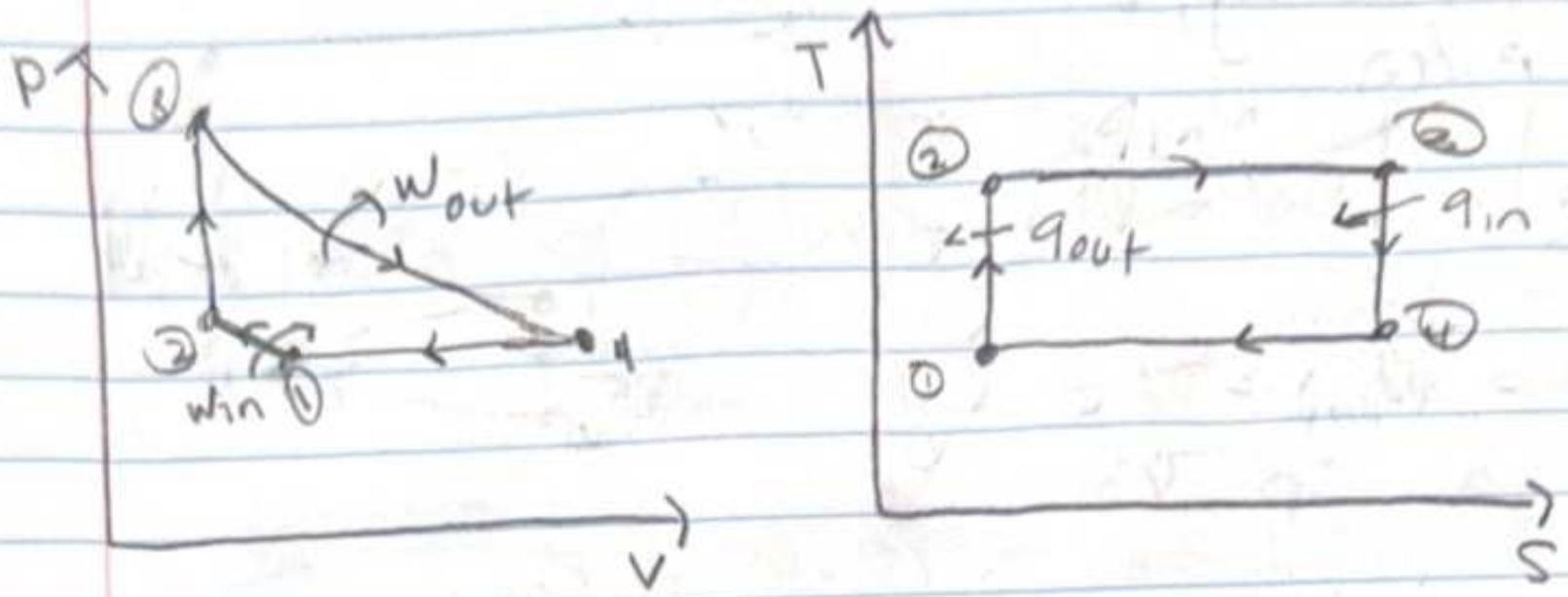
1/27/25
Mizell
Smalls

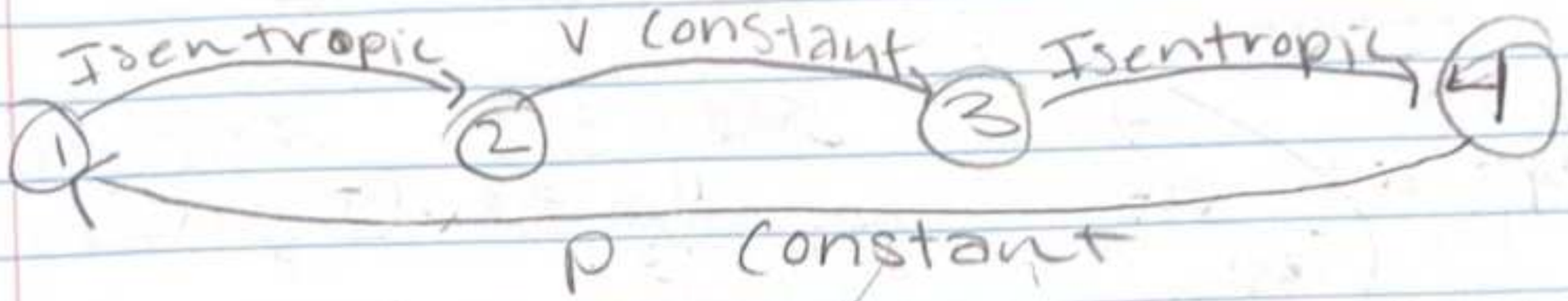
Homework 1.2

9-13



$C_p = 1.005$

$C_v = .718$



* $p_1 = 100 kpa$
* $T_1 = 295.15k$
$V_1 = .847 m^3/kg$

$pV = RT$

$V_1 = \frac{RT_1}{p_1} = \frac{R}{100}(0.287)(295.15)$

* $V_1 = .847$

* $p_2 = 600 kpa$ * $T_3 = 1500k$

$\Delta U = C_v \Delta T$

$\Delta U = 865.2$

$r = \frac{V_4}{V_1} = \frac{.847}{.847} = \frac{V_4}{.847}$

$(.287) = \frac{V_4}{.847}$

$0.243 = V_4$

* $V_2 = .141$ * $V_3 = .141$
* $T_2 = 295.15$ * $p_3 = 3,053.19$

$V_2 = \frac{RT_2}{P_2} = \frac{(.287)(295.15)}{600} = .141$

* $p_4 = 100 kpa$
* $V_4 = 0.243$
* $T_4 = 84.66$

$pV = RT$

$\frac{pV}{R} = T$

