\[
\begin{align*}
\Delta h_{12} &= h_2 - h_1 = 232 - 230 = 2 \text{kJ/kg} \\
\Delta KE_{12} &= \frac{C_2^2 - C_1^2}{2000} = \frac{(91)^2 - (15)^2}{2000} \\
&= 4.028 \text{kJ/kg} \\
\Delta PE_{12} &= \frac{g(z_2 - z_1)}{1000} \\
&= \frac{9.81(3.35 - 58)}{1000} = -0.54 \text{kJ/kg}
\end{align*}
\]

\[
\begin{align*}
q_{12} - w_{12} &= \Delta h_{12} + \Delta KE_{12} + \Delta PE_{12} \\
-10 - w_{12} &= 2 + 4.028 + (-0.54) \\
w_{12} &= 16.955 \text{kJ/kg} \\
W &= m \cdot \omega_{12} = 1 \times 16.955 = 16.955 \frac{\text{kJ}}{\text{s}} \\
&= 1017.3 \text{kJ/min}.
\end{align*}
\]

\[
\begin{align*}
\begin{array}{c}
h_1 = \mu_1 + P_1v_1 = 2400 + 600 \times 0.3 \\
&= 2580 \text{kJ/kg} \\
h_2 = \mu_2 + P_2v_2 = 1800 + 160 \times 0.9 \\
&= 1944 \text{kJ/kg} \\
\Delta h &= h_2 - h_1 = 1944 - 2580 \\
&= -636 \text{kJ/kg} \\
\Delta KE &= \frac{C_2^2 - C_1^2}{2000} = \frac{80^2 - 250^2}{2000} \\
&= -28.05 \text{kJ/kg} \\
z_2 &= z_1 - 15
\end{array}
\end{align*}
\]

\[
\begin{align*}
\Delta PE &= \frac{g(z_2 - z_1)}{1000} \\
&= \frac{9.81(z_2 - 15 - z_1)}{1000} = -0 \\
&= -0.147 \text{kJ/kg} \\
-w &= \Delta h + \Delta KE + \Delta PE - q_{12} \\
w &= -\Delta h - \Delta KE - \Delta PE + q_{12} \\
&= (-636) - (-28.05) - (-0.147) + \left( \frac{120}{415} \right) \\
&= 637.53 \text{kJ/kg} \\
W &= m \cdot w = 4.5 \times 637.53 \\
&= 2868.887 \text{kW}
\end{align*}
\]
\[
\Delta \text{KE} = -\Delta h = -C_p(T_2 - T_1) \\
= \frac{R\gamma}{\gamma - 1}(T_1 - T_2)
\]
\[
\frac{300^2 - 900^2}{2000} = 0.289 \times 1.4(273 - T_2) \\
T_2 = 629 \text{ K}
\]

\[
P_2 = P_1\left(\frac{T_2}{T_1}\right)^{\gamma - 1} = 140\left(\frac{629}{273}\right)^{1.4 - 0.4}
\]
\[
= 2590 \text{ kN/m}^2
\]
\[
\Delta \mu_{12} = C_v(T_2 - T_1) \\
= 0.717 \times 356 \\
= 255 \text{ kJ/kg}
\]

\[
\Delta h = (\mu_1 - \mu_2) + (P_1v_1 - P_2v_2) = (2100 - 1500) + (620 \times 0.37 - 130 \times 1.2)
\]
\[
= 673 \text{ kJ/kg}
\]

\[
\Delta \text{KE} = \frac{C_1^2 - C_2^2}{2} = \frac{300^2 - 150^2}{2 \times 10^3}
\]
\[
= 33.75 \text{ kJ/kg}
\]

\[
w = \Delta h + \Delta \text{KE} - q \\
= 673 + 33.75 - 30 = 676.75 \text{ KJ/Kg}
\]
\[
W = w \cdot m = 676.75 \times 4 \\
= 2707 \text{ kW}
\]
(6.14)

\[ \eta_b = \frac{Q_{12}}{Q_{in}} = \frac{\dot{m}_s \cdot q_{12}}{\dot{m}_f \cdot LCV} = \frac{\dot{m}_s (h_2 - h_1)}{\dot{m}_f \cdot LCV} \]

\[ \dot{m}_s = \frac{\eta_b \cdot \dot{m}_f \cdot LCV}{h_2 - h_1} = \frac{0.8 \times 3000 \times 28000}{2700 - 280} = 2776.6 \text{ kg/h} \]

(6.15)

\[ \begin{align*}
\text{a)} \quad w_{12} &= -\Delta \mu_{12} = \mu_1 - \mu_2 = 2946 - 2722 = 224 \text{ kJ/kg} \\
\text{b)} \quad w_{12} &= -\Delta h_{12} = h_1 - h_2 = 3248 - 2958 = 290 \text{ kJ/kg} \\
\text{c)} \quad C_2 &= \sqrt{2000 \times \Delta h} = \sqrt{2000 \times 290} = 761.6 \text{ m/s} 
\end{align*} \]
\[
\Delta h = h_2 - h_1 = 2200 - 165 = 2035 \text{ kJ/kg}
\]
\[
\Delta KE = \frac{C_2^2 - C_1^2}{2000} = 32^2 - 13^2 = 0.43 \text{ kJ/kg}
\]
\[
\Delta PE = g \Delta Z = 9.81 \times 16 \times 10^{-3} = 0.157 \text{ kJ/kg}
\]
\[
q = \Delta h + \Delta KE + \Delta PE = 2035 + 0.43 + 0.157 = 2035.6 \text{ kJ/kg}
\]
\[
0.65Q = m \cdot q = 1000 \times 205.6
\]
\[
Q = \frac{2.056 \times 10^6}{0.65} = 3.13 \times 10^6 \text{ kJ/h}
\]
\[
\dot{m}_f = \frac{Q}{CV} = \frac{3.13 \times 10^6}{32000} = 97.86 \text{ kJ/h}
\]

\[
h_2 = q_{12} + h_1 = 3500 + 112 = 3612 \text{ kJ/kg}
\]
\[
H_2 = \dot{m}h_2 = 5.5 \times 3612 = 19866 \text{ kW}
\]
\[
W_{23} = \Delta H_{23} = H_3 - H_2
\]

(189)
\[
\dot{Q}_c = m_c \Delta h_c = 35(255 - 2200)
= -68075 \text{ kJ/min}
\]
\[
\dot{Q}_w = m_w \Delta h_w = 730 \times 92
= 67160 \text{ kJ/min}
\]
\[
\dot{Q}_o = 68075 - 67160 = 915 \text{ kJ/min}
\]

\[
q_{12} = (h_2 - h_1) + \frac{C_2^2 - C_1^2}{2000}
= (162 - 2400) + \frac{6^2 - 366^2}{2000} = -2305 \text{ kJ/kg}
\]
\[ Q_{12} = \dot{m}_w \cdot C_p \cdot \Delta T \]
\[ = 10.4 \times 4.187 \times (15 - 7) \]
\[ = 348.5 \text{ kJ/min} \]
\[ W_{12} = \dot{Q} \cdot \eta_{\text{motor}} = \]
\[ = 18 \times 0.84 \times 60 \]
\[ = 907 \text{ kJ/min} \]
\[ m_1 = \frac{P_1 V_1}{RT_1}, \quad m_2 = \frac{P_2 V_2}{RT_2} \]
\[ \dot{m}_a = \frac{1}{5} (m_2 - m_1) = \frac{1}{5} \left( \frac{P_2 V_2}{RT_2} - \frac{P_1 V_1}{RT_1} \right) \]
\[ = \frac{V}{5R} \left( \frac{P_2}{T_2} - \frac{P_1}{T_1} \right) = \frac{1.2}{5 \times 0.287} \left( \frac{1270}{522} - \frac{330}{285} \right) \]
\[ = 2.4 \text{ kg/min} \]
\[ \Delta h = h_2 - h_1 = (\mu_2 + P_2 v_2) - (\mu_1 + P_1 v_1) \]
\[ = 88 + (490 \times 0.16 - 100 \times 0.85) \]
\[ = 81.4 \text{ kJ/kg} \]

\[ \Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{4.5^2 - 6^2}{2000} \]
\[ = -0.00787 \text{ kJ/kg} \]

