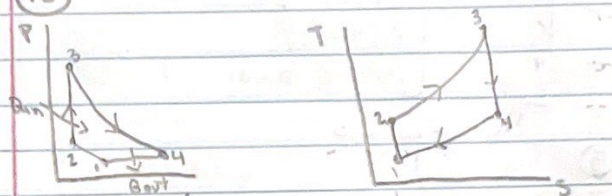
HW 1.2 MET 350 KIANA DAVIES

CHAPTER 9

(13)

a)



1-2 → isentropic comp. from 100 kPa & 22°C to 600 kPa

2-3 → v = const heat addition to 1500 K

3-4 → isentropic expansion to 100 kPa

4-1 → p = const. heat rej. to initial state

* cp cv variable

isentrop ① | v const ② | isentrop ③ | pconst. ④

$s_2 = s_1$ | $P_2 = 600$ kPa | $T_3 = 1500$ K | $P_4 = 100$ kPa

$P_1 = 100$ kPa | $\frac{T_2}{295} = \left(\frac{600}{100}\right)^{\frac{1.4-1}{1.4}}$ | $v_3 = v_2$ | $\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$

$T_1 = 295$ K | $T_2 = 492.21$ | $\frac{P_3}{T_3} = \frac{P_2}{T_2}$ | $T_4 = \left(\frac{100}{1828.5}\right)^{\frac{1.4-1}{1.4}} (1500)$

$PV = RT/P$ | $V_2 = \frac{(.2006)(295\text{K})}{100\text{kPa}} = \frac{600}{492.21} v1500$ | | $T_4 = 653.87$ K

$P_3 = 1828.5$ kPa

$C_P = 1.005$

$C_V = 0.718$

b) $\eta = \frac{W_{net}}{q_{in}} = \frac{q_{in} - q_{out}}{q_{in}}$

$W_{net} = C_v(T_3 - T_2) - C_p(T_4 - T_1)$

$= 0.718(1500 - 492.21) - 1.005(653.87 - 295)$

$W_{net} = \boxed{362.93 \text{ kJ/kg}}$

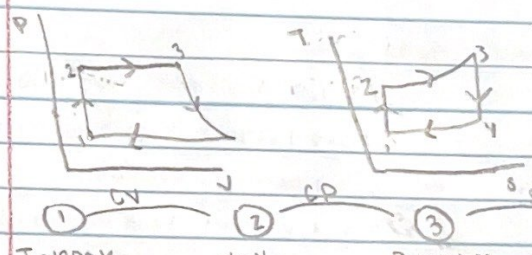
c) $\eta_{TH} = 1 - \frac{C_p}{C_v}\left[\frac{T_4 - T_1}{T_3 - T_2}\right]$

$= 1 - \frac{1.005}{0.718}\left[\frac{653.87 - 295}{1500 - 492.21}\right]$

$= 1 - 1.31\,(358.87/1007.79)$

$\eta_{TH} = .533$ or $\boxed{53.3\ \%}$

9-18



carnot cycle	
$P_{r_1} = 238$ kPa	$w_{net} = 0.5$ kJ
$P_{r_4} = 2.379$	
variable cp, cv	

1 — CV — 2 — CP — 3 — S (const) — 4 — CP

1	2	3	4
$T_1 = 1200$ K	$v_1 = v_2$	$P = 150$ kPa	$T_4 = 350$ K
$P_1 = 150$ kPa	$P_2 = 300$ kPa	$T = 700$	$P_4 = 300$ kPa
$PV = RT$	$v_2 = 0.137$		$v_4 = \frac{RT}{P} = \frac{(0.08206)(1200)}{150}$
$v = \frac{(.08206)(1200)}{150}$	$T_2 = \frac{Pv}{R} = \frac{300 \times 0.1115}{0.08206}$		$v_4 = 0.656$
$v_1 = 0.137$	$T_2 = 700.1$		

a) $P_{max} = \frac{P_{r_1}}{P_{r_4}} = \frac{238}{2.379} \times 300 = 30012.61$ kPa $\rightarrow$ **30.01 mPa**

b) Q_{in}?

