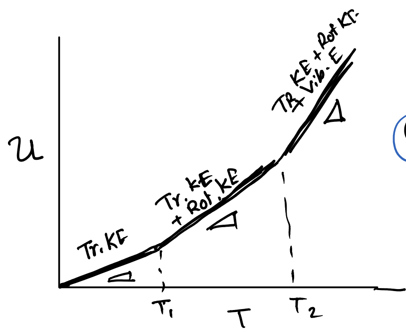
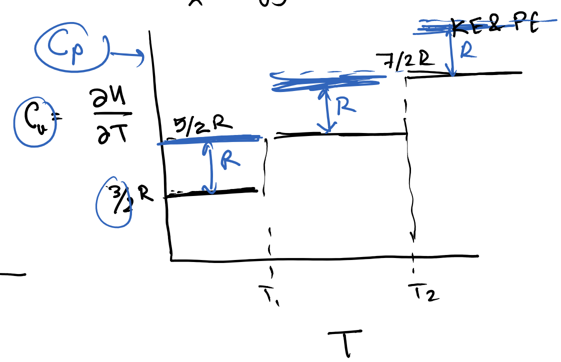
U = internal energy = manifestation of translational k.E. of the molecules + rotational kinetic energy + vibration en.





$$\boxed{C_p - C_v = R}$$

For an ideal gas C_p & C_v are pure functions of T ONLY.

① Collision is elastic

② Vol. of molecules <<<< total vol.

③ No interaction betn. the molecules except elastic collision

-es

$$\boxed{U = f(T, p \text{ or } V)}$$

Sp. Heat ⇒ $C_n = \frac{Q}{m(T_2 - T_1)} = C_v\left(\frac{k-n}{1-n}\right)$

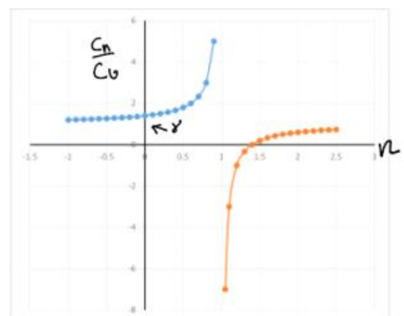
$$\boxed{\frac{C_n}{C_v} = \left(\frac{k-n}{1-n}\right)}$$

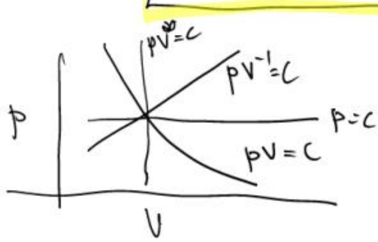
If $n < k$
$n > 1$
$\boxed{1 < n < k}$

$n = 1.3$

$pV^{-1} = C$
$pV = C$

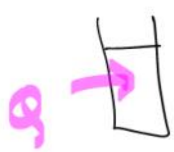
$$\boxed{\frac{C_n}{C_v} = \frac{0.1}{-0.3}} = -0.33$$



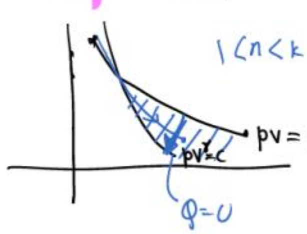


plot of C_n/C_v against n
For $n = 1$, C_n is indeterminate
For $1 < n < \gamma$, C_n is -ve
For $n = 0$ $C_n/C_v = \gamma$

$Q = 10$ kJ
$W = 12$ kJ
$$\boxed{Q - W = -2 \text{ kJ}}$$



ΔT is -ve



⇒ $\boxed{Q = W}$

$n > 1$
$n < k$

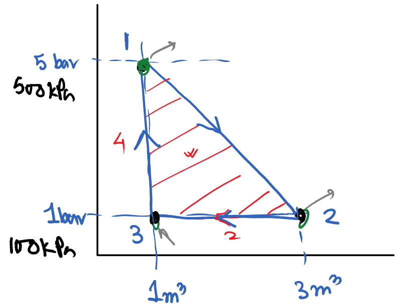
Pr. An ideal gas M = 100 executes an internally reversible cycle

Find ① Heat addition to the cycle

Pr. An ideal gas M = 100 executes an internally reversible cycle

Find
1. Heat addition to the cycle
2. Net work done
3. η of the cycle where $\eta = \frac{W_{net}}{Q_+}$

Assume $\gamma = 1.5$



	Q (kJ) $mC_p\Delta T$	W (kJ)	ΔU (kJ) $mC_v\Delta T$
1–2	200	600	−400
2–3	−600 $mC_p\Delta T$	−200	−400
3–1	800	0	+800
	400	400	0

$\Delta U = mC_v \Delta T$

$$W = \text{Area of } \Delta 123 = \frac{1}{2} \times 2 \times 400 \ \ m^3 \cdot kPa = 400 \text{ kJ}$$