\[ q = \frac{\dot{Q}}{m} = \frac{59}{0.4} = 147.5 \text{ kJ/kg} \]

\[ w = -[\Delta h + \Delta KE - q] \]
\[ = -[81.4 + (-0.00787 - 147.5)] \]
\[ w = -228.9 \text{ kJ/kg} \]

\[ W = m \times w = 0.4 \times 223.9 \]
\[ = 91.56 \text{ kW} \]

\[ A_1 = \frac{m \times v_1}{C_1} = \frac{0.4 \times 0.85}{6} = 0.057 \text{ m}^2 \]

\[ A_2 = \frac{m \times v_2}{C_2} = \frac{0.4 \times 0.16}{4.5} = 0.014 \text{ m}^2 \]

\[ Q = 60 \times 0.3 = 18 \text{ kW} \]

\[ W = 60 \times 0.6 = 36 \text{ kW} \]

\[ Q - W = \Delta H = mC_p(T_2 - T_1) \]
\[ - 18 - (-36) = 0.5 \times 1.005 \times (T_2 - 293) \]

\[ T_2 = 365K = 92^\circ \text{C} \]
The air at 20°C and 100 kPa enters the tube at 50 m/s. It is heated to 120 m/s and passes through a pipe with a cross-sectional area of 5 cm². The temperature at the end of the pipe is 10% higher than the inlet temperature. Calculate:

\[ R = 0.287 \text{ kJ/kg.K} \]

\[ \hat{C}_p = 1.004 \text{ kJ/kg.K} \]

\[ R = 0.287 \text{ kJ/kg.K} \]

\[ \hat{C}_p = 1.004 \text{ kJ/kg.K} \]

The mass flow rate of the air is

\[ m_{in} = \frac{A_1 C_1}{v_1} = \frac{A_1 C_1 P_1}{RT_1} \]

\[ m_{in} = \frac{9 \times 10^{-3} \times 50 \times 100}{0.287 \times 293} \]

\[ m_{in} = 0.535 \text{ kg/s} \]

\[ m_{in} = 0.535 = m_o = \frac{A_2 C_2 P_2}{RT_2} \]

\[ T_2 = \frac{A_2 C_2 P_2}{m_o R} \]

\[ T_2 = \frac{5 \times 10^{-4} \times 120 \times 10^3}{0.535 \times 0.287} \]

\[ T_2 = 390.8 \text{ K} \]

\[ T = \hat{Q} - W = \Delta H + \Delta KE \]

\[ = m \left[ C_p (T_2 - T_1) + \frac{C_2^2 - C_1^2}{2} \right] \]

\[ 0.1\hat{W} = 0.535 \left[ 1.004 \times (390.8 - 293) + \frac{120^2 - 50^2}{2 \times 10^3} \right] \]

\[ \hat{Q}_o = 10\% \hat{W}_{in} \]

\[ P_2 = 1 \text{ MPa} \]

\[ C_2 = 120 \text{ m/s} \]

\[ A_2 = 5 \text{ cm}^2 \]

\[ P_1 = 100 \text{ kPa} \]

\[ t_1 = 20 \text{ °C} \]

\[ C_1 = 50 \text{ m/s} \]

\[ A_1 = 90 \text{ cm}^2 \]

\[ W = \frac{0.535}{0.9} \left[ 98.2 + 5.95 \right] = -62 \text{ kW} \]
\[
\dot{m} = \frac{AC}{\nu} \Rightarrow \dot{m} = AC \Rightarrow \dot{V} = AC
\]

\[
C_1 = \frac{\dot{V}_1}{A_1} = \frac{50 \frac{L}{s} \cdot 1m}{\pi \cdot 0.15^2 / 1000L} = 2.83 \frac{m}{s}
\]

\[
C_2 = \frac{\dot{V}_2}{A_2} = \frac{50 \cdot 10^{-3}}{\pi \cdot 0.18^2 / 4} = 1.96 \frac{m}{s}
\]

\[
\dot{m} = \frac{\dot{V}}{\nu} = 8. \dot{V} = 10^3 \cdot 50 \cdot 10^{-3} = 50 \frac{kg}{s}
\]

\[
-W = \dot{m} \left[ C_v(T_2 - T_1) + \frac{C_2^2 - C_1^2}{2000} + \frac{g\Delta Z}{1000} \right]
\]

\[
W = -60kW
\]

\[
\dot{V} = 50 L/s
\]

\[
t_1 = 20^\circ C
\]

\[
D_1 = 15 cm
\]

\[
\Delta Z = 100m
\]

\[
(-60) = 50 \left[ 4.2(T_2 - 293) + \frac{1.96^2 - 2.83^2}{2000} + \frac{9.81 \cdot 100}{1000} \right]
\]

\[
T_2 = 293.05 K = 20.05^\circ C
\]

\[
\dot{m} = \delta_w \cdot \dot{V} = 10^3 \frac{kg}{m^3} \cdot 0.015 \frac{m^3}{s} = 15 \frac{kg}{s}
\]

\[
C_1 = \frac{\dot{m}}{\delta A_1} = \frac{15}{10^3 \cdot \pi \cdot (0.15)^2 / 4} = 0.85 \frac{m}{s}
\]

\[
C_2 = \frac{\dot{m}}{\delta A_2} = \frac{15}{10^3 \cdot \pi \cdot (0.2)^2 / 4} = 0.48 \frac{m}{s}
\]

\[
W_{sh,in} = \dot{m} \left[ C_w\Delta T + \frac{C_2^2 - C_1^2}{2000} + \frac{g(Z_2 - Z_1)}{1000} \right]
\]

\[
W_{sh,in} = 15 \left[ 4.2 \cdot 1 + \frac{(0.48)^2 - (0.85)^2}{2000} + \frac{9.81 \cdot 65}{1000} \right] = 15(4.2 + (-0.246) + 0.638) = 68.88kW
\]
6.26

(46 kJ/kg) يُخرج من المحور (45 kg/min) يُدخل في المحور (105 kg/min) يُخرج ويُدخل في محور (175 kJ/kg) يُخرج ويُدخل في محور (85%)

\[ \dot{q} - \dot{w} = \dot{m} \Delta h \]

\[ \left(-\frac{105}{60}\right) - \dot{W} = \frac{45}{60}(175 - 46) \]

\[ \dot{W} = -98.5 \text{ kW} \]

\[ P = \frac{\dot{W}}{\eta} = \frac{98.5}{0.85} = 115.9 \text{ kW} \] (6.27)

(2.1 bar) يُدخل (1 bar) يُخرج (56 kJ/kg) يُدخل ويُخرج (1200 kg/min) يُخرج ويُدخل (0.5 m³/kg) يُخرج (0.825 m³/kg)

\[ w_{12} = -(h_2 - h_1) = -[(\mu_2 + P_2 \nu_2) - (\mu_1 + P_1 \nu_1)] = -[(\mu_2 - \mu_1) + (P_2 \nu_2 - P_1 \nu_1)] \]

\[ = -[(\Delta \mu_2) + (P_2 \nu_2 - P_1 \nu_1)] = -[56 + (210 \times 0.5 - 100 \times 0.825)] = -785 \text{ kJ/kg} \]

\[ \dot{W} = \dot{m} \cdot w_{12} = \frac{135}{60} \times (-78.5) = 176.7 \text{ kW} \] (6.28)

(45 kg/min) يُخرج ويُدخل (85%) يُخرج ويُدخل (45 kg/min) يُخرج ويُدخل (2100 kg/min) يُدخل ويُخرج (24000)

\[ \dot{Q} - \dot{W} = \Delta H = \dot{m} \Delta h \]

\[ (-2100) - \dot{W} = 45(-580) = -24000 \]

\[ \dot{W} = 400 \text{ kW} \]
(6.29)

\[ \Delta h = h_2 - h_1 = 2260 - 3080 = -820 \text{kJ/kg} \]

\[ \Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{140^2 - 0}{2000} = 9.81 \text{kJ/kg} \]

\[ w = \Delta h + \Delta KE = -820 + 9.81 = -810.2 \text{kJ/kg} \]

\[ w = 810.2 \times 0.92 = 745 \text{kJ/kg} \]

\[ W = m \times w = 12.5 \times 745 = 9312.5 \text{kW} \]

(196)

