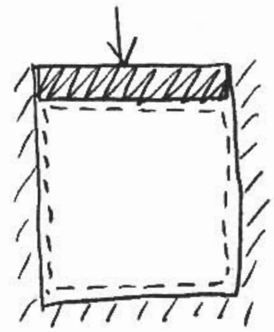
SOLUTIONS TO T4 (WAITZ)

a) QUASI-STATIC, ADIABATIC COMPRESSION



$p_1 = 100\,kPa$, $p_2 = 500\,kPa$

$T_1 = 300\,K$

$$V_1 = \frac{287 \cdot 300}{100{,}000} = 0.861\ \frac{m^3}{kg}$$

$pV^{\gamma} = CONST.$ (FOR WHOLE PROCESS) $\therefore$ $\frac{P_2}{P_1} = \left(\frac{V_1}{V_2}\right)^{\gamma}$ $\quad 5 = \left(\frac{0.861}{V_2}\right)^{1.4}$

$\therefore$ $\boxed{V_2 = 0.273}$

$$T_2 = \frac{500{,}000 \cdot 0.273}{287} = \boxed{475\ K}$$

$\Delta u = \cancel{q}^{0} - w \quad \Delta u = -w, \; C_v \Delta T = -w$

$w = -716.5(475 - 300) = \boxed{-125\ kJ/kg}$

BY THE SYSTEM — NEGATIVE SINCE ENERGY TRANSFERRED TO SYSTEM.

b) INITIAL STATE IS THE SAME.
KNOW $p_f = 500\,kPa$ BUT DON'T KNOW T_f OR V_f

* DON'T KNOW BEHAVIOR OF STATE OF SYSTEM DURING PROCESS → BUT FIRST LAW STILL HOLDS.

* HOWEVER, NOW WE MUST USE EXTERNAL INFORMATION TO RELATE PROPERTIES AT INITIAL AND FINAL STATE

1^{ST} LAW: $\Delta u = \cancel{q}^{\,0} - w$

(STILL INSULATED)

$$C_V \Delta T = -w = -\underset{\sim\sim\sim}{P_{ext} \Delta V}$$

1) $C_V(T_f - T_i) = -P_{ext}(V_f - V_i)$

AND IDEAL GAS LAW HOLDS AT INITIAL CONDITION AND FINAL CONDITION (BUT NOT IN BETWEE)

2) $P_f V_f = R T_f$ WHERE $P_f = P_{ext}$

2 EQNS IN 2 UNKNOWNS (T_f, V_f)

SUBSTITUTING,

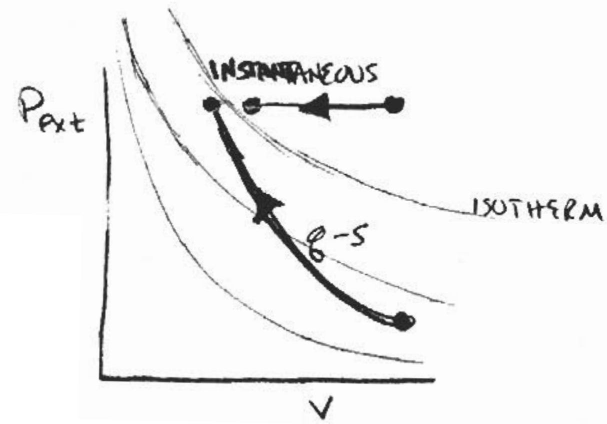
$$T_f = \frac{P_{ext} V_i + C_V T_i}{C_V + R} = \boxed{643.2\,K}$$

$$V_f = \frac{287 \cdot 643.2}{500{,}000} = \boxed{0.369\ m^3/kg}$$

ENDED UP AT A DIFFERENT STATE!

$$W = -C_V \Delta T = -716.5(643.2 - 300) = \boxed{-245.9\ kJ/kg}$$

c)



LESS WORK REQUIRED TO COMPRESS THE GAS TO THE SAME PRESSURE VIA A Q-S PROCESS. ∴ MORE EFFICIENT