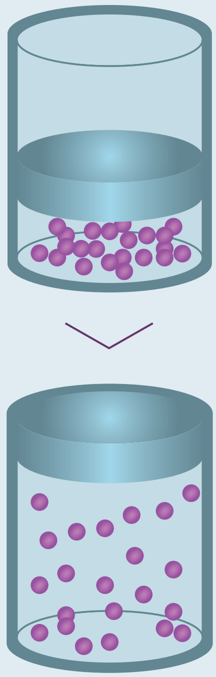
P-CHEM: A TALE OF TWO APPROACHES

Most P-chem problems have one right answer but multiple ways to reach it. The following has a **mathematical approach** and a **theoretical approach**. See which works best for you.



The problem

A piston filled with 0.0400 moles of a perfect gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0 °C. As it does so, it absorbs 208 J of heat from the surroundings. Calculate q, w, ΔH, and ΔU for this process.

Define trigger words and phrases

- **Perfect gas:** The equation of state is $PV = nRT$.
- **Reversibly:** Infinitesimally small changes, meaning you may need to use calculus.
- **Constant temperature:** $\Delta T = 0$, which is important because it relates to the change in internal energy, ΔU.
- **Absorbs 208 J of heat:** Heat (q) for this process is a positive value.

What you know:

- $n = 0.0400$ moles of gas
- $V_i = 50.0$ mL
- $V_f = 375$ mL
- $T = 37.0$ °C $= 310$ K

What you need to find:

- q (heat)
- w (work)
- ΔH (change in enthalpy)
- ΔU (change in internal energy)

Theoretical approach

- You are given the value of q and know that $\Delta T = 0$.
- No change in temperature leads you to determine that $\Delta U = 0$, because for perfect gases, the internal energy U is only concerned with kinetic energy. (If the average kinetic energy of the system—the temperature—remains constant, so will U.)
- Because $\Delta U = q + w$, and you already know that $\Delta U = 0$, w must be equal to $-q$ (simple algebraic rearrangements are all you need so far). From the problem, $q = +208$ J. Thus, $w = -208$ J.
- Solve for ΔH using $\Delta H = \Delta U + \Delta(PV)$. You already know that $\Delta U = 0$. The change in PV would be final minus initial. Using the perfect gas law, $PV = nRT$, you realize that because there was no change either in temperature T or in the number of moles n, $\Delta(PV) = 0$, and thus $\Delta H = 0$.

Mathematical approach

- The problem gives you the value of heat ($q = +208$ J)
- Derive the equation for work (w) for an isothermal reversible expansion of a perfect gas, and calculate w.
- Add together the values for q and w to get ΔU.
- For ΔH, you have ΔU and now need to find $\Delta(PV)$. Use the perfect gas law to find the pressure for the final and initial states in atm.
- Keep as many digits in the calculator as possible when you multiply the pressures and volumes, to ensure that you get the correct value for ΔH (i.e., zero). Rounding too soon introduces errors that will result in an incorrect answer.

Answers (the same for either approach)

$q = +208$ J $w = -208$ J $\Delta H = 0$ J $\Delta U = 0$ J