(6.30)

\[ \Delta h = h_2 - h_1 = 1900 - 2480 = -580 \text{kJ/kg} \]

\[ w = -(\Delta h - q) = \left[ (-580) - \left( -\frac{2100}{60} \right) \right] \]

\[ w = 545 \text{kJ/kg} \]

\[ W = m \times w = \frac{45}{60} \times 545 = 408.75 \text{kW} \]
6.31

\[ \Delta h = h_2 - h_1 = 2530 - 2990 \]
\[ = -460\text{kJ/kg} \]
\[ \Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{37^2 - 16^2}{2000} \]
\[ = -1.11\text{kJ/kg} \]

\[ w = -\left(\Delta h + \Delta KE - q\right) \]
\[ = -\left[(-460) + (-0.11) - (-25)\right] \]
\[ = 435.11\text{kJ/kg} \]
\[ W = \dot{m} \times w = \frac{324000}{3600} \times 435.11 \]
\[ = 39159.9\text{kW} \]

6.32

\[ \Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{180^2 - 15^2}{2000} \]
\[ = 16.09\text{kJ/kg} \]
\[ w = -\left[\Delta h + \Delta KE - q\right] \]
\[ = -\left[(-420) + 16.09 - (-23)\right] \]
\[ = 381\text{KJ/Kg} \]
\[ W = \dot{m} \times w = \frac{4500}{3600} \times 381 \]
\[ = 476.14\text{kW} \]
\[ \Delta h = h_2 - h_1 = 360 - 1200 = -840 \text{kJ/kg} \]
\[ \Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{150^2 - 60^2}{2000} = 9.45 \text{kJ/kg} \]
\[ q = \Delta h + \Delta KE + w = -840 + 9.45 + \frac{14000}{17} \]
\[ q = -7.02 \text{kJ/kg} \]
\[ Q = \dot{m} \times q = 17 \times (-7.02) = -119.3 \text{ kW} \]
\[ A_1 = \frac{m \cdot v_1}{C_1} = \frac{17 \times 0.5}{60} = 0.142 \text{ m}^2 \]

\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{\gamma}{\gamma-1}} = 923 \left( \frac{1}{7} \right)^{\frac{1.333}{1.333-1}} \]
\[ = 567 \text{K} \]
\[ \Delta h = h_2 - h_1 = C_p(T_2 - T_1) \]
\[ = 1.11 (567 - 923) \]
\[ = -395.16 \text{kJ/kg} \]
\[
C_p = 1.004 \text{ kJ/kg.K} \quad \dot{U}_f = 1.4 \ .
\]

\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\gamma-1} = 673 \left( \frac{0.015}{2} \right)^{1.4-1} = 166 \text{ K}
\]

\[
\Delta h = C_p(T_2 - T_1) = 1.004(166 - 673) = -509 \text{kJ/kg}
\]

\[
\Delta KE = \frac{C_2^2 - C_1^2}{2000} = \frac{(180)^2 - (50)^2}{2000} = 14.95 \text{kJ/kg}
\]

\[
\Delta PE = g(z_2 - z_1) = 9.81(6 - 10) \times \frac{1}{1000} = -0.04 \text{kJ/kg}
\]

\[
w_o = -(\Delta h + \Delta KE + \Delta PE) = -(509 + 14.95 - 0.04) = 494.1 \text{kJ/kg}
\]

\[\text{kg/m}^3 \times 1000 = 10.12 \text{ Kg/s} \]

\[\text{m}^2 \text{s}^{-2}
\]

\[\text{W} = \frac{\dot{W}}{w} \text{ = } \frac{5000}{494.1} = 10.12 \text{ Kg/s}
\]

\[\text{m}^2 \text{s}^{-2}
\]

\[
C_1 = \frac{m v_1}{A_1} = \frac{30 \times 0.2491}{0.045} = 16.6 \text{ m/s}
\]

\[
C_2 = \frac{m v_2}{A_2} = \frac{30 \times 1.694}{0.31} = 163.9 \text{ m/s}
\]

\[
-W = m \left[ (h_2 - h_1) + \frac{C_2^2 - C_1^2}{2} \right] = 30 \left[ (2675.5 - 3582.3) + \frac{(163.9^2 - 16.6^2)}{2} \right] = -26800 \text{ kW}
\]

\[
W = 26.8 \text{ MW}
\]

\[\text{kg/m}^3 \times 1000 = 10.12 \text{ Kg/s}
\]

\[\text{m}^2 \text{s}^{-2}
\]

\[
\frac{A_1}{0.045 \text{ m}^2} \quad \frac{P_1}{15 \text{ MPa}} \quad h_1 = 3582.3 \text{ kJ/kg} \quad t_1 = 600^\circ \text{C} \quad \nu_1 = 0.02491 \text{ m}^3/\text{kg}
\]

\[\text{kg/m}^3 \times 1000 = 10.12 \text{ Kg/s}
\]

\[\text{m}^2 \text{s}^{-2}
\]

\[
A_2 = 0.31 \text{ m}^2 \quad h_2 = 2675.5 \text{ kJ/kg} \quad \nu_2 = 1.694 \text{ m}^3/\text{kg}
\]
\( \dot{m}_1 = \delta_1 A_1 C_1 = \frac{1}{0.018} \times \frac{\pi \times 0.15^2}{4} \times 90 \)
\( = 88.3 \text{kg/s} \)
\( \dot{m}_1 = \dot{m}_2 = 88.3 \text{kg/s} \)
\( C_2 = \frac{\dot{m}_2}{\delta_2 A_2} = \frac{88.3}{0.018} \times \frac{\pi \times 0.6^2}{4} \)
\( = 196.1 \text{m/s} \)

\( R = 0.287 \text{kJ/kg.K} \)
\( \delta_1 = \frac{P_1}{RT_1} = \frac{80}{0.287 \times 283} = 0.985 \text{kg/m}^3 \)
\( \dot{m} = \delta C_1 A_1 = 0.985 \times 200 \times 0.4 \)
\( = 78.8 \text{kg/s} \)

\( O = h_2 - h_1 + \frac{C_2^2 - C_1^2}{2000} \)
\( h_2 = h_1 - \left( \frac{-C_1^2}{2000} \right) = 283.14 + \frac{40000}{2000} \)
\( = 303.14 \text{kJ/kg} \)
\( \dot{H}_2 = h_2 \times \dot{m} = 303.14 \times 78.8 \)
\( = 23887.4 \text{kW} \)
\[ \Delta h_{12} = h_2 - h_1 = 2.79 - 2.94 = -0.15 \text{kJ/kg} \]

\[ q_{12} = \Delta h_{12} + \Delta KE \]

\[ O = -0.15 + \frac{C_2^2 - 55^2}{2000} \]

\[ C_2 = 545 \text{ m/s} \]
\[ C_2 = \sqrt{2 \times 10^3 (h_1 - h_2)} \]
\[ = \sqrt{2000(2800 - 2250)} \]
\[ = 1050 \text{ m/s} \]
\[ m = \frac{A_2 C_2}{v_2} \]
\[ A_2 = \frac{m v_2}{C_2} = \frac{14 \times 1.25}{1050} \]
\[ = 0.0166 \text{ m}^2 \]

(6.42)

\[ A_1 = \frac{\text{max} \times v_1}{C_1} = \frac{1.3 \times 0.0997}{508} = 0.000255 \text{ m}^2 \]
\[ A_2 = \frac{\text{max} \times v_2}{C_2} = \frac{1.3 \times 0.2}{820} = 0.000317 \text{ m}^2 \]

(6.43)

\[ \Delta h + \Delta KE = C_p(T_1 - T_2) + \frac{C_2^2 - C_1^2}{2} \]

\[ C_p = 1.006 \text{ kJ/kg.K} \]
\[ \bar{C}v = 0.717 \text{ kJ/kg.K} \]
\[ O = \Delta h + \Delta KE = C_p(T_1 - T_2) + \frac{C_2^2 - C_1^2}{2} \]

\[ \frac{C_2^2 - C_1^2}{2000} = \frac{300^2 - 900^2}{2000} = 1.006(273 - T_2) \]
\[ T_2 = 629 \text{ K} \Rightarrow \Delta T = T_2 - T_1 = 629 - 273 = 356 \text{ K} \]
\[ P_2 = P_1 \left( \frac{T_2}{T_1} \right)^\gamma = 140 \left( \frac{629}{273} \right)^{\frac{14}{1.4-1}} = 2590 \text{ kN/m}^2 \]
\[ \Delta P = P_2 - P_1 = 2590 - 140 = 2450 \text{ kN/m}^2 \]
\[ \Delta U = Cv(T_2 - T_1) = 0.717(629 - 273) = 255 \text{ kJ/kg} \]

