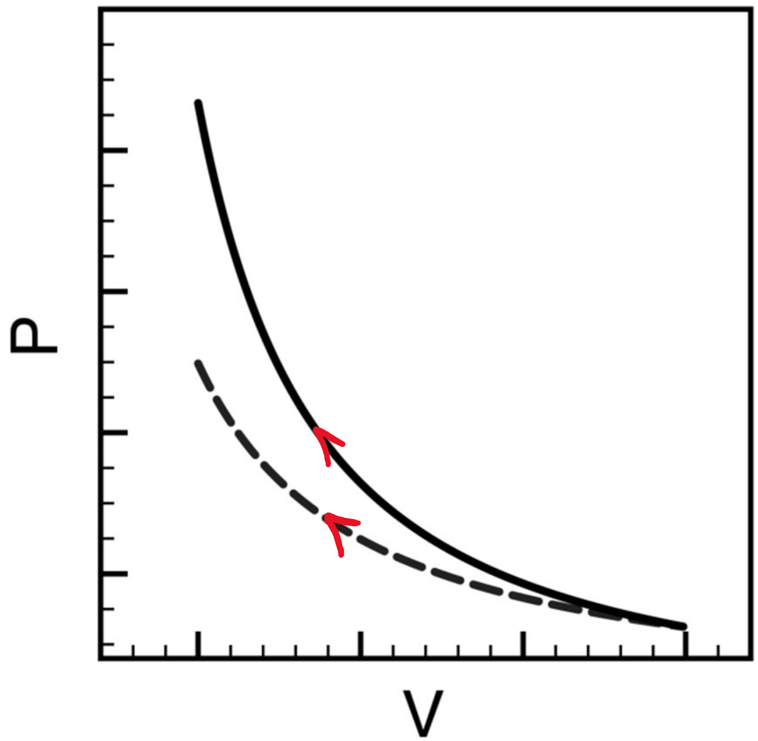
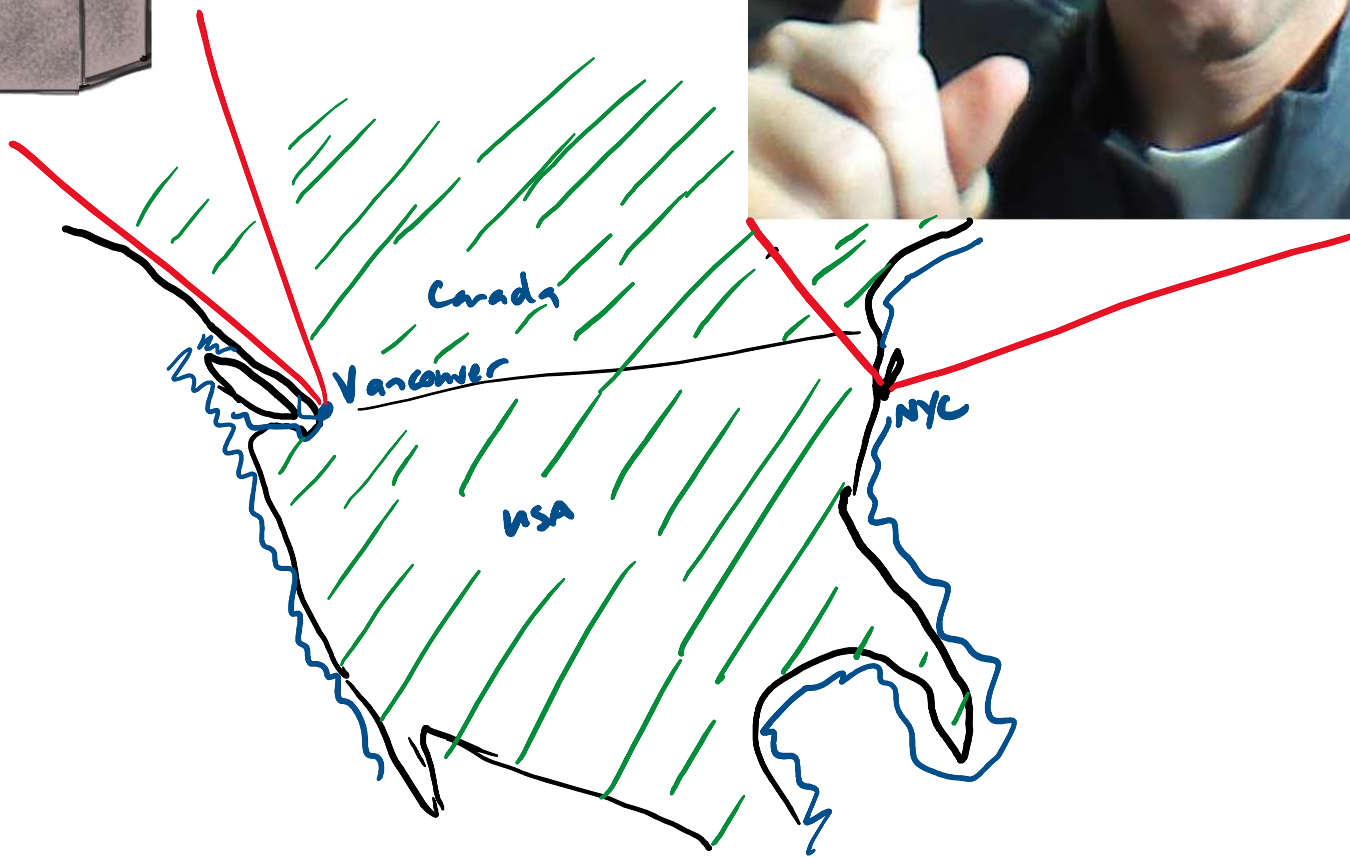


