

Example: Q5 problem sheet

The equation of state of an idealised elastic substance (e.g. rubber) is, in one dimension,

$$F = KT \left(\frac{l}{l_0} - \frac{l_0^2}{l^2} \right)$$

where F is the tensional force, l is the length and l_0 is the unstretched length, K is a constant and T is the temperature; l_0 is a function of temperature only.

Calculate the work required to compress this material reversibly and isothermally from l_0 to $\frac{l_0}{2}$.

f

$$W = -P dV$$

$l_0 \rightarrow \frac{l_0}{2}$: compress^o : ^{unstretched} length

S??

$\Rightarrow T = \text{const}$

Ur

compress^o

$$dW = F dl \Rightarrow W = \int F dl$$

$$\int_{l_0}^{l_0/2} F dl$$

$$= \int_{l_0}^{l_0/2} uT \left(\frac{l}{l_0} - \frac{l_0^2}{l^2} \right) dl$$

$$dW = uT \left(\frac{l^2}{2l_0} + \frac{l_0^2}{l} \right) \Big|_{l_0}^{l_0/2}$$

$$\left. \left(\frac{(l_0/2)^2}{2l_0} + \frac{l_0^2}{l} \right) \right|_{l_0} - \left[\frac{(l_0/2)^2}{2l_0} + \frac{l_0^2}{l} \right]$$

$$= kT \left| \frac{1}{2l_0} - \frac{l_0/2}{l_0} \right|^4 \left(\frac{2l_0 + l_0^2}{l_0} \right)$$

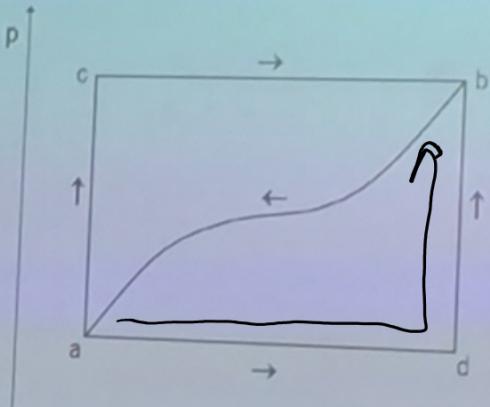
$$= \left(\frac{5}{8} \right) kT l_0$$

+ : doing work to the system which makes size in compression

Example: Q6 Problem sheet

A system is taken from state a to state b along path acb during which 800 J of heat flows into the system and the system does 300 J of work.

- How much heat flows into the system along path adb if the work done by the system is then 100 J?
- When the system returns from b to a along the curved path, the work done on the system is 200 J. Does the system absorb or liberate heat, and how much?



a) $W_{on} = 100 \text{ J}$

$W_{out} = 300 \text{ J} ?$

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

$300 - 100$

$500 - (-100)$

$600 ?$

I think this is
done wrong

b) liberty: $300 ?$

work on syst

$800 + 200 = 1000$

$(1000) \cdot 700$

$\Delta Q = 200$

liberty

700 J heat

800 J of heat flows into the system and the system does 300 J of work.

1st law $\Delta U = \Delta Q + \Delta W$.

$\Delta Q > 0$ if heat is given to the system

$\Delta W > 0$ if work is done on the system

$$\Delta U = \Delta Q + \Delta W = 800 \text{ J} - 300 \text{ J} = 500 \text{ J}$$

Here work done by system & heat flows into system

a) (adb) $\Delta W = -100 \text{ J}$ (work done **by** system)
 $\Delta Q = \Delta U - \Delta W =$
 $500 \text{ J} + 100 \text{ J} = 600 \text{ J}$

b) (b->a) $\Delta W = 200 \text{ J}$ (work done **on** system)
 $\Delta Q = -\Delta U - \Delta W = -500 \text{ J} - 200 \text{ J} =$
 -700 J
so the system liberates 700 J of heat.