(202)
\[ (10\text{bar}) \quad \Delta H = -\Delta KE = \left( \frac{C_p^2 - C_i^2}{2000} \right) \cdot \Delta T_{12} = \frac{550^2 - 70^2}{2000} \times \frac{1000}{3600} = -41.333 \text{kW} \]

\[ \Delta H = m \cdot C_p \cdot \Delta T_{12} = \frac{1000}{3600} \cdot 1.004 \times \Delta T_{12} \]

\[ \Delta T_{12} = -148.2 \text{K} \]

\[ h_1 = h_2 \]

\[ h_i = \mu_i + P_1 \nu_1 \]

\[ h_2 = \mu_2 + P_2 \nu_2 \]

\[ \mu_2 - \mu_1 = (h_2 - h_1) - (P_2 \nu_2 - P_1 \nu_1) = 0 - (100 \times 1.8 - 10 \times 0.3) = 120 \text{kJ/kg} \]

\[ 0.7 \times (T_2 - 30) = 700 \times 0.12 - 100 \times 0.96 \]

\[ T_2 = 286 \text{K} \]

\[ \text{Cv} \cdot (T_2 - T_1) = P_1 \nu_1 - P_2 \nu_2 \]

\[ \text{Cv} = 0.72 \text{kJ/kg.K} \]

\[ \text{Cv} = 0.96 \text{kJ/kg.K} \]
\[
\begin{align*}
\text{(1)} & \\
W_C &= \dot{W}_T \\
\dot{m}(h_1 - h_2) &= \dot{m}_T(h_1 - h_2) \\
&= \frac{20}{3600}(50 - 1500) = \frac{40(5000 - h_2)}{3600} \\
h_2 &= \frac{5000.2kJ/kg}{h} \\
H &= \dot{m}.h_2 = 40 \times 5000.2 \\
&= 200008.1kW \\
\end{align*}
\]

\[
\begin{align*}
\text{(2)} & \\
\dot{m}_c &= 20 + 0.2 \times 20 = 24kg/h \\
W &= \dot{W}_T \\
W_C &= \dot{m}_c(h_1 - h_2) = \dot{m}_T(h_1 - h_2) \\
&= \frac{20}{3600}(50 - 1500) = \frac{24(5000 - h_2)}{3600} \\
h_2 &= \frac{5000.24kJ/kg}{h} \\
H &= \dot{m}.h_2 = 40 \times 5000.24 \\
&= 200009.6kW \\
&= 200009.6 - 200008.1 = 1.5kW \\
\end{align*}
\]

\[
\begin{align*}
(18.3^\circ\text{C}) & \\
\text{Cp}=1.005 \text{kJ/kg.K} \quad \gamma=1.4 \\
T_2 &= T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 291.3 (4)^{\frac{1.4-1}{1.4}} \\
&= 432 K \\
T_4 &= T_3 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 977 (4)^{\frac{1.4-1}{1.4}} \\
&= 657 K \\
q_{in} &= \text{Cp}(T_3 - T_2) = 1.005(977 - 432) \\
&= 548kJ/kg \\
\end{align*}
\]

\[
\begin{align*}
q_o &= \text{Cp}(T_4 - T_1) = 1.005(657 - 291.3) \\
&= 367 kJ/kg \\
w &= q_{in} - q_o = 548 - 367 = 181kJ/kg \\
\eta &= \frac{q_{in}}{q_o} = \frac{548}{367} = 0.328 \\
\frac{m_a}{w} &= \frac{375}{181} = 2.07 \text{ kg/s} \\
\end{align*}
\]
\[
C_1 = \frac{800 \times 1000}{3600} = 222.2 \text{ m/s}
\]
\[
C_1^2 = 2000 \Delta h_{12} = 2000 \text{Cp} \Delta t_{12}
\]
\[
\Delta t_{12} = \frac{C_1^2}{2000 \text{Cp}} = \frac{(222.2)^2}{2000 \times 1.004}
\]
\[
t_2 = \Delta t_{12} + t_1 = 24.6 + (-24.6) = 0^\circ \text{C}
\]
\[
P_2 = P_1 \left( \frac{T_2}{T_1} \right)^{\gamma - 1} = 46.6 \left( \frac{273}{248.6} \right)^{\frac{1.4}{1.4 - 1}}
\]
\[
= 64.8 \text{kPa}
\]
\[
T_3 = T_2 \left( \frac{P_3}{P_2} \right)^{\gamma - 1} = 273 \left( \frac{280}{64.8} \right)^{0.4}
\]
\[
= 414.94 \text{ K}
\]
\[
w_C = w_T = \text{Cp}(T_3 - T_2)
\]
\[
= 1.004(414.94 - 273)
\]
\[
= 142.36 \text{ K}
\]
\[
= 142.30 \text{ kJ/kg}
\]
\[
W_T = w_T \times m = 142.36 \times 95
\]
\[
= 13524.2 \text{ kW}
\]

\[
T_2 = T_1 \left( \frac{P_1}{P_2} \right)^{\gamma - 1} = 288(4.4)^{\frac{1.4 - 1}{1.4}}
\]
\[
= 400 \text{ K}
\]
\[
T_3 = T_2 + \Delta T = 440 + 390 = 830 \text{ K}
\]
\[
T_4 = T_3 \left( \frac{P_3}{P_4} \right)^{\gamma - 1} = 830 \left( \frac{1}{4} \right)^{\frac{1.4 - 1}{1.4}}
\]
\[
= 543 \text{ K}
\]
\[
W_c = \text{Cp}(T_2 - T_1) = 1.005(440 - 288)
\]
\[
= 153 \text{ kJ/kg}
\]
\[
W_T = \text{Cp}(T_3 - T_4) = 1.005(830 - 543)
\]
\[
= 288 \text{ kJ/kg}
\]
\[
W_{net} = W_T - W_c = 288 - 153
\]
\[
= 135 \text{ kJ/kg}
\]
\[
\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{135}{1.005 \times 390} = 0.343
\]
(6.52)

\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{1}{\gamma}} = 298 \left( \frac{800}{101} \right)^{0.286} = 538 \text{ K} \]

\[ w_{12} = -\frac{\gamma R(T_2 - T_1)}{\gamma - 1} = -\frac{1.4 \times 0.287 \times (538 - 298)}{0.4} = -241.1 \text{ kJ/kg} \]

\[ \therefore w_{12} = -177 \text{ kJ/kg} \]

(6.53)

\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{n-1}{n}} = 303 \left( \frac{900}{200} \right)^{1.25-1} = 409.3 \text{ K} \]

\[ w_{12} = -\frac{n R(T_2 - T_1)}{n - 1} = -\frac{1.25 \times 4.124 \times (409.3 - 303)}{1.25 - 1} = -2193 \text{ kJ/kg} \]
(6.1) 

\[ \text{มวล الماء} = 8 \text{kg/m}^3 \]

(6.2) 

\[ \text{มวล الماء} = 6 \text{kg/m}^3 \]

(6.3) 

\[ \text{มวล الماء} = 0.18 \text{kg/m}^3 \]

(6.4) 

\[ \text{มวล الماء} = 0.95 \text{kg/m}^3 \]

(207)
(6.5) 
(2m/s) ذإين أ (30°C) لحرو لة (4bar) عسك حضث و (يتزلف أهليت ود أهليت) 
(Cv=0.717 kJ/kg.K) \( \dot{V}_{f} = .14 \) لف كود زل. (175m/s) ذإين أ (1.2bar) عسك حضث 
: يل.of 
.عكر لحرو لة ود أهليت (1) 
.عكر لحرو لة ود أهليت (2) 
(3.147 kg/m³) \( \dot{V}_{f} = 15.25 \text{ K} \) :