Find T_1, T_2 & T_3

$$C_p - C_v = R$$
$$C_p/C_v - 1 = \frac{R}{C_v}$$
$$(\gamma - 1) = R/C_v \Rightarrow C_v = \frac{R}{\gamma - 1}$$

$$pV = mRT$$
$$T_1 = \frac{p_1V_1}{mR} = \frac{500}{mR}$$
$$T_2 = \frac{300}{mR}$$
$$T_3 = \frac{100}{mR}$$

$$R = \frac{R_u}{M} = \frac{8.315}{100} = 0.08315 \text{ kJ/kg K}$$
$$C_v = \frac{R}{(\gamma - 1)} = \frac{0.08315}{0.5} = 0.1663 \frac{kJ}{kg K}$$
$$C_p = C_v \times \gamma = 0.249 \text{ kJ/kgK}$$

$$\boxed{C_v = 2R}$$

$$\boxed{\Delta U = mC_v \Delta T} \Rightarrow U_2 - U_1 = m(2R)(T_2 - T_1) = (2mR)\left(\frac{-200}{mR}\right) = -400$$

$$U_3 - U_2 = m(2R)(T_3 - T_2) = 2\cancel{mR}\left(-\frac{200}{\cancel{mR}}\right) = -400 \text{ kJ}$$

$$U_1 - U_3 = m \times 2R \times (T_1 - T_3) = 2\cancel{mR} \times \frac{400}{\cancel{mR}} = 800 \text{ kJ}$$

$$Q_+ = 1000 \text{ kJ}, \quad W_{net} = 400 \text{ kJ} \quad \boxed{\eta = 0.4}$$

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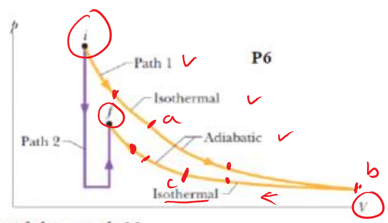
6. Figure P6 shows two paths that may be taken by a gas from an initial point i to a final point f. Path 1 consists of an isothermal expansion (work is 50 J in magnitude), an adiabatic expansion (work is 40 J in magnitude), an isothermal compression (work is 30 J in magnitude), and then an adiabatic compression (work is 25 J in magnitude). What is the change in the internal energy of the gas if the gas goes from point i to point f along path 2?



P6

$(U_f - U_i)$

| Q | W | ΔU |

$(U_f - U_i)$

energy of the gas if the gas goes from point *i* to point *f* along path 2?

	Q	W	ΔU	
i – a		+50	0	$U_a - U_i$
a – b	0	+40	−40	$U_b - U_a$
b – c		−30	0	$U_c - U_b$
c – f	0	−25	+25	$U_f - U_c$
			−15	

$U_f - U_c = -15$ J

$(U_f - U_i)$

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7. 4.4 kg of CO_2 gas is expanded quasi-statically in a piston cylinder device at constant pressure of 1.0 MPa until its volume increases from 0.4 m^3 to 0.8 m^3. Then the piston is pinned (fixed) and the gas is cooled until its pressure drops to half of the initial value. Finally, the gas is compressed quasi-statically following a polytropic process back to the initial state. Find the (i) exponent of the polytrope, and (ii) the work done by the gas during the cycle. Also, identify the process(es) during which heat rejection will take place, and calculate the heat rejection(s). Assume $C_p/C_v = 1.26$ for CO_2.

$m = 4.4$ kg $\gamma = 1.26$, $R = \frac{8.315}{44}$ kJ/kg K

$n = ?$

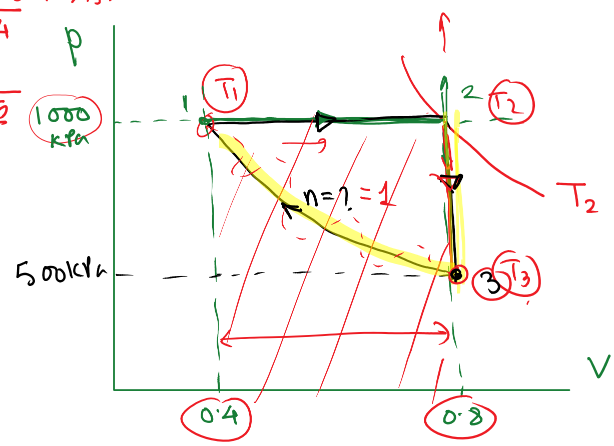
$W_{net} = ?$

$Q_{-ve} = ?$

$T_1 = \frac{P_1 V_1}{mR} = \frac{1000 \times 0.4}{4.4 \times \frac{8.315}{44}} = 481$ K

$T_2 = 962$ K

$T_3 = 481$ K



	Q	W	ΔU
1 – 2	940.5	400	+540.5
2 – 3	−540.5	0	−540.5
3 – 1	? −277	? −277	0

isothermal $Q - W = 0 \Rightarrow Q = W$

$W = P V \ln \frac{V_1}{V_3}$

$= 400 \ln 0.5 \Rightarrow$

$=$

$\Delta U = m C_v \Delta T$

$= m \frac{R}{\gamma - 1} \Delta T$

$= 4.4 \times \frac{8.315}{44} \times \frac{1}{0.74} \Delta T$

$= 1.12 \Delta T$