In the two processes shown, gas is compressed adiabatically in one case and isothermally in the other. We can say that

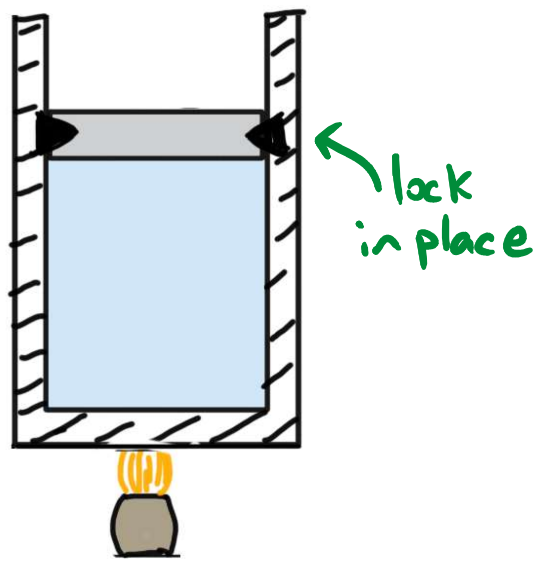
A) The solid line represents the isothermal process
B) The solid line represents the adiabatic process
C) We don't have enough information to tell which process is which.

EXTRA: Can you give a conceptual explanation for your answer?

Last time in Physics 157...



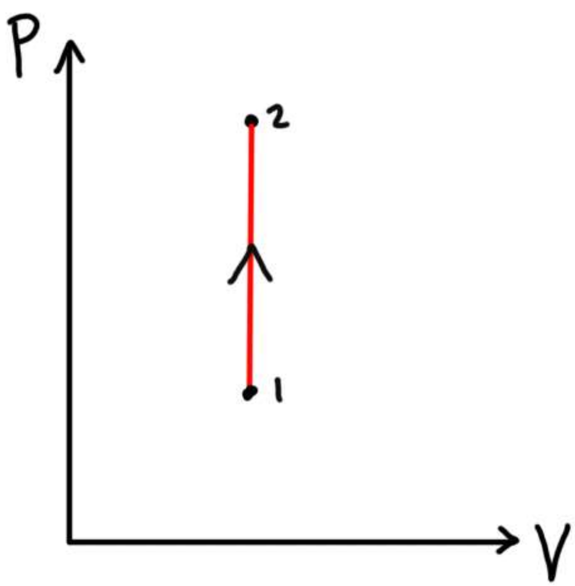
CONSTANT VOLUME:



Ideal gas law $\Rightarrow$ $\frac{T_2}{T_1} = \frac{P_2}{P_1}$

$W = 0$ so

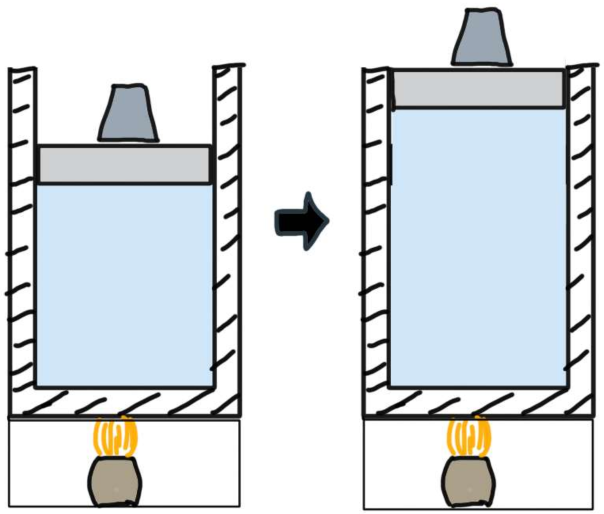
$Q = \Delta U = n C_v \Delta T$



"isochoric"

Constant Pressure

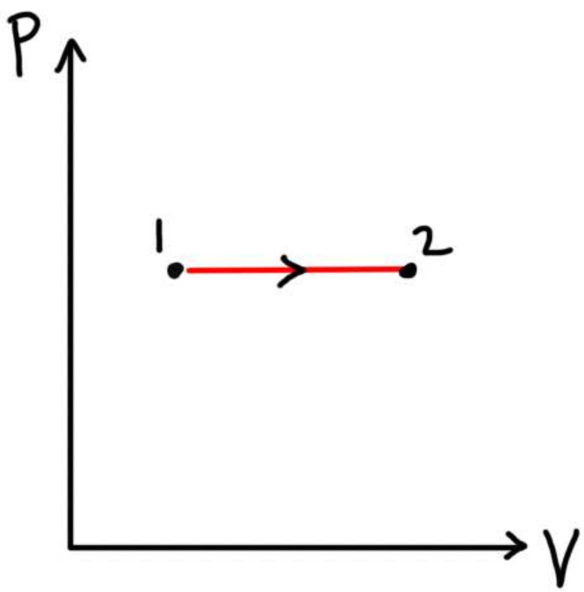
Ideal Gas Law $\Rightarrow \dfrac{T_2}{T_1} = \dfrac{V_2}{V_1}$