(6.6) 
أlsaوى (1bar) عسك لة (165kg/h) 3 حل كيرماد رايرفا ن يبمومي. أساوى (8bar) عسك لة (60m/s) ذإين أ (0.9m³/kg) 
أساوى (12m/s) ذإين أ (0.18m³/kg) 
أساوى (14kW) أساوى (3138kJ/kg) أساوى (2562kJ/kg) . أساوى (423.6 kW) :

(6.7) 
(6m) Aساوى (50m/s) ذإين حبرس ه (100kg/min) نير ساي روفاة أساوى (3m) Aساوى (200m/s) ذإين Suc (3138kJ/kg) أساوى أساوى 
لجدن كي العملات نم. (5.7kJ/kg) أساوى (2562kJ/kg) . أساوى (919.3 kW) :

(6.8) 
Aساوى (50m/s) ذإين حبرس ه (0.8kg/s) يفة سا لفآكيلو دخأج أساوى 250°C) Aساوى لحرو (100m/s) ذإين حبرس (900°C) 
: Aساوى أساوى أساوى لفآكيلو يل.of. (120 kJ/kg) أساوى 
Cp=1.005 kJ/kg.K 
(423.6 kW) :

(208)
(6.9) 

The gas input is 18 kW. The input gas temperature (34°C) is supplied to the gasifier. The gasifier can operate at pressures above 84% (12.7 bar) with a gas flow rate of 18 kW. The gas flow rate is 10.4 kg/min at an exit temperature of 7°C. The gas flow rate is 140 kg/h, which is required to meet the energy demand of 720 kJ/min. The gas flow rate is 1.2 m³.

(6.10) 

The gas input is 325 kJ/kg. The gas input gas temperature (3600 m/min) is supplied to the gasifier. The gasifier can operate at pressures above 40 kg/h. The gas flow rate is 8 bar. The gas flow rate is 7 bar with a gas flow rate of 180 m³/kg. The gas flow rate is 4.2 kg/min at an exit temperature of 4.2 kJ/kg.K. The gas flow rate is 1 (bar) with a gas flow rate of 45 m/s.

(6.11) 

The gas input is 0.834 kJ/kg.K. The gas flow rate is 1.333 (bar) with a gas flow rate of 45 m/s.
(6.12)

معدل توربين في الأدابات الغازية يتدفق (20kg/s) على درجة حرارة (80°C) ويتسبب في خروجها بدرجة تصل إلى (400°C). ثم، درجة حرارة الأتربين تصبح على مدى بؤرة (80°C).

إذا كانت درجة حرارة الغازية الأبتدائية (800°C) وطاقته للاحتراق والطاقات الطاقية في التغير ACEM.

(787.9 m/s Û 7760 kW) :

(6.13)

حفرة في (2.4kg/min) حفرة في (12kW) وجي. وتغطيrab لب (8m) وفرم (3600m/min) تذكر (0.9m³/kg) وازدياد (100kN/m²) ونهر الحرة وفرم (4m) وفرم (15m/s) تذكر (0.18m³/kg) وازدياد (8bar) ونية جذب لف (299kJ/kg) تذكر إن وذ (4.2 kJ/kg.K) تذكر الطاقة (70.3 kg/h) :

(6.14)

حفرة في (15m/s) تذكر (4500h) حفرة في (172kJ/kg) وازدياد (0.82m³/kg) وازدياد (6bar) توفر (172) توفر (0.82m³/kg) وازدياد (1bar) حفرة في (180m/s) تذكر (10%) حفرة في (164kJ/kg) . حفرة في (164kJ/kg) حفرة في (458.75 kW)
(6.15) 


cالبة (5kg/s) 

\[ y_{\text{مذ}} = 5 \text{kg/s} \]


\[ 25 \text{m/s} \]

\[ 20 \text{m/s} \]

\[ 2800 \text{kJ/kg} \]

\[ 120 \text{kJ/kg} \]

\[ -1 \text{bar} \]

\[ 0.86 \text{m}^3/\text{kg} \]

\[ 0.17 \text{m}^3/\text{kg} \]

\[ 4.5 \text{kg/min} \]

\[ 28 \text{kJ/kg} \]

\[ 110 \text{kJ/kg} \]

\[ 76 \text{kJ/kg} \]

\[ 3284 \text{ kW} \]

\[ -14.3 \text{ kW} \]

\[ 0.172 \text{ m}^3 \]

\( \)
(6.19)

نَرَأَيَّ كَثِّرَةَ (800°C) إِلَى (15°C) لِتَحْدِيرَةَ التَّنْبُوْسِ وَيَسْرُّنَّ بِهَا أيَّ جُرُوحَتْ يُضْرِبُغَ فيَّ (15°C) عِنْدَ قُطْعَ مَتَّى (30m/s) وَهَلْ يَعْبُرُ النَّفَسُ يَتُبْعَدُ. يُصَبُّ (500°C) نَرَأَيَّ وَيْدُ (فَرْمَبَ زُبَأْ) (30m/s) إلى (2kg/s) لِتَضَادُ النَّبضِ بِهَا. (553 m/s ًÚ298.8 kW ًÚ1577.85 kJ)

(6.20)

يَنْتَظِرُ (93°C) نَرَأَيَّ (389.6kJ/kg) لِلَّدَادَة*. يُخْلِصُ النَّبْضُ (1.5kJ) إِبْنَاءً فَنْدَأَ قُطْعَ (182 kg/min) (15m) بِنَطِيقَ (38°C ًÚ479.5 kW)

(6.21)

يَنْتَظِرُ (290K) أَ(0.095MPa) وَهُوَ إِلَى (200K) عِنْدُ قُطْعَ مَتَّى (0.38MPa) عِنْدُ قُطْعَ (40000kW) وَهُوَ إِلَى (200K) عِنْدُ قُطْعَ. (158.4 kg/s ًÚ62.42 MW)
\[ \text{Cp} = 1.005 \text{ kJ/kg.K} \]

\[ \Omega \in 0.16 \text{m}^3/\text{kg} \]

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\[ \text{Cp} = 1.005 \text{ kJ/kg.K} \]

\[ \Omega \in 0.16 \text{m}^3/\text{kg} \]

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\[ \text{Cp} = 1.005 \text{ kJ/kg.K} \]

\[ \Omega \in 0.16 \text{m}^3/\text{kg} \]

\[ \text{Cp} = 1.005 \text{ kJ/kg.K} \]

\[ \Omega \in 0.16 \text{m}^3/\text{kg} \]
(6.25)

\[
\text{حرارة وضغط الغاز (0.1MN/m}^2\text{) عند } 15°C \text{ و (0.5MN/m}^2\text{) عند } 900°C \text{.}
\]

(6.24)

\[
\text{حرارة وضغط الغاز (0.1MN/m}^2\text{) عند } 15°C \text{ و (0.5MN/m}^2\text{) عند } 900°C \text{.}
\]

\[
C_p=1.005 \text{ kJ/kg.K , } \gamma=1.4
\]

\[
(36.8\% \text{ و } 265 \text{ kJ/kg})
\]

(6.27)

\[
\gamma = 1.4 \text{ , } C_p = 1.005 \text{ kJ/kg.K}
\]

\[
(265.34 \text{ kg/s و } 76.53 \text{ Mw})
\]
6.28

حرارة بذرة الحواء يدخل عليها ارتفاع النفايات الطائرية. (24.6°C) معقدة وقدرتية (46.6kPa) عند إذا 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إذا 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(215)
\[ (6.31) \]

\[
\text{إذاً (1000°C) يدخل الغاز (10bar) يغلي على درجة حرارة (1bar) يدخل الغاز (5bar) يذوب (5bar)}
\]

\[ (6.32) \]

\[
\text{إذاً (27°C) يدخل الغاز (101kPa) يذوب (5) يذوب (1050°C) يذوب (Cp=1.004 kJ/kg.K)}
\]

\[ (6.33) \]

\[
\text{إذاً (600°C) يذوب (6bar) يذوب (W=5000kJ/s) يذوب (1bar) يذوب (R=0.287 kJ/kg.K)}
\]

(216)
Friction (7.1)

Mechanical Friction (7.1)

\[
P = \frac{V}{A}, \quad F = \frac{V}{A}
\]

\[
\begin{align*}
\text{Fig. 7.1 (a), (b):} & \quad \text{Effect of friction on the gas flow.} \\
\text{Fig. 1.7 (a):} & \quad \text{Effect of pressure on the gas flow.} \\
\text{Fig. 2.7 (a):} & \quad \text{Effect of temperature on the gas flow.}
\end{align*}
\]
\[
\begin{array}{|c|c|c|}
\hline
(a) & (b) & (c) \\
\hline
(P-P_{atm}) A-F & (P-P_{atm}) A+F & \text{2. Fluid Friction} \\
\hline
d_w=[(P-P_{atm})A-F]dL & d_{in}=[(P-P_{atm})A+F]dL & (dL) \text{ (7.2)} \\
\hline
\end{array}
\]

\[\therefore d_{in} > d_w\]

Fluid Friction \(\text{yesterday}\) \(\therefore\) 2.