$\frac{(100)(.243)}{(.287)} =$

$pV = RT$

$p = \frac{RT}{V}$

$= \frac{(.287)(1500)}{.141}$

$$W_{in}_{1-2} = P_1(V_1 - V_2)$$

$$= 100(.947 - .1411)$$

$$W_{in} = 70.6 kJ/kg$$

$$W_{out} = \int_3^4 PDV = RT_3 \ln\left(\frac{V_4}{V_3}\right) = 234.32$$

$$W_{net} = W_{out} - W_{in}$$

$$= 234.32 - 70.6$$

$$\boxed{W_{net} = 163.72}$$

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

$$\eta_{th} = \frac{163.72}{1016.2}$$

$$\boxed{\eta_{th} = 0.161}$$

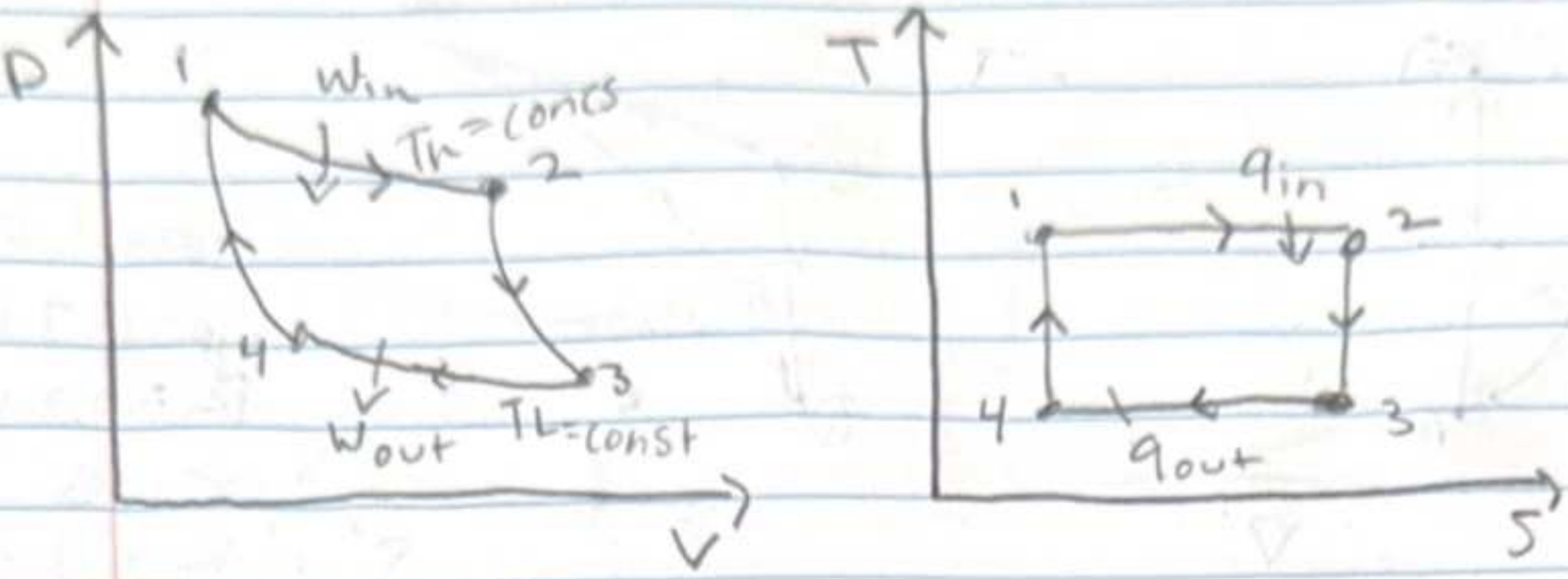
$$q_{in}_{3-4} = Cv(T_3 - T_4)$$

$$= .718(1500 - 84.66)$$

$$= .718(1415.34)$$

$$q_{in} = 1,016.2$$

9-18



1 Isothermal → 2 Isentropic → 3 isothermal → 4

Isentropic comp ←

T1 = 1200K T2 = 1200K T3 = 350K T4 = 350K