$$W = P\Delta V$$

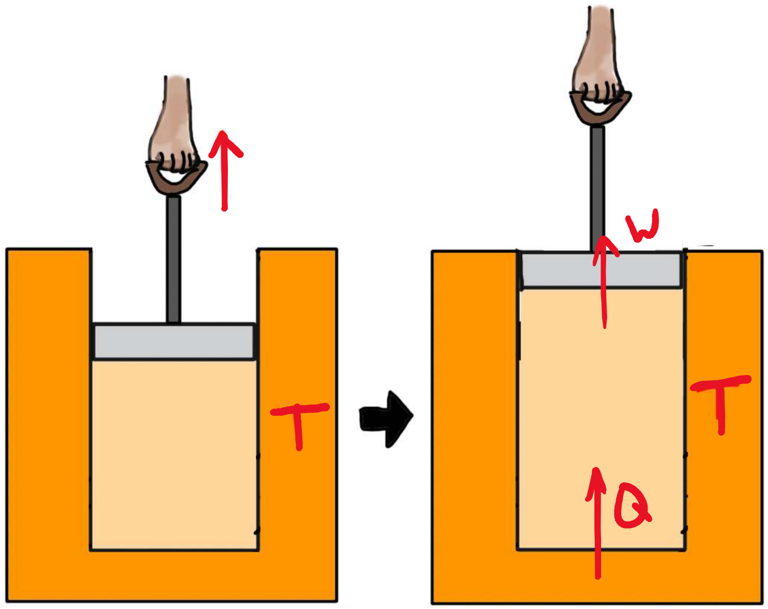
$$Q = n C_p \Delta T$$

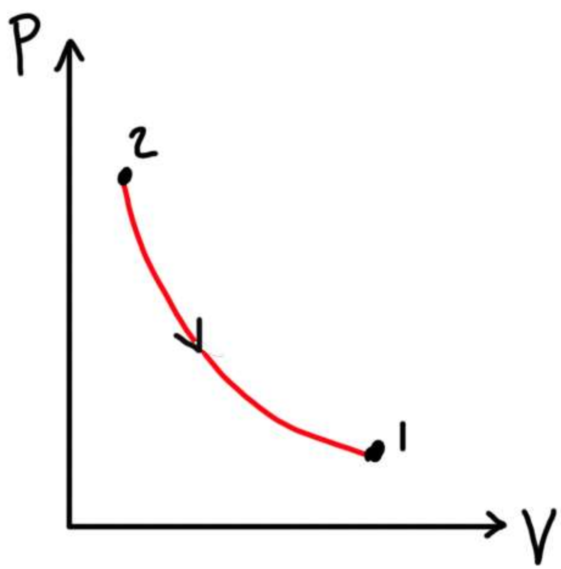
$C_v + R$



"isobaric"

CONSTANT TEMPERATURE





Ideal Gas Law $\Rightarrow$ $PV = \text{const.}$

so $P \propto \frac{1}{V}$

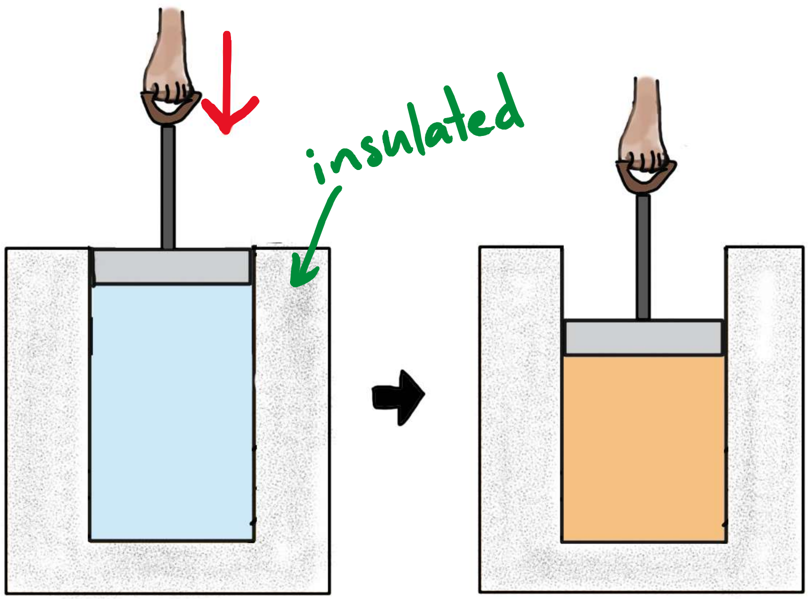
$$\Delta U = 0$$

$$Q = W = nRT \ln\left(\frac{V_f}{V_i}\right)$$

$$\int_{V_i}^{V_f} P(V)\,dV$$

"isothermal"

ADIABATIC: $Q = 0$ (insulated or very fast)



First Law: $\Delta U = -W$

compressed gas heats up!