Reversibility or Reversible Process

\(\ldots\)

\(\text{Fluid Friction}\) \(\text{yesterday}\) \(\therefore\) (7.2)

\(\ldots\)
Irreversible Process (7.3)

\[
\begin{align*}
\text{Irreversible Process} & \quad (7.3) \\
\end{align*}
\]


(220)
The Heat Engine

(7.5)

\[ \text{The Heat Engine} \]

The Heat Engine is a system that operates within thermal sources. It works thermodynamically in two thermal sources, \( T_{\text{max}} \) and \( T_{\text{min}} \). The engine absorbs heat from \( T_{\text{max}} \) and rejects heat to \( T_{\text{min}} \). The engine converts the absorbed heat into work, \( W_0 \), and rejects the remaining heat, \( Q_0 \).

\[ W_0 = Q_{\text{in}} - Q_0 \]

(7.1)

\[ Q_{\text{in}} = Q_0 + W_0 \]

(7.3)

\[ Q_{\text{in}} = Q_0 + W_0 \]

(7.3)
\[
\begin{align*}
\Delta E_{sc} & = 0 \quad \text{(كاملة الطاقة المعدنة وتصبح)} \\
Q - W & = \Delta E_{sc} \quad \text{..................................................(7.2)} \\
Q & = W \\
\sum Q & = \sum W \\
Q_{in} + (-Q_{o}) & = W_{o} + (-W_{in}) \\
Q_{in} - Q_{o} & = W_{o} - W_{in} = W_{net} \quad \text{..................................................(7.3)}
\end{align*}
\]
Efficiency of Energy Conversion System or Engine Thermal Efficiency

\[ W_{\text{net}} = Q_{\text{in}} - Q_O \]  \hspace{1cm} (7.4)

\[ \eta_{th} = \frac{W_{\text{net}}}{Q_{\text{in}}} = \frac{Q_{\text{in}} - Q_O}{Q_{\text{in}}} = 1 - \frac{Q_O}{Q_{\text{in}}} \]  \hspace{1cm} (7.5)

\[ \text{T}_{\text{max}} \]

\[ \text{Hot body} \]

\[ \rightarrow \]

\[ \Sigma W \]

\[ \text{Energy Conversion System} \]

\[ \rightarrow \]

\[ \text{Cold body} \]

\[ \text{T}_{\text{min}} \]
\[ \eta_{th} = \frac{\dot{W}_o}{m_f \times LCV} \] ..........................(7.6)

**Reversed Heat Engine (Heat pump)**

Refrigerator

- \( T_{min} \) is the boundary temperature of the system.
- \( T_{max} \) is the maximum temperature at which the system can operate.

7.7. (a) refrigerator or \( \text{capillary tube} \)

7.7. (b) \( \text{heat exchanger} \) or \( \text{condenser} \).
Coefficient of Performance - (7.8)

\[
(COP)_{H.P} = \frac{Q_O}{W_{in}} = \frac{Q_O}{Q_O - Q_{in}} \quad \text{(7.7)}
\]

\[
(COP)_{Ref} = \frac{Q_{in}}{W_{in}} = \frac{Q_{in}}{Q_O - Q_{in}} \quad \text{(7.8)}
\]

\[
\eta_{HE} = \frac{1}{COP} \quad \text{(7.9)}
\]

\[
(COP)_{H.P} = \frac{Q_O}{W_{in}} = \frac{Q_{in} + W_{in}}{W_{in}} = \frac{Q_{in}}{W_{in}} + \frac{W_{in}}{W_{in}} = (COP)_{Ref} + 1 \quad \text{(7.10)}
\]
The second Law of Thermodynamics

The energy conservation law states that energy cannot be created or destroyed, only transformed from one form to another. This law underlies the concept of efficiency in various processes.

During a process, some energy is lost as heat, which is why the efficiency of a process cannot exceed 100%.

In thermodynamics, the second law is often associated with the concept of entropy, which measures the degree of disorder in a system. According to this law, the total entropy of an isolated system can never decrease over time.

This law has significant implications for various fields, including engineering, physics, and chemistry, as it governs the feasibility and efficiency of processes involving energy transfer and conversion.
لیست نامه‌ای که در آن جریان‌های گاز را در شرایط مختلف به‌طور دقیق توصیف می‌کند.

2.

در صورتی که جریان‌های گاز را در محیط‌های مختلفی انجام دهیم، فاصله بین پایین و بالا در جریان‌های گازی به‌طور قطعی می‌باشد.

3.

یکی از جریان‌های گازی در محیط‌های مختلفی ضروری است که جریان‌های گازی را در محیط‌های مختلفی انجام دهیم.

4.

سیستم‌ها و جریان‌های گازی در محیط‌های مختلفی ضروری است که جریان‌های گازی را در محیط‌های مختلفی انجام دهیم.

(228)
١٨٢٤، حيث أن القياس الأول، الذي ينص على أن النواحي التي تفتح للاستعمال، لا تزال في الوقت الثاني للقانون، تكون في الوقت الأولى للقانون.

الإجراءات نستخرج ثمثنية في النظام على الثاني، القانون حيث كمها، وعندما تكون في النظام من أوائل، فإنه يمكن الوصول إلى الالتزام.

المعرض العالم إلى اكتشافه في مدة، ويعود كاهن الفرنسي (Sadi Carnot) (171) 1824، حيث أن جدول الدراسات (Games Prescott Joule) ينتمي جداً.

(1) كاهن الفرنسي (Kelvin-Plank) (وكلوديوس (Clausius) (258) (20) النواحي من النظام، أداء التالية، حيث أن بعض الأعضاء وال您的孩子: (1) 

The Second Law Statements (7.10) - (2) 

حيث أن (لديه) ليس، (Q ≠ W)، (Wo = Qin - Qo) لذا

(229)
(7.11) 

\[ W = Q_1 \] 

(7.12) 

\[ W = Q_0 - Q_2 \]
\[
Q_1 = Q_0 - Q_2 \\
Q_0 = Q_1 + Q_2
\]

\[(7.13)\]

\[T_{\text{max}} \geq 0, \quad T_{\text{min}} \leq 0 \]

\[Q_2 = \begin{cases} 0 & \text{if } T_{\text{min}} \leq 0 \\ T_{\text{max}} & \text{if } T_{\text{max}} \geq 0 \end{cases}
\]
(7.1) 

\[ \text{età} = \frac{W}{Q_{\text{in}}} = \frac{W}{\dot{m}_f \times LCV} = \frac{200 \times 10^3}{70 \times 10^3 \times 041000} = 0.25 \]

\[ Q_{\text{o}} = \dot{Q}_{\text{in}} - W = \dot{m}_f \times LCV - W = 70 \times 10^3 \times 41000 - 200 \times 10^3 = 215 \times 10^7 \text{kJ/h} \]

\[ \dot{m} = \frac{\dot{Q}_o}{C_w \times \Delta T_1} = \frac{215 \times 10^7}{4.2 \times (28 - 20)} = 642 \times 10^6 \text{kg/h} \]

(7.2) 

\[ W_{12} = \eta \times \dot{Q}_{\text{in}} = \dot{m}_f \times LCV = 0.2 \times \frac{20.4}{3600} \times 43 \times 10^3 = 48.73 \text{kW} \]

\[ Q_{\text{o}} = \dot{Q}_{\text{in}} - W_{12} = \dot{m}_f \times LCV - W_{12} = \frac{20.4}{60} \times 43 - 48.733 \times \frac{60}{1000} = 11.7 \text{MJ/min} \]