P1 = 30,012 P2 = P3 = 150kpa P4 = 300kpa

$W_{net,out} = 0.5kj$

$\frac{P1}{P4} = \frac{Pr_1}{Pr_4}$ → $Pr_1 = 238$, $Pr_4 = 2.379$

$\eta = .287$

$\eta_{th} = 1 - \frac{T_L}{T_H} = 1 - \frac{350K}{1200K} = 0.708$

$q_{in} = W_{net,out} / \eta_{th}$

$= 0.5 / 0.708$

$q_{in} = .7062\ kj$

$P1 = \frac{238}{2.379}(300)$

$P1 = 30{,}012\ kPA$

30 MPA

$PV = RT$

$V = \frac{RT}{P}$ → $\frac{(.287)(1200)}{30{,}012}$

$V1 = 0.0114$

$W_{net} = 0.199(T_H - T_L)$

$W_{net} = 0.199(1200 - 350)$

$= 169.15$

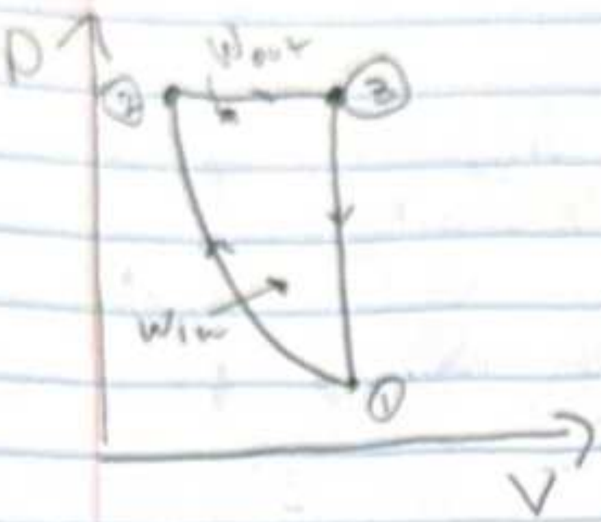
$\Delta S = (S_4 - S_3) - R\ln\left(\frac{P_4}{P_3}\right)$

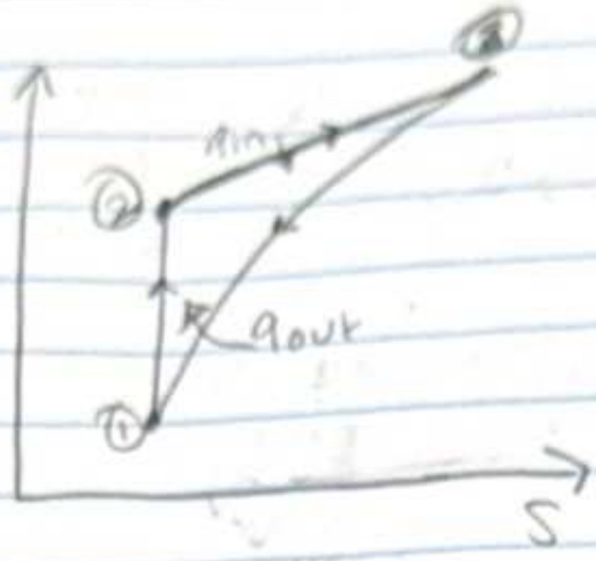
$= -.287 \ln\left(\frac{300}{150}\right)$

