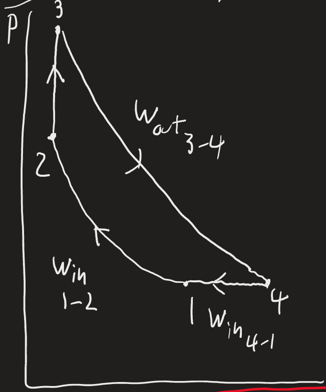
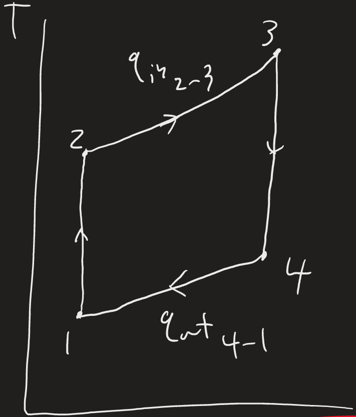
Homework 1.2

Monday, January 22, 2024 1:11 PM

9-13

a)





$$\rightarrow 1 \xrightarrow{\text{Isentropic}} 2 \xrightarrow{v = \text{const}} 3 \xrightarrow{\text{Isentropic}} 4 \xrightarrow{P = \text{const}}$$

1
$P_1 = 100\,kPa$
$T_1 = 295\,K$
$V_1 = \frac{RT_1}{P_1} = 24.93\,m^3$

2
$P_2 = 600\,kPa$
$T_2 = 490\,K$
$V_2 = 6.79\,m^3$
$\frac{P_2}{P_1} = \frac{P_{r_2}}{P_{r_1}}$

3
$T_3 = 1500\,K$
$V_3 = 6.79\,m^3$
$P_3 = \frac{RT_3}{V_3}$
$P_3 = 1837\,kPa$

4
$P_4 = 100\,kPa$
$T_4 = 910\,K$
$V_4 = \frac{RT_4}{P_4}$
$V_4 = 75.67$

$$\frac{600}{00} = \frac{P_{r2}}{1.3068}$$

$$P_{r2} = 7.8408$$

$$\approx T_2 = 490K$$

$$V_2 = \frac{RT_2}{P_2}$$

$$\frac{P_4}{P_3} = \frac{P_{r4}}{P_{r3}}$$

$$\frac{100}{1832} = \frac{P_{r4}}{1475}$$

$$P_{r4} = 80.3$$

$$\approx T_4 = 910K$$

b) $W_{net} = W_{in_{1-2}} + W_{in_{4-1}} - W_{out_{3-4}}$

$$W_{in_{1-2}} = \frac{R(T_2 - T_1)}{K-1}$$

$$= \frac{8.314(490-295)}{1.4-1}$$

$$= 4053.32$$

$$W_{in_{4-1}} = P(V_4 - V_1)$$

$$= 100(75.67 - 24.53)$$

$$= 5114$$

$$Wat_{3-4} = \frac{R(T_3 - T_4)}{1.4-1}$$

$$= \frac{8.3145(1500-910)}{1.4-1}$$

$$= 4905.555$$

$$W_{net} = 4053.32 + 5114 - 4905.555$$

$$W_{net} = 4261.8 \text{ kJ/kg}$$

( ) $\eta_{th} = \frac{W_{net}}{q_{in}}$

$$q_{in} = U_3 - U_2$$

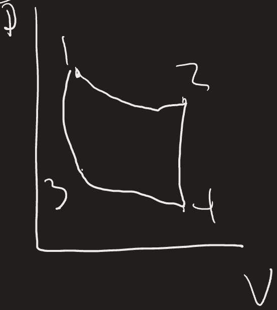
$$= 1205.41 - 352.08$$

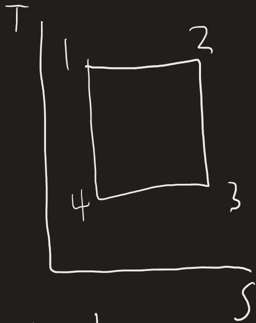
$$= 853.33 \text{ kJ}$$

$$\eta_{th} = \frac{4261.8}{853.33}$$

$$= 4.99$$

9-18





Isothermal

1	2	3	4	1
$T_1 = 1200K$ $P_1 = P_{max}$	$T_2 = 1200K$	$P_3 = 150kpa$ $T_3 = 350K$	$P_4 = 300kpa$ $T_4 = 300K$	