(7.3) 

\[ \eta = \frac{W}{\dot{Q}_{\text{in}}} \Rightarrow \dot{Q}_{\text{in}} = \frac{W}{\eta} = \frac{500 \times 3600}{0.28} = 6 \times 43 \times 10^6 \text{MJ/h} \]

\[ \dot{m}_f = \frac{\dot{Q}_{\text{in}}}{L.C.V} = \frac{6 \times 43 \times 10^6}{29.5} = 217917 \text{kg/h} \]
7.4

\[ \dot{m}_f = \frac{3.045 \times 10^3}{3600} = 0.846 \text{ kg/s} \]

\[ \eta_{\text{th}} = \frac{W}{\dot{m}_f \times \text{L.C.V}} = \frac{4.1}{0.846 \times 28} = 0.173 \]

7.5

\[ \dot{Q}_{\text{in}} = \dot{m}_f \times CV = 20.4 \times 43 = 877.2 \text{ MJ/h} = 243.7 \text{ kW} \]

\[ W = \eta \dot{Q}_{\text{in}} = 0.2 \times 877.2 = 175.44 \text{ MJ/h} = 48.7 \text{ kW} \]

\[ \dot{Q}_O = \dot{Q}_{\text{in}} - W = 243.7 - 48.7 = 195 \text{ KW} = 11698 \text{ kW/min} \]

7.6

\[ \eta_{\text{the}} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{293}{586} = 0.5 \]

\[ \eta_{\text{Act}} = 0.6 \times 0.5 = 0.3 \]

\[ Q_{\text{in}} = \frac{W}{\eta} = \frac{75000}{0.3} = 25 \times 10^5 \text{ kW} \]

\[ \dot{Q}_O = 0.7 \times 25 \times 10^5 = 175 \times 10^4 \text{ kW} \]

\[ \dot{m}_w = 165 \times 10^3 \text{ Kg/s} \]

\[ \Delta T = \frac{\dot{Q}_{\text{in}}}{\dot{m} \times C_w} = \frac{25 \times 10^5}{165 \times 10^3 \times 4.2} = 2.54 \text{ K} \]
(7.7)

\[ \text{COP}_{HP} = \frac{Q_o}{W} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} \]

\[ = \frac{2254}{604} = 1 - \frac{273}{373} \]

\[ W = 604 \text{kJ} \]

\[ Q_{in} = Q_o - W \]

\[ = 2254 - 604 = 1650 \text{kJ} \]

(7.8)

(A) When: \( W_A = W_B \)

\[ Q_{inA} - Q_{oA} = Q_{inB} - Q_{oB} \]

\[ Q_{inA} - Q_{oA} = Q_{oA} - Q_{oB} \]

\[ Q_{inA} - Q_{oB} = Q_{oA} + Q_{oA} = 2Q_{oA} \]

\[ (627 + 273) + (27 + 273) = 2T \]

\[ T = 600 \text{K} \]

(B) When: \(-\eta_A - \eta_B\)

\[ \frac{T_{\text{max}}}{T_{\text{max}} - T_{\text{min}}})A = \frac{T_{\text{max}}}{T_{\text{max}} - T_{\text{min}}})B \]

\[ \frac{900}{900 - T} = \frac{T}{T - 300} \]

\[ T = 519.6 \text{K} \]
\[ W_A = 2W_B \]
\[ Q_{inA} - Q_{oA} = 2(Q_{inB} - Q_{oB}) \]
\[ Q_{inA} - Q_{oA} = 2(Q_{O1} - Q_{oB}) \]
\[ T_{\text{max}} - T_m = 2(T_m - T_{\text{min}}) \]
\[ T_m = 416 \text{k} \]
\[ \eta_A = 1 - \frac{T_m}{T_{\text{max}}} = 1 - \frac{416}{694} = 0.4 \]

\[ \eta_B = 1 - \frac{T_{\text{min}}}{T_m} = 1 - \frac{277.4}{416} = 0.33 \]
\[ W_A = \eta_A . Q_{inA} = 0.4 \times 200 = 80 \text{kJ} \]
\[ Q_{oA} = Q_{inA} - W_A = 200 - 80 = 120 \text{kJ} \]
\[ W_B = \frac{W_1}{2} = \frac{80}{2} = 40 \text{kJ} \]
\[ Q_{oB} = Q_{inB} - W_B = Q_{oA} - W_B = 120 - 40 = 80 \text{kJ} \]

\[ \text{COP} = \frac{T_{\text{max}}}{T_{\text{max}} - T_{\text{min}}} \]
\[ = \frac{300}{300 - 265} = 8.57 \]
\[ 8.57 = \frac{Q_O}{W_{in}} = \frac{200000}{W_{in}} \]

\[ W_{in} = 23337.2 \text{kJ} / h \]
\[ Q_{in} = Q_O - W_{in} \]
\[ Q_{in} = 176662.8 \text{kJ} / h \]
\[ = 49.073 \text{kJ} \]

(235)
(7.11)

\[
\begin{align*}
Q_{in} &= W + Q_o = 57 + 70 = 127 \text{kJ} \\
\dot{W} &= \frac{Q_o}{(COP)_{HP}} = \frac{8}{2.23} = 3.6 \text{kJ} \\
\zeta &= (COP)_{ref} = (COP)_{HP} - 1 = 2.23 - 1 = 1.23
\end{align*}
\]

(7.12)

\[
\begin{align*}
(COP)_{ref} &= \frac{Q_{in}}{\dot{W}} = \frac{T_{min}}{T_{max} - T_{min}} \\
\frac{1230}{\dot{W}} &= \frac{238}{306 - 238} \\
\dot{W} &= 351.4 \text{W} \\
Q_o &= \dot{W} + \dot{Q}_{in} = 351.4 + 1230 = 1.582 \text{KW}
\end{align*}
\]

(7.13)

\[
\begin{align*}
W_{HE} &= W_{HP} \\
\eta_{HE} \times Q_1 &= \frac{Q_3}{(COP)_{HP}} \\
\frac{Q_3}{Q_1} &= \eta_{HE} \times (COP)_{HP} \\
&= \frac{T_1 - T_2}{T_1} \times \frac{T_3}{T_4 - T_3}
\end{align*}
\]

(236)
(7.1) 

\[ \text{ال khúcبة} \times \text{الخارجية} = (120000kJ/h) \] 

(7.2) 

\[ \text{ال khúcبة} \times \text{الخارجية} = (333K)A (944K) \] 

(7.3) 

\[ \text{ال khúcبة} \times \text{الخارجية} = (4000kJ/kg) \] 

(7.4) 

\[ \text{ال khúcبة} \times \text{الخارجية} = (1450kJ) \]

(237)
(7.5) 

(7.6) 

(7.7)
7.8

\[ U(20 \, ^\circ C) = 48000 \text{kJ/hr} \]  

7.9

\[ U(25 \, ^\circ C) = 2400 \text{kJ/hr.K} \]

7.10

\[ N = 1000 \text{kJ} \]  

\[ (816 \text{kJ}, 576 \text{kJ}, 600 \text{kJ}) \]
Ideal Gas Cycle  

\begin{align}
\text{Ideal Gas Cycle (8.1)} \\
\text{Ideal Gas Cycle} \\
\text{Ideal Gas Cycle}
\end{align}

Carnot Principle

\begin{align}
\text{Carnot Principle (8.2)} \\
\text{Carnot Principle}
\end{align}
渤海管理局于2025年于卡龙发表的论文中，解释了这一角色。


(242)
The Carnot Cycle (8.3)

The Carnot Cycle cannot be performed by a device that operates between two temperatures, but it can be fulfilled by any device that satisfies the conditions of the Carnot cycle. The Carnot cycle consists of four processes:

1. **Process 1-2**: Heat is transferred from the high temperature reservoir to the system, increasing its internal energy. The system expands, doing work on the surroundings.

2. **Process 2-3**: The system is adiabatically isolated, and the gas expands, decreasing its pressure and temperature. The work done by the system is transmitted to the surroundings.

3. **Process 3-4**: Heat is transferred from the system to the low temperature reservoir, decreasing its internal energy. The system contracts, doing work on the surroundings.

4. **Process 4-1**: The system is adiabatically isolated, and the gas contracts, increasing its pressure and temperature. The work done by the surroundings is transmitted to the system.