$= -0.199\ kj/kg \cdot K$

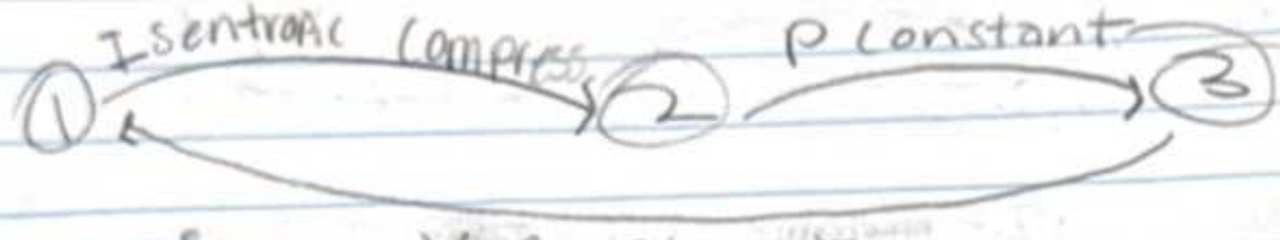
$m = \frac{0.5}{169.15}$ → 0.00295

9-22





$C_p = 1.005$
$C_v = 0.7\ kJ/kg \cdot K$
$R = 0.3\ kJ/kg \cdot K$
$r = 5$
$k = 1.4$



$20°C$
$+273.15$
$T_1 = 293.15K$
$V_1 = 659$
$P_1' = 0.133$

$PV = RT$

$P = \frac{RT}{V}$

$P = \frac{(0.3)(293.15)}{659}$

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

$P_2 = \frac{(0.3)(558.05)}{131.8}$

$T_2 = 558.05$
$V_2 = 131.8$
$P_2 = 1.27$

$V2 = \frac{V1}{6}$

$= \frac{659}{5}$

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

$\frac{T2}{293.15} = \left(\frac{659}{131.8}\right)^{1.4-1}$

$293.15 \cdot \frac{T2}{293.15} = 5^{0.4} \cdot 293.15$

$T1 = 558.05$

$W_{in} = \frac{0.3(558.05 - 293)}{1.4 - 1}$

$T_3 = 2789.76$
$V_3 = 659$
$P_3 = 1.27$

$T3 = \frac{P_3 V_3}{R}$

$T3 = \frac{(1.27)(659)}{0.3}$

$W_{out\ 2-3} = \frac{R(T2 - T3)}{k-1}$

$= \frac{0.3(558.05 - 2789.76)}{1.4 - 1}$

$W_{out} = -1672.7$

$W_{in\ 1-2} = \frac{R(T_2 - T_1)}{k-1}$

$W_{in} = 198.67$

9-22 cont.

