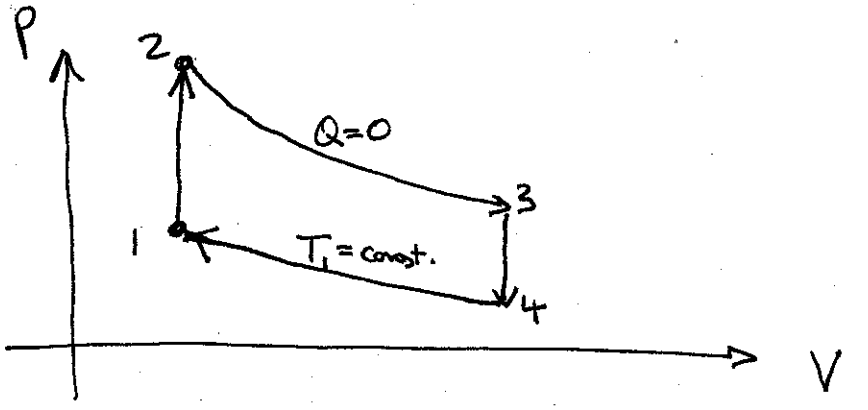
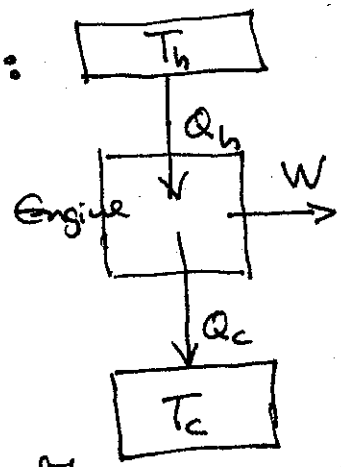
Jeopardy Engine Problem



Solution should have been: $Q_h = Q_{12} + \underbrace{Q_{23}}_{=0}$

$= \Delta U_{12} = \frac{f}{2} N k (T_2 - T_1)$

Here for each process:



$1 \to 2$: $W_{12} = 0$ $\quad Q_{12} \overset{1^{st} \text{ Law of Th.}}{=} \Delta U_{12} = \frac{f}{2} N k (T_2 - T_1)$

You heat up engine by having heat flow into engine

↳ Q_{12} contributes to Q_h

$2 \to 3$: $W_{23} = \int_2^3 p\,dV$ $\quad Q_{23} = 0 \to$ no contribution

all if would have chosen $2 \to 3$ along isotherm:

if I would have asked for $2 \to 3$ along isotherm: you would have expanded system, ~~to stay~~ so system would try to cool down, to stay along isotherm you need to let heat flow into system, so would have given contribution to Q_h

$3 \to 4$: $W_{34} = 0$ $\qquad$ $Q_{34} \overset{\text{1st Law of Th.}}{=} \Delta U_{34} = \frac{f}{2} Nk(T_3 - T_4) < 0$

$Q_{34} < 0$ so flows out of engine → contributes to Q_c

(Or, you release pressure & to stay at same volume, System releases heat)

$4 \to 1$: $W_{41} = \int_4^1 p\,dV$

$$\Delta Q_{41} = \underbrace{\Delta U_{41}}_{=0 \text{ along isotherm}} + \int_4^1 p\,dV = NkT_1 \ln\left(\frac{V_1}{V_4}\right) < 0$$

$\Delta Q_{41} < 0$ → heat flows out of system → contributes to Q_c (not Q_h)

OR you compress system, so put in work, you do work on system. To have system not heat up, ~~the system~~ i.e. to stay on isotherm, System has to give up heat, so heat flows out of engine → contribution to Q_c