2.17

$p = 4 - 10V$ ($p$ in bar en $V$ in $m^3$)

$$W = \int_{V_1}^{V_2} p\,dV = \int_{0.3\,m^3}^{0.1\,m^3} [4 - 10V] \left[\frac{10^5\ N/m^2}{1\ bar}\right] \left[\frac{1\ kJ}{10^3\ Nm}\right] dV$$

$$= [4V - 5V^2]_{0.3}^{0.1} \cdot 10^2 = -40\ kJ]$$

2.36 $m(u_2 - u_1) = Q - W$

$$u_2 = u_1 + \frac{Q - W}{m} = 300\ \frac{kJ}{kg} + \frac{(-1000) - (-200)\ kJ}{20\ kg}$$

$$= 260\ \frac{kJ}{kg}$$

2.41 $W = \int_{V_1}^{V_2} p\,dV$ ; indien $pV^n$ = constant en $n \neq 1$

dan $W = \dfrac{P_2 V_2 - P_1 V_1}{1 - n}$

(sectie 3.0 M.S.S)

$P_1 = 0$ bar $V_1 = 0.02\ m^3$
$P_2 = 2$ bar
$\Big\}$ $V_2 = \left(\frac{P_1}{P_2}\right)^{1/1.2} = 0.0635\ m^3$

$$W = \frac{(2\ bar)(0.0635\ m^3) - (0)(0.02)}{1 - 1.2} \left[\frac{10^5\ N/m^2}{1\ bar}\right] \left[\frac{1\ kJ}{10^3\ Nm}\right]$$

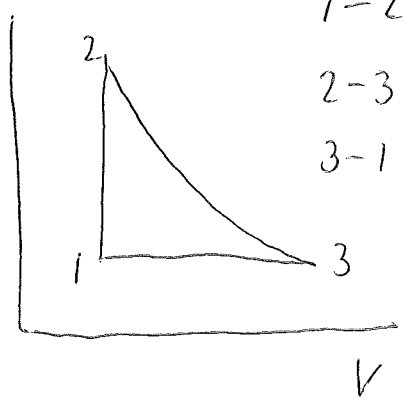
$= 16.5\ kJ]$

$$Q = m\Delta u + W = (0.25\ kg) \cdot (-55\ kJ/kg) + 16.5\ kJ]$$

$= 2.75\ kJ]$

## 2.49

a)




1-2 : $V = 0.020\ m^3$ $\quad U_2 - U_1 = 26.4\ kJ$

2-3 : $pV = \text{constant}$ $\quad U_3 = U_2$

3-1 : $p = 1.4\ bar$ $\quad W_{31} = -10.5\ kJ$

$$W_{23} = \int_{V_2}^{V_3} p\,dV = \int_{V_2}^{V_3} \frac{C}{V}\,dV = C \ln \frac{V_3}{V_2} = p_3 V_3 \ln \frac{V_3}{V_2} \quad ; V_2 = V_1$$

$$W_{31} = \int_{V_3}^{V_1} p\,dV = p(V_1 - V_3) \Rightarrow V_3 = V_1 - \frac{W_{31}}{p}$$

$$\text{dus } V_3 = 0.020\ m^3 - \left(\frac{-10.5\ kJ}{1.4\ bar}\right)\left(\frac{1\ bar}{10^5\ N/m^2}\right)\left(\frac{10^3\ Nm}{1\ kJ}\right)$$

$$= 0.103\ m^3$$

$$W_{23} = (1.4\ bar)\left(\frac{10.5\ N/m^2}{1\ bar}\right)(0.103\ m^3) \ln \frac{0.103}{0.020} = 10.70\ kJ$$

b) $W_{cycle} = 0 + 10.70 - 10.5 = 0.20\ kJ$

c) $Q_{23} = W_{23}$

d) $U_1 - U_3 = Q_{31} - W_{31} \Rightarrow Q_{31} = (U_1 - U_3) + W_{31}$

$(U_2 - U_1) + (U_3 - U_2) + (U_1 - U_3) = 0 \Rightarrow U_1 - U_3 = -26.4\ kJ$

$Q_{31} = -26.4 + (-10.5) = -36.9\ kJ$

3.16

$P_1 = 7$ bar

$T_1 = 500\,^\circ C$

$V = 1\ m^3$

Uit tabel A-4 volgt dat $T_{sat} = 164{,}97\,^\circ C$

$\Rightarrow$ alles in damp

het ~~molaire~~ specifieke volume is $v = 0.5070\ m^3/kg$

Uit tabel A2 $T_a = T_{sat}@v_a = 140\,^\circ C$

Bij 0.5 bar: $V_f = 1.03 \cdot 10^{-3}\ m^3$

$V_g = 3.24\ m^3$

$$x_2 = \frac{V_g - V_f}{V_g - V_f} = \frac{0.507 - 1.03 \cdot 10^{-3}}{3.24 - 1.03 \cdot 10^{-3}} = 0.1567$$

