First law of thermodynamics

$$\Delta U = Q - W$$

Clicker Question

Two identical gas-cylinder systems are taken from the same initial state to the same final state, but by different processes. Which are the same in both cases:

A. work done on or by the gas

B. heat added or removed

C. change in internal energy

D. any two of the above

E. all of the above are the same.

Types of thermodynamics processes

isothermal – constant temperature process

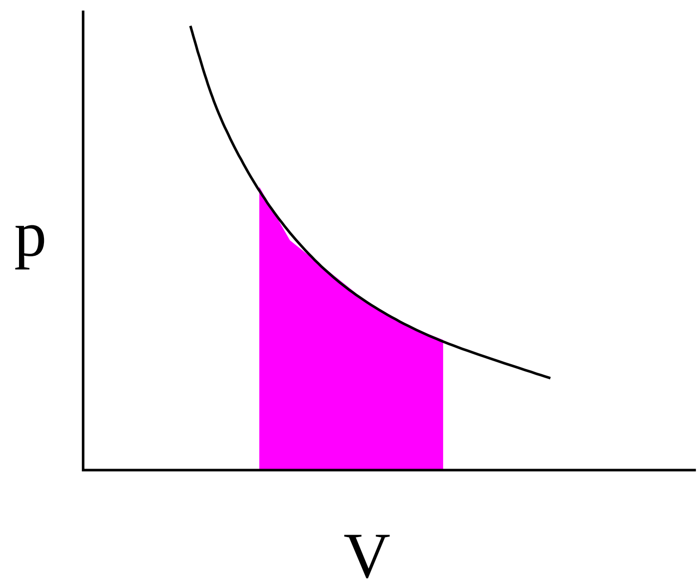
isochoric – constant-volume process (AKA isometric, isovolumetric)

isobaric – costant pressure process

adiabatic – process with no heat exchange

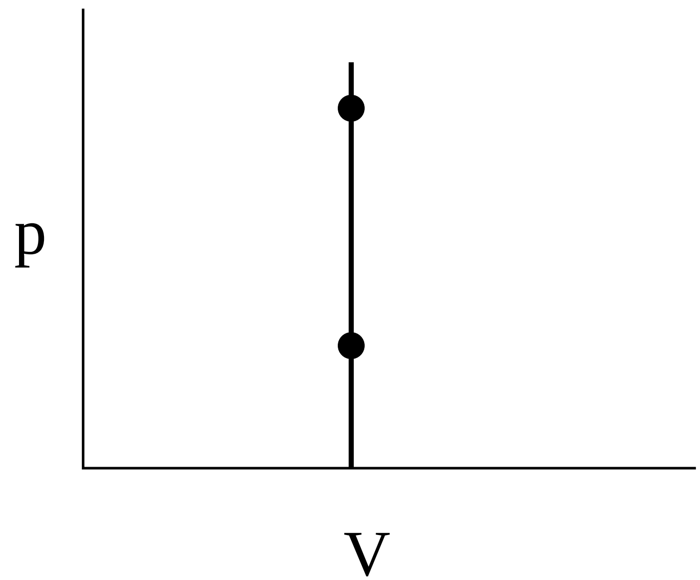
Isothermal process for an ideal gas

Calculate ΔU, Q and W for an ideal gas undergoing an isothermal process.



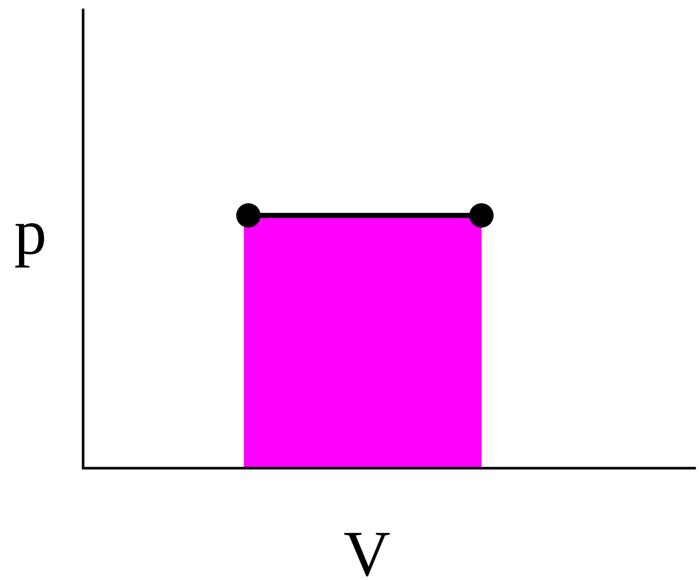
Constant volume process for an ideal gas

Calculate ΔU, Q and W for an ideal gas undergoing a constant volume process (in terms of molar specific heat, C_V).



