$$\Delta U = Q + W$$

$Q > 0$	system absorbs heat from the environment
$Q < 0$	system releases heat to the environment
$W > 0$	work done on the system by the environment
$W < 0$	work done by the system on the environment

A system can be described by three thermodynamic variables. — pressure, volume, and temperature. Well, maybe it's only two variables. With everything tied together by the ideal gas law, one variable can always be described as dependent on the other two.

$$PV = nRT \Rightarrow \begin{cases} P = \dfrac{nRT}{V} \\ V = \dfrac{nRT}{P} \\ T = \dfrac{PV}{nR} \end{cases}$$

Temperature is the slave of pressure and volume on a pressure-volume graph (PV graph).

Function of State

$$\Delta U = \frac{3}{2} nR\Delta T$$

Function of Path: Work

$$W = \int \mathbf{F} \cdot d\mathbf{s} = \int P\, dV$$
$$W = -\, area\ on\ PV\ graph$$

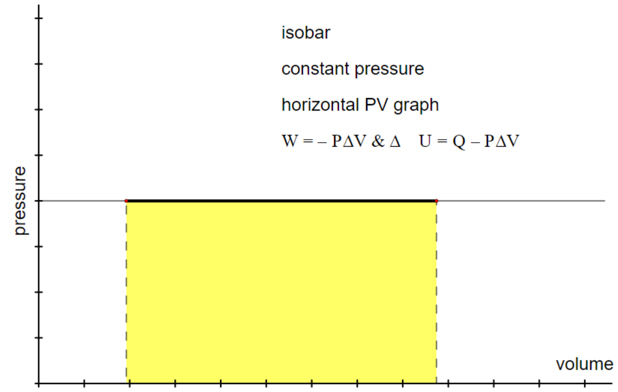
Function of Path: Heat

$$Q = \Delta U + W = nc\Delta T$$
c_P = specific heat at constant pressure
c_V = specific heat at constant temperature

curves

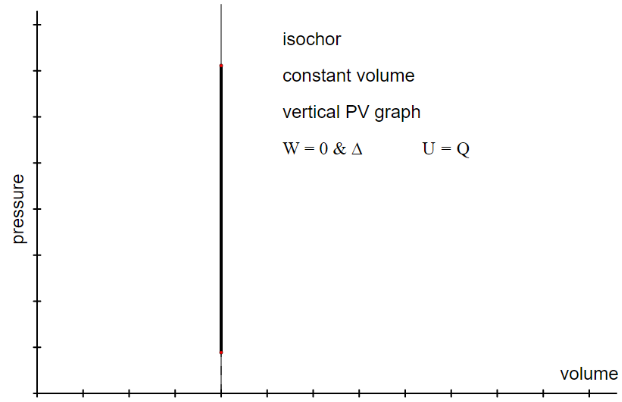
- isobaric
  - constant pressure
  - "bar" comes from the greek word for heavy: βαρύς [*varys*]
  - examples: weighted piston, flexible container in earth's atmosphere, hot air balloon
  - PV graph is a horizontal line

$$W = -P\Delta V \Rightarrow \Delta U = Q - P\Delta V$$



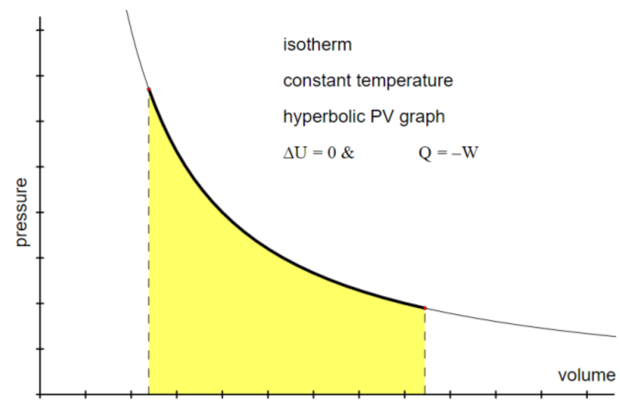
- isochoric
  - constant volume
  - "chor" comes from the greek word for volume: χώρος [*khoros*]
  - examples: closed rigid container, constant volume thermometer
  - PV graph is a vertical line

  $W = 0 \Rightarrow \Delta U = Q$



- isothermal
  - constant temperature
  - "therm" comes from the greek work for heat: θερμότητα [*thermotita*]
  - examples: "slow" processes, breathing out through a wide open mouth
  - PV graph is a rectangular hyperbola

  $\Delta U = 0 \Rightarrow Q = -W$



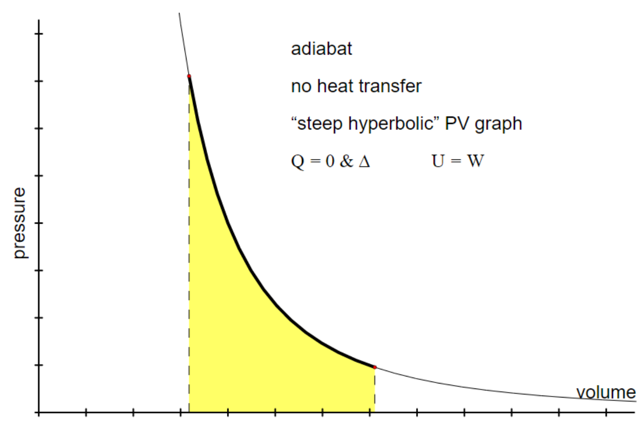
- adiabatic
  - no heat exchange with the environment
  - adiabatic has a complex greek origin that means "not+through+go": α + Δια + βατός [*a* + *dia* + *vatos*]
  - examples: "fast" processes, forcing air out through pursed lips, bicycle tire pump
  - PV diagram is a "steep hyperbola"

  $Q = 0 \Rightarrow \Delta U = W$

  Gamma = $\gamma = \frac{c_P}{c_V} = \frac{\alpha + 1}{\alpha}$

  $\frac{3/2 + 1}{3/2} = \frac{5}{2}$ monatomic

  $\frac{5/2 + 1}{5/2} = \frac{7}{5}$ diatomic



$PV^{\gamma} = constant$