dus fractie gecondenseerd $= 1 - 0.1567 = 0.8430$

totale massa: $m = \frac{V}{v_1} = \frac{1\ m^3}{0.507\ m^3/kg} = 1.972\ kg$

volume liquid $= 1.972 \cdot 1.03 \cdot 10^{-3}\ m^3/kg = 0.00203\ m^3$

3.63

$M = 33\ kg/kmol$

$p_1 = 3\ bar$ $\qquad pV^n = constant;\ n = 1.3$

$T_1 = 300\ K$

$V_1 = 0.1\ m^3$

$c_V = 0.6 + 2.5 \cdot 10^{-4} T \left[\frac{kJ}{kg\,K}\right]$

$\Delta U = Q - W$

(1) $W = \int_{V_1}^{V_2} p\,dV = \frac{P_2 V_2 - P_1 V_1}{1-n} = \frac{mR(T_2 - T_1)}{1-n}$

(2) $\Delta U = m \int_{T_1}^{T_2} c_V(T)\,dT = m\left[(0.6)(T_2 - T_1) + \left(\frac{2.5 \cdot 10^{-4}}{2}\right)(T_2^2 - T_1^2)\right]$

$$m = \frac{P_1 V_1}{R T_1} = \frac{(3\ bar)(0.1\ m^3)}{\left(\frac{8.314}{33}\right)\left(\frac{kJ}{kg\,K}\right)(300\,K)} \cdot \left[\frac{10^5\ N/m^2}{1\ bar}\right]\left[\frac{1\ kJ}{10^3\ N\,m}\right]$$

$$= 0.397\ kg$$

$T_2$ oplossen uit (1) en (2) met $m = 0.397\ kg$

levert $T_2 = 243.7\ K$

b) $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} \Rightarrow P_2 = \left(\frac{T_2}{T_1}\right)^{n/n-1} P_1 = 1.219\ bar$

c) $\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1} \Rightarrow V_2 = \left(\frac{P_1}{P_2}\right)^{1/n} V_1 = 0.1999\ m^3$

d) $$W = \frac{mR(T_2 - T_1)}{1-n} = \frac{0.397\ kg \cdot \frac{8.314}{33}\ \frac{kJ}{kg\,K}\,(243.7 - 300)}{1 - 1.3}$$

$$= 10.7\ kJ$$

4.29

$$\frac{dm_{cv}}{dt} = 0 = \dot{m}_1 - \dot{m}_2 - \dot{m}_3 \Rightarrow \dot{m}_3 = \dot{m}_1 - \dot{m}_2$$

tabel A4 $\Rightarrow v_1 = 0.0994\ m^3/kg$

$$\dot{m}_1 = \frac{(AV)_1}{v_1} = \frac{25\ m^3/min}{0.0994\ m^3/kg}\left[\frac{1\ min}{60\ s}\right] = 14.25\ kg/s$$

$$\frac{dE_{cv}}{dt} = 0 = \underset{0}{\dot{Q}_{cv}} - \dot{W}_{cv} + \dot{m}_1 h_1 - \dot{m}_2 h_2 - \dot{m}_3 h_3$$

dus $0 = -\dot{W}_{cv} + \dot{m}_1 h_1 - \dot{m}_2 h_2 - \dot{m}_3 h_3$

$= -\dot{W}_{cv} + \dot{m}_1 (h_1 - h_3) - \dot{m}_2 (h_2 - h_3)$

met gegevens uit tabel A4

$$\dot{m}_2 = \frac{-11400\ kW\left[\frac{1\ kJ/s}{1\ kW}\right] + \left(14.25\ \frac{kg}{s}\right)(3230.9 - 2375.0)\ \frac{kJ}{kg}}{(2012.0 - 2375.0)\ kJ/kg}$$

$= 3.000\ kg/s = 11000\ kg/h$

$\dot{m}_3 = \dot{m}_1 - \dot{m}_2 = 40.212\ kg/hr$

$$A_2 = \frac{\dot{m}_2 v_2}{V_2} = \frac{3.000\ \frac{kg}{s}\ 0.4045\ m^3/kg}{20\ m/s} = 0.0623\ m^2$$

$$d_2 = \sqrt{\frac{4 A_2}{\pi}} = 0.702\ m$$