

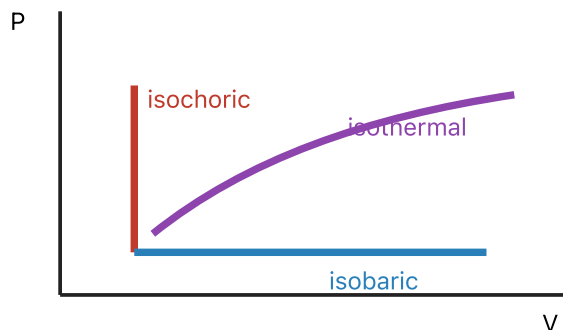
THERMO DAY 10: P–V DIAGRAMS I: WORK AS AREA

CED 9.4 · Skill 1.B · FRQ: TBR · target: confusing path slope with work

READ THE AXES BEFORE THE PATH

WARMUP Predict the work

Two gases expand from 1.0 m^3 to 3.0 m^3 . Gas A expands at 100 kPa; Gas B expands at 250 kPa. Which gas does more work on its surroundings?



$$W_{by} = \int P dV \quad W_{on} = - \int P dV$$

The area under a path on a P–V graph is work. Expansion gives positive W_{by} and negative W_{on} ; compression reverses those signs.

QUICK At 200 kPa, a gas expands from 1.2 m^3 to 2.0 m^3 . Find W_{by} and W_{on} .

THREE NAMED PROCESSES

Process	Graph feature	Work	Useful consequence
Isochoric	vertical; $\Delta V = 0$	0	$\Delta U = Q$
Isobaric	horizontal; P constant	$W_{by} = P\Delta V$	rectangle area
Isothermal ideal gas	curved; $PV = \text{constant}$	area under curve	$\Delta U = 0$

WE DO A gas expands isobarically at 150 kPa from 0.80 m³ to 1.40 m³ while absorbing 120 kJ as heat. Find W_{by} , W_{on} , and ΔU .

YOU DO A rigid tank is heated with 75 kJ. Find the work and change in internal energy.

TRANSLATE GRAPH ↔ WORDS ↔ ENERGY

REPRESENT For each path in the graph on page 1, state whether volume changes, whether pressure is constant, the sign of W_{on} , and whether the path could be isochoric, isobaric, or isothermal.

Isothermal ideal gas

Because internal energy depends only on temperature, $\Delta T = 0 \Rightarrow \Delta U = 0$. The First Law becomes $Q = -W_{on} = W_{by}$. During isothermal expansion, heat must enter to replace the energy transferred out as work.

CHECK An ideal gas expands isothermally and does 48 kJ of work. Find ΔU , W_{on} , and Q .

PRACTICE

1. A gas expands at 220 kPa from 0.50 m³ to 0.90 m³. Find W_{by} .

2. A gas is compressed at 180 kPa from 1.6 m³ to 1.1 m³. Find W_{on} .

3. During an isobaric expansion, $Q = +140$ kJ and $W_{by} = 55$ kJ. Find ΔU .

4. During isothermal compression, 35 kJ of work is done on an ideal gas. Find Q .

5. Sketch an isochoric heating path and an isobaric expansion starting from the same point. Label the sign of work for each.