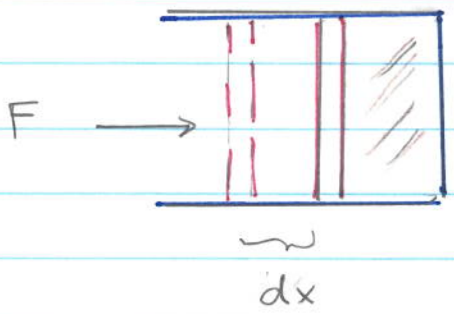
Work

- Consider the compression of a gas



$$\text{đ}W = F \cdot dx$$

now $A\,dx = -dV$

So since $p = F/A$ we have

$$\boxed{\text{đ}W = -p(T,V)\,dV}$$

work by me

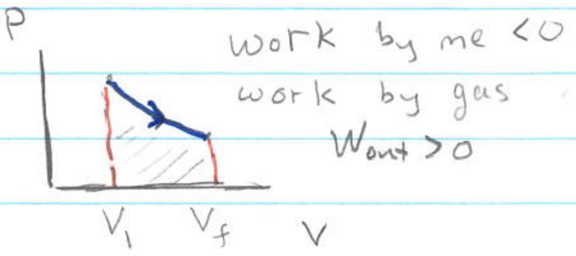
determined by EOS β_p, κ_T

- This is the work by me on gas. Of course, the work by the gas on me is minus this, $\text{đ}W_{out} = +p\,dV$.

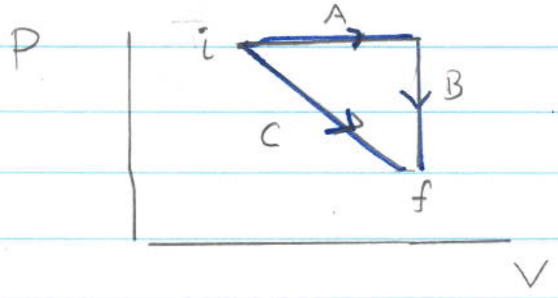
- So

$$W_{if}^{out} = \int_i^f p(T,V)\,dV$$

$$= \text{Area under curve}$$



- The work done depends on the path e.g.



$$W_C \neq W_A + W_B$$

- i.e. the work $W_A + W_B \neq W_c$

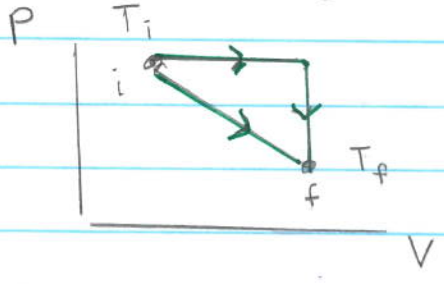
We say $\text{đ}W$ is an inexact differential. Meaning it represents a small <u>amount</u> of work, dV is an exact differential and represents a small <u>change</u> in volume V, $dV = V_f - V_i$, it does not depend on the path

The first Law

- The change in energy of the system is the heat put in and the work done

$$\underbrace{dU}_{\text{Change in energy}} = \underbrace{\text{đ}Q}_{\text{amount of heat put in}} + \underbrace{\text{đ}W}_{\text{amont of work done on gas}} = \text{đ}Q - \text{đ}W_{out}$$

- The change in energy is independent of the path

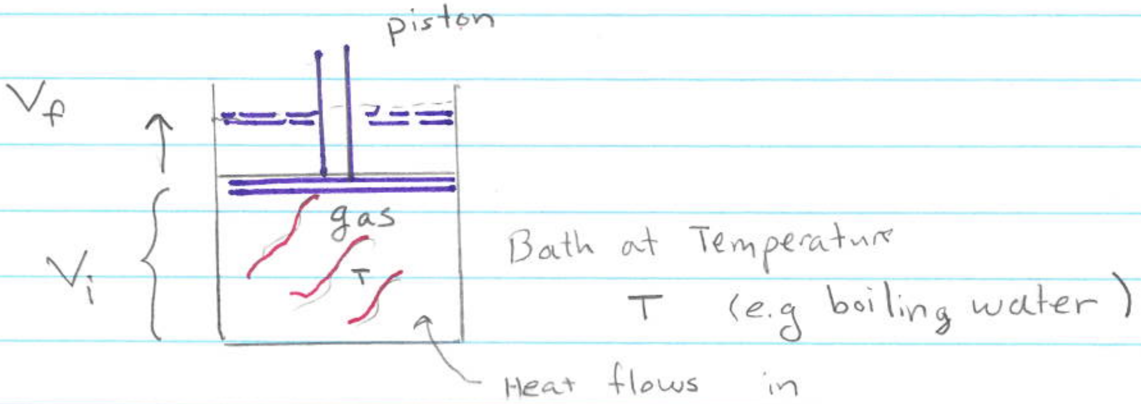


- At the initial and final points the temperature is determined by the eos $P = P(T,V)$

And $\Delta U = U_f - U_i$

with e.g. $U_f = U(T_f, V_f)$

Isothermal Expansion of Ideal Gas



- As the piston is raised the gas does work $p dV$ (we do negative work $đW = -p dV$.) Heat flows in from bath to maintain a constant temperature. We do it slowly enough so that T is constant at all times. Lets consider ideal gasses where $U = N e_0(T)$. Since T is fixed $dU = 0$. What is the heat flowing in?

$$\overset{0}{\cancel{dU}} = đQ + dW$$

$$đQ = - đW = p\, dV$$

So

$$\Delta Q = \int_i^f đQ = \int_i^f p(T,V)\, dV = \int_{V_i}^{V_f} \frac{N k_B T}{V} dV$$

At all times we are in equilibrium so

$$p = \frac{N k_B T}{V}$$

So integrating

$$\boxed{\Delta Q = N k_B T \ln\left(\frac{V_f}{V_i}\right)}$$

heat inflow of ideal gas during isothermal expansion

We remind that $\Delta U = 0$ but $-W_{if} = Q_{if}$. The work done by the gas is $W_{if}^{out} = Q_{if}$