$$nC_v \Delta T = -W$$

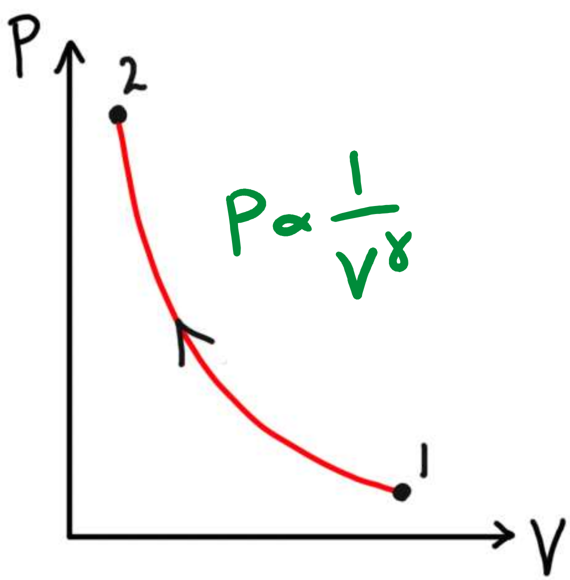
+ ideal gas law

$\frac{PV}{T}$ = constant

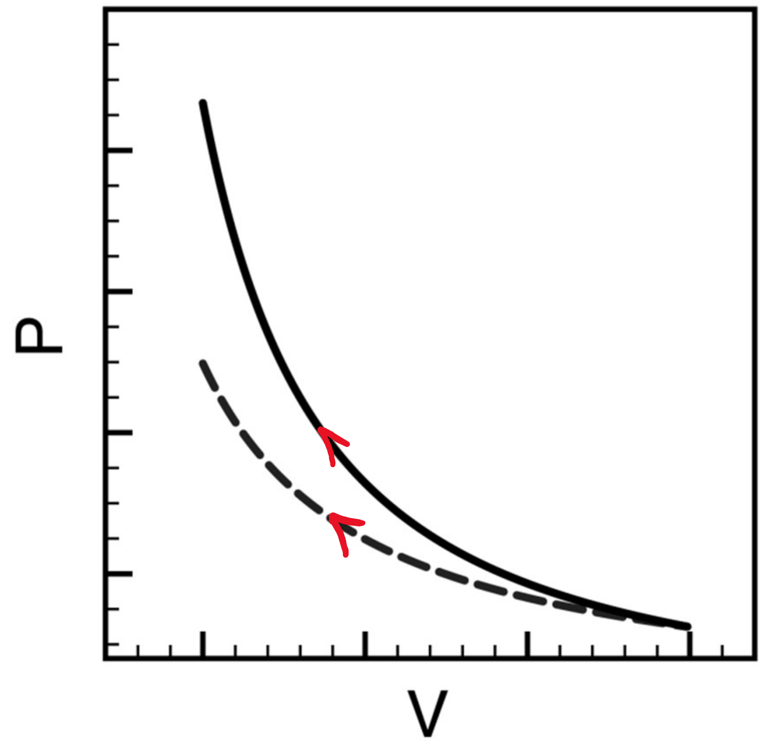
$$PV^{\gamma} = \text{constant}$$

$$TV^{\gamma-1} = \text{constant}$$

see 19.8 or video derivation



$$\gamma = \frac{C_p}{C_v} = 1 + \frac{R}{C_v}$$



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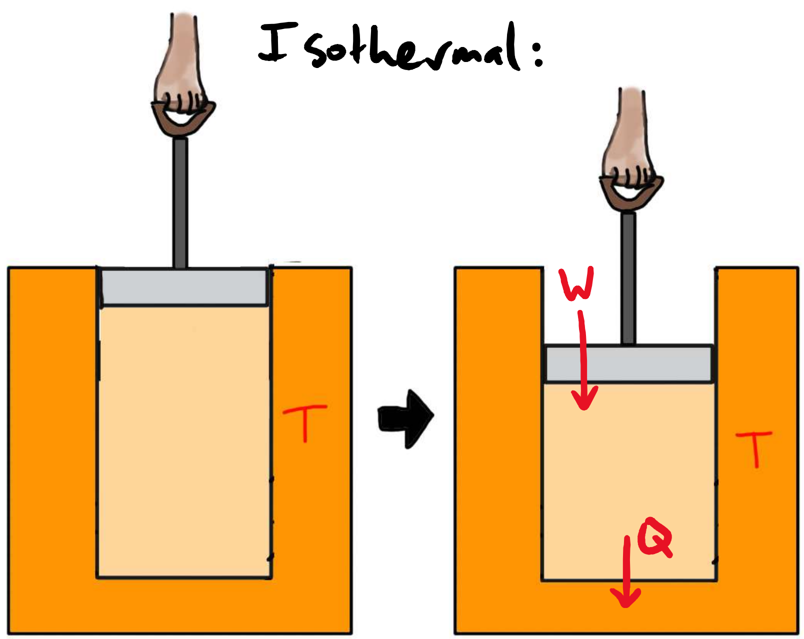
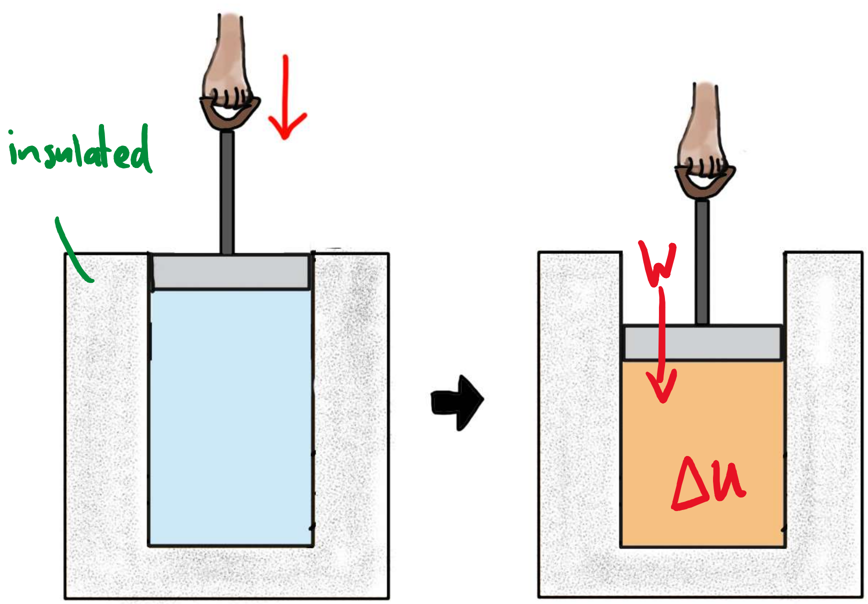
EXTRA: Can you give a conceptual explanation for your answer?

