\_\ $$ mol

$N = n \times N_A =$ ____________ molecules of air, sealed in your syringe

A4 The Constancy Check

Fill the **P·V column** of your data table (units: kPa·mL). Then compare the largest-volume row against the smallest-volume row:

$P{\cdot}V$ (largest V) = _________ kPa·mL $P{\cdot}V$ (smallest V) = _________ kPa·mL percent difference $= \frac{|\text{difference}|}{\text{mean}} \times 100 =$ ______ %

A percent difference smaller than your measurement uncertainty is consistent with a constant product.

A5 Uncertainty — Which End of the Line to Trust

The volume scale reads to ±0.5 mL at every setting. Compute the percent uncertainty at the two ends of your data range:

at 18.0 mL: $\frac{0.5\ \mathrm{mL}}{18.0\ \mathrm{mL}} \times 100 =$ ______ % at 9.0 mL: $\frac{0.5\ \mathrm{mL}}{9.0\ \mathrm{mL}} \times 100 =$ ______ %

The less-trustworthy volume readings plot at the **left / right** (circle one) end of the P vs 1/V graph. In one line, defend your circled choice: ____

A6 Why Slowly?

Your procedure required compressing slowly and pausing about 10 s before each pressure reading. Which held-constant quantity from D1(c) does the pause protect — and if your group had read the sensor *immediately after a fast push*, would the recorded pressure sit above or below your best-fit line? Explain in 1–2 sentences.

CONCLUSION — CLAIM, EVIDENCE, REASONING

CER The Argument Your Record Supports

Claim — one sentence: how does the pressure of a sealed air sample depend on the sample's volume when temperature is held constant?

Evidence — cite two specific results from your record: the shape of your P vs 1/V graph, and the behavior of your P·V column.

Reasoning — connect the claim to the collision model from Day 1: what do the molecules do differently in a smaller volume, and what about each molecule stays unchanged?