$$P_1 = \frac{P_{r_1}}{P_{r_4}}(P_4)$$

$$P_1 = \frac{238}{2.379}(300)$$

a) $\underline{P_1 = 30 MPa}$

$W_{net} = 0.5\,kJ$

b) $q_{in} = ?$

$$q_{in} = \frac{T_h W_{net}}{T_h - T_L}$$

$$= \frac{1200 \times 0.5}{1200 - 350}$$

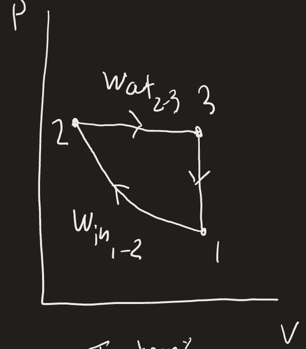
$$\underline{= 0.706\ kJ}$$

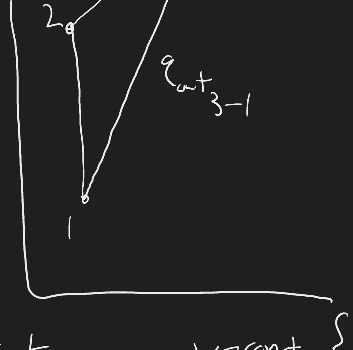
c) $S_1 - S_2 = -0.199\ kJ/kg \cdot K$

$W_{net\ out} = S_2 - S_1\,(T_H - T_L) = 169.15\ kJ/kg$

$$m = \frac{W_{net\ out}}{w_{net\ out}} = \frac{0.5}{169.15} \underline{= 0.00296\ kg}$$

9-22





$$1 \xrightarrow{\text{Isentropic}} 2 \xrightarrow{P=\text{const}} 3 \xrightarrow{V=\text{const}} 1$$

$T_1 = 293\,K$ $T_2 = 584.4\,K$ $T_3 = 2922\,K$

$\frac{V_1}{V_2} = 5$

b)

$\boxed{1\text{-}2}$ $C_p = C_v + R = 0.7 + 0.3 = 1.0\ kJ/kg \cdot K$

$k = \frac{C_p}{C_v} = \frac{1.0}{0.7} = 1.429$

$$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{k-1}$$

$$= 293\,(5)^{0.429} = 584.4\ K$$

$$W_{1-2} = C_v\,(T_2 - T_1) = \underset{\frac{kJ}{kg\cdot K}}{(0.7)}\;\underset{K}{(584.4 - 293)}$$

$$\underline{= 204\ kJ/kg}$$

2-3)

$$T_3 = 584.4\,(5) = 2922\ K$$

$$W_{2-3} = R\,(T_3 - T_2)$$

$$= 0.3\,\frac{kJ}{kg\cdot K}\,(2922 - 584.4)\,K$$

$$\underline{= -701.3\ kJ/kg}$$

$$q_{2-3} = c_p(T_3 - T_2)$$

$$= 1\,\text{kJ/kg}\cdot\text{K}\,(2922 - 584.4)\,\text{K}$$

$$= 2338\,\text{kJ/kg}$$

3-1

$$q_{3-1} = C_v(T_3 - T_1)$$

$$= 0.7\,(2922 - 293)$$

$$= 1840.3\,\text{kJ/kg}$$

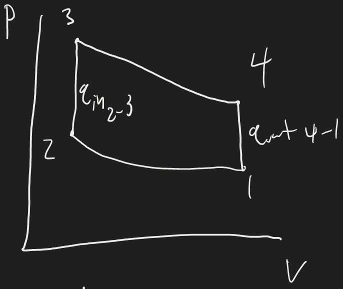
$$w_{3-1} = 0$$

$$w_{net} = 701.3 - 204 = 497.3\,\frac{\text{kJ}}{\text{kg}\cdot\text{K}}$$

$$\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{497.3}{2338} = 0.213$$

$\underline{21.3\%}$

9-31



$$\frac{V_1}{V_2} = 10.5$$

$$\eta_{th} = 1 - \frac{1}{r^{k-1}} = 1 - \frac{1}{10.5^{0.4}} = 0.6096$$

$$= \underline{61\%}$$

$$\dot{Q}_{in} = \frac{\dot{W}_{net}}{\eta_{th}} = \frac{90\text{kW}}{0.6096} = \underline{148\text{kW}}$$