Isothermal:



$\Delta U = 0$



Adiabatic

$\Delta U > 0$ so $T \uparrow$

- same final volume
- higher T

higher final P for adiabatic

Answer is

B

Gas with $C_V = 3\,R$, initially at room temperature, is compressed very rapidly in a cylinder. The **compression ratio** is 15.

a) Estimate the final temperature of the gas.

b) If the tube contains 0.0004 moles of gas, how much work was required to compress the gas?

Gas with $C_V = 3\,R$, initially at room temperature and atmospheric pressure, is compressed very rapidly in a cylinder. The **compression ratio** is 15.

a) **Estimate the final temperature of the gas.**

b) If the tube contains 0.0004 moles of gas, how much work was required to compress the gas?

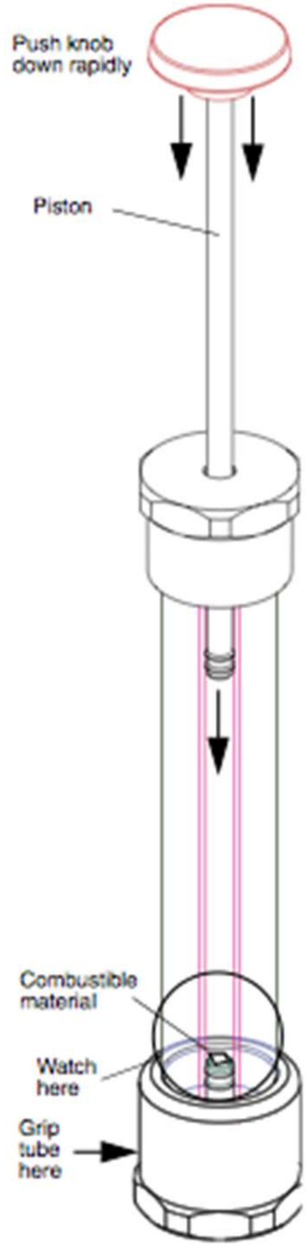
$$\gamma = \frac{C_P}{C_V} = \frac{C_V + R}{C_V} = \frac{4R}{3R} = \frac{4}{3}$$

Have $TV^{\gamma-1}$ constant

$$T_2 V_2^{\gamma-1} = T_1 V_1^{\gamma-1}$$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 293\text{K} \cdot (15)^{\frac{1}{3}}$$

$$= 723\text{K}$$



Demo: we can ignite cotton just by compressing the air!

Gas with $C_V = 3\,R$, initially at room temperature and atmospheric pressure, is compressed very rapidly in a cylinder. The **compression ratio** is 15.

a) Estimate the final temperature of the gas.

b) If the tube contains 0.0004 moles of gas, how much work was required to compress the gas?

