Pressure Under Pressure

Design and test a model for trapped air

CHE.7.5 "Enrichment: Use an engineering design process and online simulations or lab investigations to design and model the results of controlled scientific investigations to produce mathematical evidence that confirms the gas-laws relationships.*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline what the team changes and the two conditions it keeps constant; circle the design rule, then number the table trials from largest to smallest volume to track how pressure changes.

Testing an Air Pocket

1. A team is designing a shock-absorbing air pocket for a shipping case. It needs a model of how pressure changes when trapped air is squeezed. The team uses a gas-syringe simulation with a pressure sensor. Its test changes only the gas volume, from one setting to another, while the air stays sealed and the temperature stays at 298 K.

2. The team records absolute pressure at four volume settings. Absolute pressure is measured from a vacuum, so the team can use it in a pressure-volume calculation. At each setting, they wait for the temperature to return to 298 K before recording pressure. The simulation results below give the evidence they will use.

GAS-SYRINGE SIMULATION RESULTS

Volume (mL)	Absolute pressure (kPa)
20	100
16	125
10	200
5	400

3. The design goal is a dependable pressure model for the case. The team sets a rule: each pressure times volume product must be within 5% of 2,000 kPa·mL, or from 1,900 to 2,100 kPa·mL. If the products meet this rule, the team can model other volume settings with pressure times volume equal to 2,000 kPa·mL.

2 ANSWER WITH EVIDENCE

Use the passage

1. Calculate the pressure-volume products for the 16 mL and 10 mL trials. Do both meet the team's design rule?

2. Why must the temperature stay at 298 K and the air stay sealed when the team tests how volume affects pressure?

3. A repeat trial at 16 mL reads 150 kPa. Calculate its pressure-volume product. Does this reading meet the design rule?

4. Use the team's model to predict the absolute pressure at 8 mL. Show your calculation.

3 YOUR TURN

Your own words

Design two new simulation trials at volumes not used above, and predict the absolute pressure for each using the team's model. Name two conditions you will control, then explain how you will use the 5% rule to judge the simulation readings.

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PART 1 · READ AND MARK

Underline what the team changes and the two conditions it keeps constant; circle the design rule, then number the table trials from largest to smallest volume to track how pressure changes. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Calculate the pressure-volume products for the 16 mL and 10 mL trials. Do both meet the team's design rule?	**16 × 125 = 2,000 kPa·mL and 10 × 200 = 2,000 kPa·mL. Both are within the required range.**
2	Why must the temperature stay at 298 K and the air stay sealed when the team tests how volume affects pressure?	**Keeping temperature and the amount of air constant lets the team test how changing volume alone affects pressure.**
3	A repeat trial at 16 mL reads 150 kPa. Calculate its pressure-volume product. Does this reading meet the design rule?	**16 × 150 = 2,400 kPa·mL. No, it is above the upper limit of 2,100 kPa·mL.**
4	Use the team's model to predict the absolute pressure at 8 mL. Show your calculation.	**2,000 kPa·mL ÷ 8 mL = 250 kPa.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would test 12.5 mL and 25 mL while keeping the air sealed and the temperature at 298 K. My model predicts 160 kPa at 12.5 mL because 2,000 ÷ 12.5 = 160, and 80 kPa at 25 mL because 2,000 ÷ 25 = 80. I would multiply each simulation pressure reading by its volume. A trial meets the rule if its product is between 1,900 and 2,100 kPa·mL.

Accept any two new volumes with pressures calculated from 2,000 kPa·mL, provided the student controls temperature and amount of gas and checks each measured pressure-volume product against the stated range.