Adiabatic Process

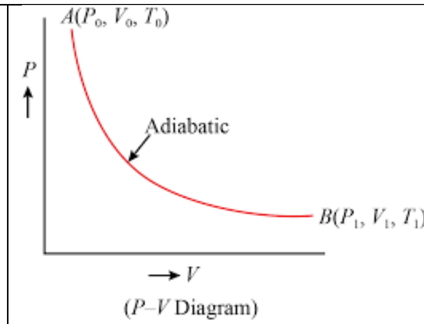
- Constant HEAT process. (Q = 0)
- Change in P, V, and T!
- Therefore… from the 1st Law simplifies

$$\Delta U = W + \cancel{Q}$$

An adiabatic expansion lowers the temp of the gas.

An adiabatic compression raises the temp of the gas.

This process allows one to use Work instead of Heat to change the temperature of a gas.

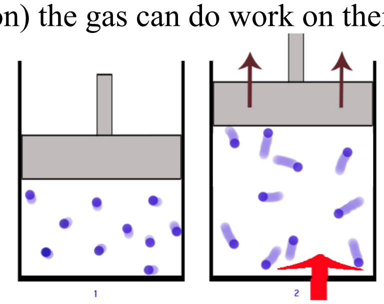


Thermodynamics

5b – Thermodynamics of an Ideal-Gas Process

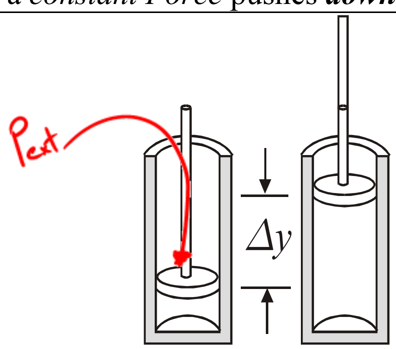
Remember that Heat and Work are just two different ways to add energy to a system.

When a gas expands (an expanding piston) the gas can do work on their surroundings.



due to P_{ext}

When a *constant Force* pushes ***down*** on a piston object Work can be calculated….

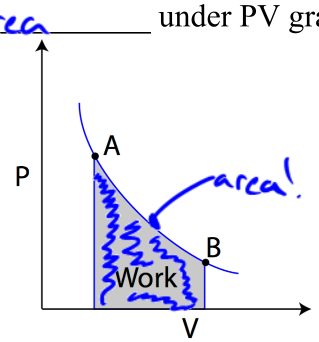


$W = F\cdot d$ $\quad P_{ext} = \frac{F}{A}$ $\quad F = P_{ext}\cdot A$

$W = (P_{ext}\cdot A)d = P_{ext}(A\cdot\Delta y)$

$W = P\cdot\Delta V \longrightarrow$ whoa...

And equally important…. Work is the area under PV graph between V_i and V_f. (ΔV)



Ok… A couple of important details

- In order for a gas to do work its volume must change
- You will ONLY see simple shapes (Squares, Rectangles, Triangles) on a PV Diagram
- Pressure must be in Pascal's (Pa); Volume in m^3
- $W_{gas} < 0$ if the gas expands; (think about it… Energy is being transferred out of the system)
- $W_{gas} > 0$ if the gas is compresses; (Energy is being transferred into of the system)

A very useful Table!

Process	Constant	PV Diagram	Ideal Gas Law	First Law of Thermodynamics
Isobaric	Pressure	Horizontal line	V α T	$\Delta U = Q + W$
Isochoric	Volume	Vertical line	P α T	$\Delta U = Q$
Isothermal	Temperature	Curved line	PV α T	$\Delta U = 0$
Adiabatic	No heat exchanged	Curved line (jumps to different isotherm)	PV = nRT (only "nR" are constant)	$\Delta U = W$

<u>Example</u>:

A substance undergoes a cyclic process shown in the graph. Heat transfer occurs during each process in the cycle.

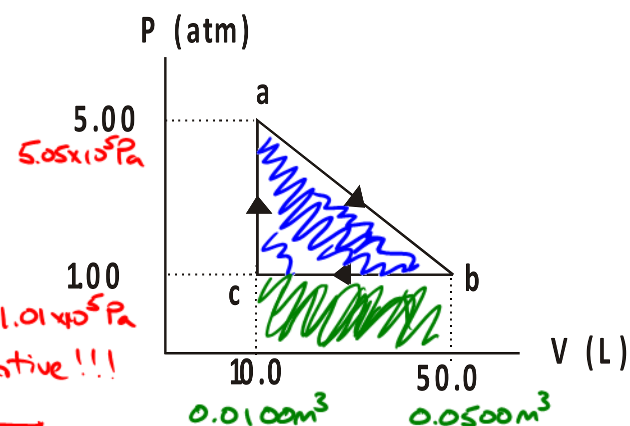
(a) What is the work output during process ***a*** → ***b***?

(b) How much work input is required during process ***b*** → ***c***?

(c) What is the net (total) work done during the cycle?

<u>Note</u>: 1 atm = 1.01×10^5 Pa

<u>Note</u>: 1 L = $0.001\ m^3$



a) $W = A_{tri} + A_{rec}$

$W = \frac{1}{2}(0.0400\,m^3)(4.04\times10^5\,Pa) + (0.0400\,m^3)(1.01\times10^5\,Pa)$

$W_{A\to B} = \boxed{-1.21\times10^4\,J}$ EXPANSION is W is negative!!!

b) $W = A_{rec}$

$W_{B\to C} = (0.0400\,m^3)(1.01\times10^5\,Pa) = \boxed{+4.04\times10^3\,J}$ CONTRACTIONS!

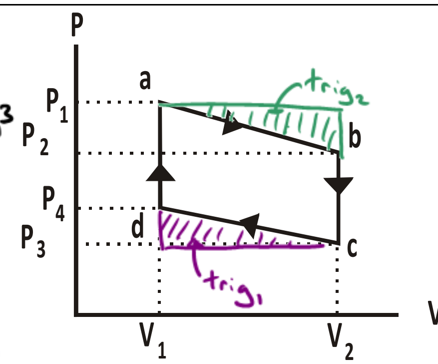
c) $W_{total} = W_{A\to B} + W_{B\to C} = -1.21\times10^4\,J + 4.04\times10^3\,J$

$W_{total} = -8.1$[illegible]$\times10^3$ J

Example:

A heat engine's cycle is shown in the PV diagram to the right.
P_1 = 345 kPa, P_2 = 245 kPa, P_3 = 125 k Pa, and P_4 = 225 kPa. V_1 = 35.0 L and V_2 = 85.0 L.

0.0350 m^3 0.0850 m^3



What is the net work done during one cycle of the engine?

Note: 1 L = 0.001 m^3

$$W = A_{rec} - A_{trig1} - A_{trig2}$$

$$W = (P_1 - P_3)(V_2 - V_1) - \frac{1}{2}(P_1 - P_2)(V_2 - V_1) - \frac{1}{2}(P_4 - P_3)(V_2 - V_1)$$

$$W = (220{,}000\,\text{Pa})(0.0500) - \frac{1}{2}(100{,}000)(0.0500) - \frac{1}{2}(100{,}00)(0.0500)$$

$$W = -6000\,\text{J}$$

+ or − ?

Expands at a higher pressure ∴ does MORE work on the surroundings than the surroundings does on!!!