Have $Q = 0$ so:

$$\Delta U = -W_{gas} = W_{\text{done on gas}}$$

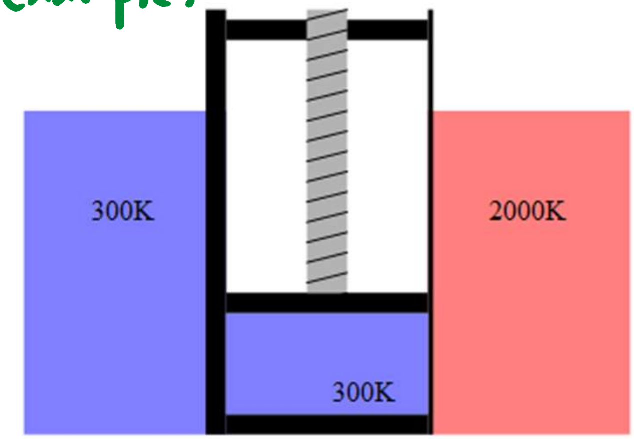
So work done equals $\Delta U = n C_v \Delta T$

$$= 0.0004 \cdot 3 \cdot 8.31 \cdot 430\,\text{J}$$

$$= 4.3\,\text{J}$$

HEAT ENGINES: (partially) convert heat to work via cyclic process

example:



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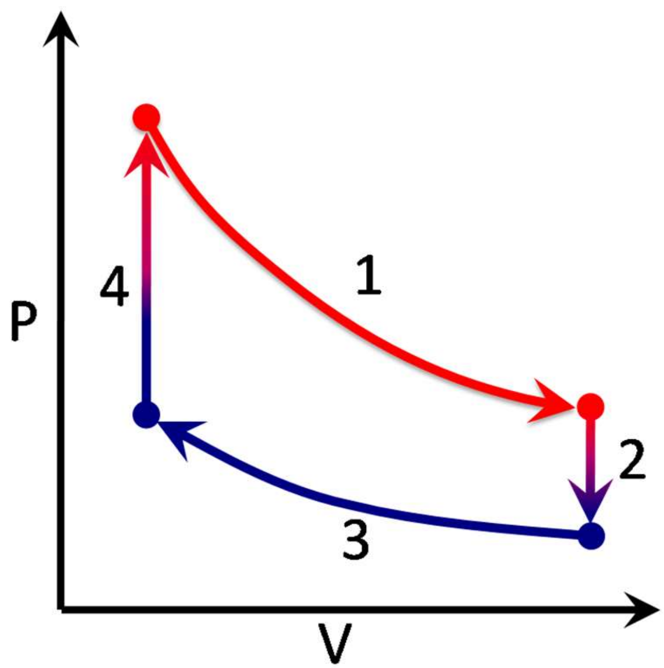
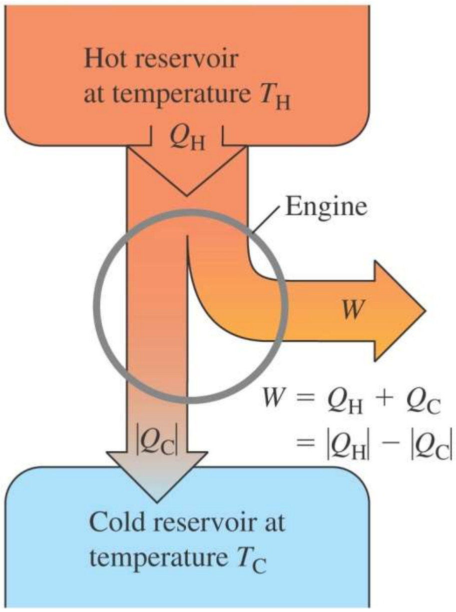


"Stirling cycle"

EFFICIENCY OF AN ENGINE



Q_H : Heat absorbed by gas each cycle

Q_c : Heat expelled by gas

W : Net work done each cycle

Efficiency is: $e = \frac{W}{Q_H}$ ← work we get out / ← heat we need to supply

$$= 1 - \frac{|Q_c|}{|Q_H|}$$