$W_{net} = W_{out_{2-3}} - W_{in_{1-2}}$

$= -1673.7 - 198.67$

$W_{net} = 1472.45$

$\eta_{th} = \frac{W_{net}}{q_{in_{2-3}}}$

$= \frac{1872.45}{1962.19}$

$\eta_{th} = 1.19$

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

$= 0.7(2789.76 - 552.05)$

$= 1862.19$

$\eta_{otto} = 1 - \frac{1}{r^{k-1}}$

$= 1 - \frac{1}{0.3^{1.4-1}}$

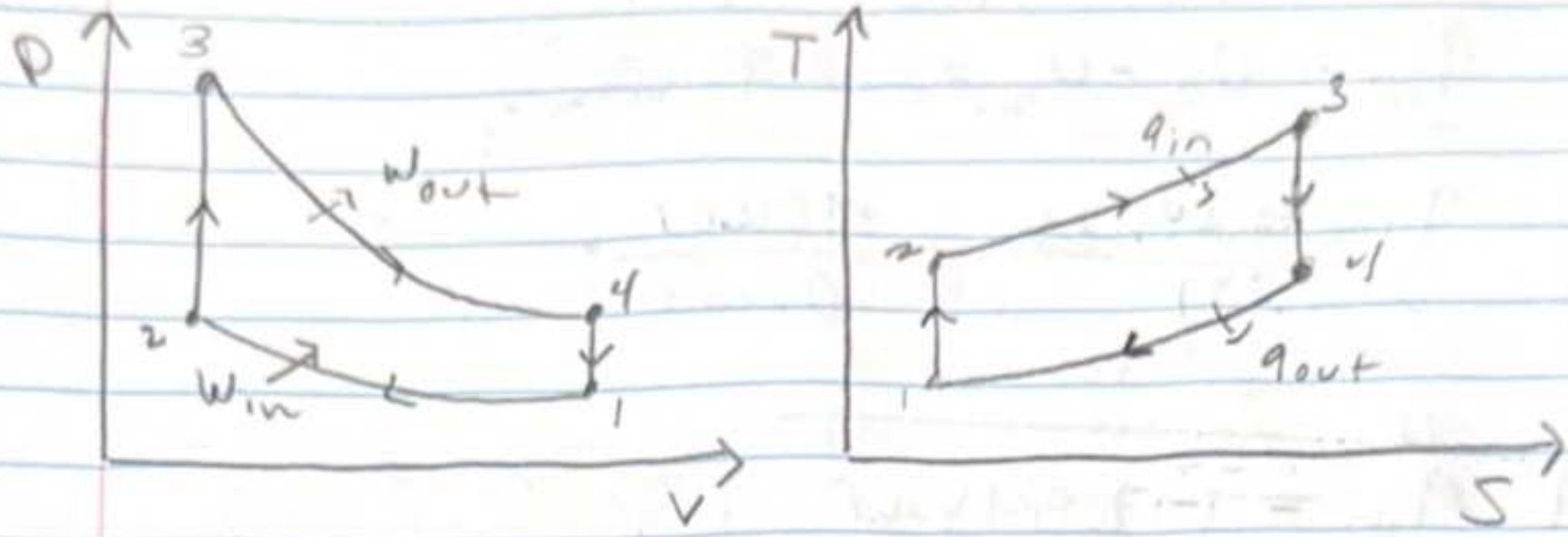
$= 1 - 0.617$

$\eta_{otto} = 0.383$

$W_{out} = -1673.7$

$W_{in} = 198.67$

9-31



r = 10.5

k = 1.4

1 → (Isentropic ↓) 2 → (V const) 3 → (Isentropic ↑) 4 → (V constant) 1

$p_1 = 90kPa$ $p_2 = 2418$ $p_3 = 2418$ $p_4 = 271.32$

$T_1 = 40°C$ $T_2 = 80.5$ $T_3 = 801.54$ $T_4 = 944.19$

$+273.15$ $V_2 = 3.48$ $V_3 = 3.418$ $V_4 = 36.54$

$313.15K$

$V = \frac{RT}{P} = \frac{10.5(313K)}{90K}$ $V2 = \frac{V1}{10.5}$ $T3 = \left(\frac{V_2}{V_3}\right)^{k-1} \cdot T_2$ $V4 = 10.5 V3$

$V1 = 36.52$ $T3 = 1.801.54$

$\eta_{th,otto} = 1 - \frac{1}{r^{k-1}}$ $\eta_{th} = \frac{W_{net}}{q_{in}}$ $T4 = \frac{V_3}{V_4}^{k-1} \cdot T_3$

$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1}$ $= 1 - \frac{1}{10.5^{1.4-1}}$ $P_3 = \frac{RT_3}{V_3}$ $= \frac{3.48}{36.54}^{.4} \cdot 2418$

$T_2 = \left(\frac{36.52}{3.48}\right)^{1.4-1} \cdot 313K$ $= 1 - .391$ $T4 = 944.19$

$T_2 = 801.5$ $\eta_{th,otto} = .609$

$= 60.9\%$ $P4 = \frac{RT_4}{V_4}$

$P_2 = \frac{RT_2}{V_2}$ $= \frac{10.5(944.19)}{36.54}$

$\frac{10.5(801.54)}{3.48} = P_2 = 2418$ $= 271.32$

$$= q_{in_{2-3}} - q_{out_{4-1}} + W_{in_{1-2}} - W_{out_{3-4}} = \Delta U$$

$$q_{in_{2-3}} = U_3 - U_2 = Cv(T_3 - T_2)$$

$$q_{in_{2-3}} = \frac{W_{net}}{\eta_{th}} = \frac{90kW}{0.61}$$

$$\boxed{q_{in_{2-3}} = 147.54kW}$$