Pressure Line

Read a gas-law graph through its slope and units

HS-PSII-2.5 "Describe the slope of the graphical representation of pressure vs. the product of: the number of particles, temperature of the gas, and inverse of the volume of the gas in terms of the ideal gas constant."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the equations that connect particle count to moles and pressure to X. Circle the quantities in the passage that determine the slope of a pressure-versus-X graph.

Inside the Gas Chamber

1. A sealed research chamber holds a dilute gas. Its pressure P depends on how many particles N it contains, its kelvin temperature T, and its volume V. The ideal gas law is $PV = nRT$, where n is the amount in moles. One mole contains $N_A = 6.02 \times 10^{23}$ particles, so $n = N/N_A$.

2. For a pressure graph, put $X = NT/V$ on the horizontal axis and P on the vertical axis. The gas law becomes $P = (R/N_A)X$. Here $R = 8.314$ Pa·m³/(mol·K). A chamber log gives the rounded measurements below. Each X entry is measured in units of 10^{25} particles·K/m³; each pressure is in kilopascals.

CHAMBER MEASUREMENTS

X (10^{25} particles·K/m³)	P (kPa)
1	0.138
2	0.276
3	0.414
4	0.552

3. An ideal gas gives a straight pressure-versus-X graph through the origin. Slope means pressure change divided by X change. Changing the horizontal axis from individual particles to moles changes the numerical slope, even when the gas behaves the same way. Check axis units before comparing a slope from measured data with a slope calculated from constants.

2 ANSWER WITH EVIDENCE

Use the passage

1. Use the first and last table rows to find the slope in kPa per table unit of X. Then convert it to $Pa \cdot m^3/(particle \cdot K)$.

2. Start with $PV = nRT$ and $n = N/N_A$. Show how these equations give the slope of a pressure-versus-NT/V graph, then calculate it using the constants in the passage.

3. A chamber starts at the table row where X = 2. Its particle count doubles while T and V stay fixed. Predict the new pressure, and explain what happens to the slope of the pressure-versus-X graph.

4. Suppose the horizontal axis instead shows $(N/N_A)T/V$, measured in $mol \cdot K/m^3$. Derive the new slope in terms of R and compare it with the slope when the axis is NT/V.

3 YOUR TURN

Your own words

Invent two gas states by giving N, T, and V for each. Make the second state have three times the first state's NT/V, then describe how their pressures compare and state the slope of their pressure-versus-NT/V line in terms of R and N_A.

Pressure Line

PART 1 · READ AND MARK

Underline the equations that connect particle count to moles and pressure to X. Circle the quantities in the passage that determine the slope of a pressure-versus-X graph. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Use the first and last table rows to find the slope in kPa per table unit of X. Then convert it to $Pa·m^3/(particle·K)$.	**(0.552 − 0.138)/(4 − 1) = 0.138 kPa per table unit. Since one table unit is 10^{25} particles·K/m^3, the slope is 1.38×10^{-23} Pa·m^3/(particle·K).**
2	Start with PV = nRT and n = N/N_A. Show how these equations give the slope of a pressure-versus-NT/V graph, then calculate it using the constants in the passage.	**Substitute N/N_A for n and divide by V: P = $(R/N_A)(NT/V)$. The slope is $R/N_A = 8.314/(6.02 \times 10^{23}) \approx 1.38 \times 10^{-23}$ Pa·m^3/(particle·K).**
3	A chamber starts at the table row where X = 2. Its particle count doubles while T and V stay fixed. Predict the new pressure, and explain what happens to the slope of the pressure-versus-X graph.	**X doubles from 2 to 4, so pressure rises from 0.276 to 0.552 kPa. The slope stays the same because the new state lies on the same pressure-versus-X line.**
4	Suppose the horizontal axis instead shows $(N/N_A)T/V$, measured in mol·K/m^3. Derive the new slope in terms of R and compare it with the slope when the axis is NT/V.	**Because $n = N/N_A$, the new axis shows nT/V. From PV = nRT, P = R(nT/V), so the new slope is R, which is N_A times the slope R/N_A for the particle-based axis.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

State A has N = 2.0×10^{22} particles, T = 300 K, and V = 1.0 m^3. State B has N = 2.0×10^{22} particles, T = 300 K, and V = 1/3 m^3. B has three times A's NT/V and three times its pressure. Both states lie on a line through the origin with slope R/N_A.

Accept any two positive, physically consistent states whose NT/V values have a 1:3 ratio. For table calculations, accept small differences caused by rounding.