Isobaric process for an ideal gas

Calculate ΔU, Q and W for an ideal gas undergoing an isobaric process (in terms of molar specific heat, C_P).



C_V and C_P for an ideal gas

$$C_p = C_V + R$$

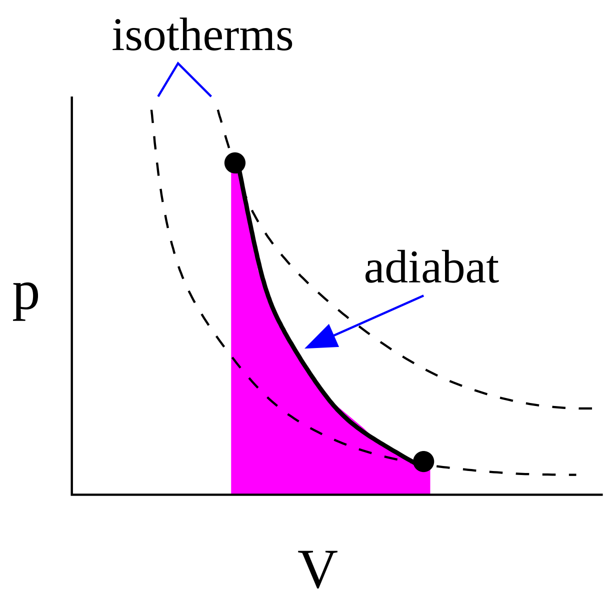
$\Rightarrow$A constant pressure process requires more heat for a given temperature change than a constant volume process

The ratio of molar specific heats is

$$\gamma = \frac{C_p}{C_V}$$

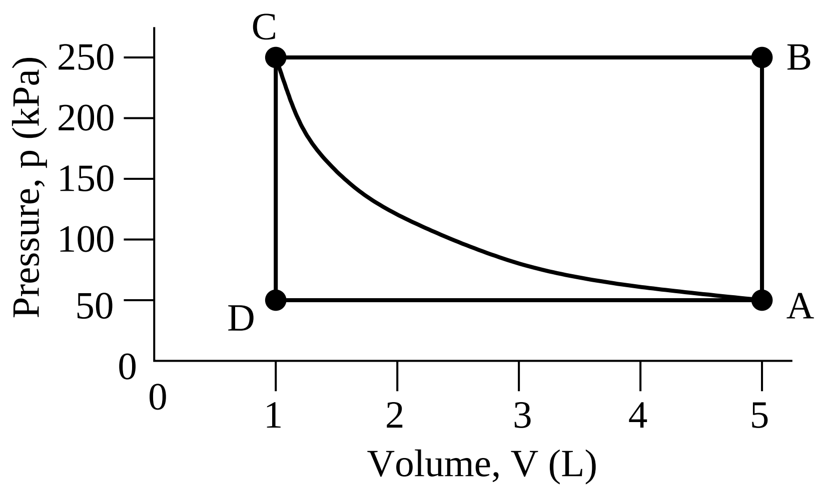
Adiabatic process for an ideal gas

Calculate ΔU, Q and W for an ideal gas undergoing an adiabatic process.



Work in a thermodynamic cycle: Example 18.55

The curved path AC lies on the 350 K isotherm for an ideal gas with $\gamma = 1.4$. (a) Calculate the net work done on the gas as it goes around the cyclic path $ABCA$. (b) How much heat flows into or out of the gas on the segment AB? ($\gamma = C_p/C_V$)



Equipartition of energy

Equipartition theorem When a system is in thermodynamic equilibrium, the average energy per molecule is $\frac{1}{2}kT$ for each degree of freedom.

Ideal gases made up of

- monatomic molecule: 3 translational degrees of freedom, $U = \frac{3}{2}nC_V T$
- diatomic molecule: 3 translational + 2 rotational degrees of freedom $U = \frac{5}{2}nC_V T$