$\eta_{TH} = 1 - \frac{T_L}{T_H} = 1 - \frac{350}{1200} = 0.708 \rightarrow 70.8\%$

$\eta_{TH} = \frac{W_{net}}{Q_{in}} \therefore 70.83 = \frac{0.5}{Q_{in}}$ **$Q_{in} = 0.706$ kJ**

c) $w = (s_2 - s_1)(T_H - T_L)$

$= -(-R \ln P_4/P_3)(T_H - T_L)$

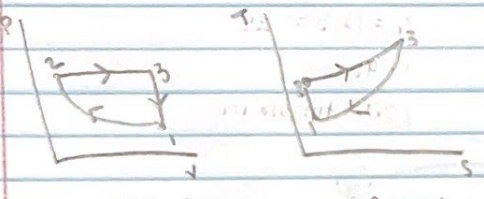
$= 0.287(\ln \frac{300}{150})(1200 - 350)$

$= 169.09$ kJ/kg

$mass = \frac{W_{net}}{w} = \frac{0.5}{169.09} =$ **0.00296 kg**

9-22

a)



constants cp, cv

$c_v = 0.7$ kJ/kg·K $c_p = c_v + R = 1$ kJ/kg·K

$R = 0.3$ kJ/kg·K $k = 1.4$

$r = 5$

① isen. comp ② P const ③ V const

$T_1 = 20 = 293$ K

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

$T_2 = T_1 (r)^{k-1}$

$T_2 = 293 (5)^{1.4-1}$

$T_2 = 584$ K

$\frac{V_2}{T_2} = \frac{V_3}{T_3}$

$T_3 = T_2 \times r$

$T_3 = 2920$ K

b) $Q_{1-2} = \boxed{0 \text{ kJ/kg}}$

$W_{1-2} = c_v(T_1 - T_2) = 0.7(293 - 584) = \boxed{-203.7 \text{ kJ/kg}}$

$Q_{2-3} = c_p(T_3 - T_2) = 1(2920 - 584) = \boxed{2336 \text{ kJ/kg}}$

$W_{2-3} = Q_{2-3} - c_v(T_3 - T_2) = 2336 - 0.7(2920 - 582) = \boxed{700.9 \text{ kJ/kg}}$

$Q_{3-1} = c_v(T_3 - T_1) = 0.7(2920 - 293) = \boxed{1839 \text{ kJ/kg}}$

$W_{3-1} = \boxed{0 \text{ kJ/kg}}$

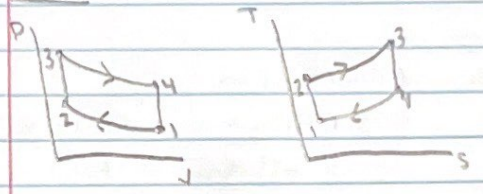
c) $\eta_{TH} = 1 - \frac{Q_{out}}{Q_{in}} \therefore 1 - \frac{Q_{3-1}}{Q_{2-3}}$

$\eta_{TH} = 1 - \frac{1839}{2336} = 0.213 = \boxed{21.3\%}$

d) $\eta = 1 - \frac{c_v(T_3 - T_1)}{c_p(T_3 - T_2)} \therefore 1 - \frac{c_v(5T_2 - T_1)}{c_p(5T_2 - T_2)}$

$\boxed{\eta = 1 - \left(\frac{r^{k-1} - 1}{5r^{k-1}}\right)}$

9-31



Otto cycle

$r_c = 10.5 = \frac{v_1}{v_2}$

P = 90 kW

2500 times/min

$T_1 = 40 = 313\ K$ $\quad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$ $\quad ?$ $\quad ?$

$P_1 = 90\ kPa$ $\quad T_2 = 313(10.5)^{1.4-1}$

$T_2 = 801.7\ k$

a) $\eta_{TH,\,OTTO} = 1 - \frac{1}{r^{k-1}}$

$= 1 - \frac{1}{10.5^{1.4-1}} = 0.61 \rightarrow \boxed{61\%}$

b) $\text{Power} = \frac{W}{T} \therefore \frac{90}{(2500/60)} = W \qquad W = 2.16\ kJ$

$Q = \frac{W}{\eta} = \frac{2.16}{0.61} = \boxed{3.54\ kJ}$