The efficiency of the Carnot cycle is given by the formula:

$$\eta = 1 - \frac{T_L}{T_H}$$

where $T_L$ is the temperature of the low temperature reservoir and $T_H$ is the temperature of the high temperature reservoir.
Thermal Efficiency \( (8.4) \)

&l;\text{\( Q_{in} = P_1 V_1 \ln \frac{V_2}{V_1} = mRT_1 \ln \frac{V_2}{V_1} \)}\r
\&r;

\( k(2 \rightarrow 3) \) \( (8.3) \)

\&l;\text{\( T_2 \) \( = \frac{V_3}{V_2} \)}\r
\&r;

&l;\text{\( Q_o = P_3 V_3 \ln \frac{V_3}{V_4} = mRT_3 \ln \frac{V_3}{V_4} \)}\r
\&r;

\( k(3 \rightarrow 4) \) \( (8.4) \)

\&l;\text{\( T_1 \) \( = \frac{V_4}{V_1} \)}\r
\&r;

\( k(4 \rightarrow 1) \) \( (8.5) \)

&l;\text{\( T_1 = T_2 \)} \text{\( \& \text{\( T_3 = T_4 \)} \)}\r
\&r;

\( \text{\( N_\text{r}(8.5) \text{\( \& \text{\( h(8.3) \)} \)} \)} \text{\( \text{\( \& \text{\( k(2 \rightarrow 3) \)} \)} \text{\( \& \text{\( k(3 \rightarrow 4) \)} \}\)\)\)\)\)}\r

(244)
\[ \frac{V_4}{V_1} = \frac{V_3}{V_2} \quad \text{OR} \quad \frac{V_2}{V_1} = \frac{V_3}{V_4} \quad \text{..........(8.6)} \]

\[ W_{\text{net}} = Q_{\text{in}} - Q_{O} = mR T_1 \ln \frac{V_2}{V_1} - mR T_3 \ln \frac{V_3}{V_4} \]

\[ = mR \ln \frac{V_2}{V_1} (T_1 - T_3) \quad \text{........(8.7)} \]

\[ \eta = \frac{W_{\text{net}}}{Q_{\text{in}}} = \frac{mR \ln \frac{V_2}{V_1} (T_1 - T_3)}{mR T_1 \ln \frac{V_2}{V_1}} = \frac{T_1 - T_3}{T_1} = 1 - \frac{T_3}{T_1} \]

\[ = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{Q_{O}}{Q_{\text{in}}} \quad \text{........(8.8)} \]

\[ \eta_{C} = 1 - \frac{Q_{O}}{Q_{\text{in}}} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} \quad \text{.........................(8.9)} \]

\[ \frac{V_2}{V_1} \cdot \frac{V_3}{V_2} = \frac{V_3}{V_1} \quad \text{........................................(8.10)} \]
The Reversed Carnot Cycle (8.5)

The reversed Carnot cycle is a thermodynamic cycle that is the reverse of the normal Carnot cycle. It is a process that occurs in a system where the energy is transferred from a hot reservoir to a cold reservoir, and the work is done by the system. The cycle consists of two isothermal processes and two adiabatic processes.

\[ \text{(COP)}_{\text{HP}} = \frac{Q_o}{W_{\text{in}}} = \frac{Q_o}{Q_o - Q_{\text{in}}} = \frac{T_{\text{max}}}{T_{\text{max}} - T_{\text{min}}} \]  \hspace{1cm} (8.11)

\[ \text{(COP)}_{\text{ref}} = \frac{Q_{\text{in}}}{W_{\text{in}}} = \frac{Q_o}{Q_o - Q_{\text{in}}} = \frac{T_{\text{min}}}{T_{\text{max}} - T_{\text{min}}} \]  \hspace{1cm} (8.12)

\[ \text{Note:} \text{lenji} \text{\_\_\_\_} \text{PoZn} \text{(ref)} \text{\_\_\_\_} \text{Pu} \text{\_\_\_\_} \text{PoZn} \text{\_\_\_\_} \text{HP} \text{\_\_\_\_} \text{Ljft} \text{\_\_\_\_} \text{wr} \]

(246)
The Carnot Cycle and The Absolute Temperature

The Carnot Cycle is a theoretical cycle of heat transfer processes that are reversible. It is named after Rudolf Carnot, who first described the cycle in 1824. The Carnot cycle consists of two isothermal (constant temperature) processes and two adiabatic (no heat exchange) processes. The efficiency of the Carnot cycle can be calculated using the formula:

$$\eta_c = 1 - \frac{Q_o}{Q_{in}} = 1 - \frac{T_{min}}{T_{max}}$$

where $\eta_c$ is the efficiency of the Carnot cycle, $Q_o$ is the work done by the external agent, $Q_{in}$ is the work input, $T_{min}$ is the minimum temperature, and $T_{max}$ is the maximum temperature.

The absolute temperature $T$ is a measure of the thermal energy of a system and is given by the formula:

$$T = \frac{E}{k_B n}$$

where $E$ is the energy, $k_B$ is the Boltzmann constant, and $n$ is the number of particles.

The Carnot cycle is the most efficient cycle possible for converting heat into work, as its efficiency is limited only by the temperatures at which the processes are carried out.
\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right) = 300 \left( \frac{6}{2} \right) \]
\[ = 900 \text{K} \]

\[ T_3 = T_1 \left( \frac{P_3}{P_1} \right)^{n-1} = 300 \left( \frac{6}{2} \right)^{1.15-1} \]
\[ = 346 \text{K} \]

\[ Q_{23} = mC_p(T_3 - T_2) \]
\[ = 4 \times 1.55(346 - 900) \]
\[ = -3434.8 \text{kJ} \]

\[ V_1 = \frac{mRT_1}{P_1} = \frac{4 \times 0.3 \times 300}{200} \]
\[ = 1.8 \text{m}^3 = V_2 \]

\[ V_3 = V_2 \cdot \frac{T_3}{T_2} = 1.8 \times \frac{346.2}{900} \]
\[ = 0.69 \text{m}^3 \]

\[ W_{23} = P(V_3 - V_2) \]
\[ = 600(0.69 - 1.8) \]
\[ = -666 \text{kJ} \]

\[ W_{31} = \frac{mR(T_3 - T_1)}{n - 1} \]
\[ = \frac{4 \times 0.3(346 - 300)}{1.15 - 1} \]
\[ = 368 \text{kJ} \]

\[ W_T = 0 + (-666) + 368 \]
\[ = -298 \text{kJ} \]
Cp=1.005kJ/kg. K, R=0.287kJ/kg. K
\[ \gamma = \frac{C_p}{C_p - R} = \frac{1.005}{1.005 - 0.287} = 1.399 \]
\[ T_1 = T_3 \left( \frac{P_1}{P_3} \right)^{\gamma-1} = 293 \left( \frac{20}{1} \right)^{\gamma-1} = 688.1K \]
\[ P_2 = T_2 \frac{P_3}{T_3} = 688.1 \left( \frac{1}{293} \right) = 2.35\text{bar} \]
\[ q_{12} = W_{12} = RT_1 \ln \frac{P_1}{P_2} = 0.287 \times 688.1 \ln \frac{20}{2.35} = 423\text{kJ/kg} \]

\[ q_{23} = C_v(T_3 - T_2) = (C_p - R)(T_3 - T_2) = 0.718(293 - 688) = -2840\text{kJ/kg} \]
\[ w_{31} = -\Delta u_{31} = -C_v(T_1 - T_3) = -[0.718 - (688.1 - 293)] = -284\text{kJ/kg} \]

R=0.287 kJ/kg . K , \( \gamma = 1.4 \)
\[ V_1 = \frac{mRT_1}{P_1} = \frac{1 \times 0.287 \times 310}{200} = 0.445\text{m}^3 \]
\[ V_2 = \frac{P_1V_1}{P_2} = \frac{200 \times 0.445}{500} = 0.178\text{m}^3 = V_3 \]
\[ P_3 = P_1 \left( \frac{V_1}{V_3} \right)^{\gamma} = 200 \left( \frac{0.445}{0.178} \right)^{1.4} = 721.35\text{kN/m}^2 \]
\[ T_3 = \frac{P_3T_2}{P_2} = \frac{721.35 \times 310}{500} = 447.3\text{K} \]
250

(8.4)

\[ T_3 = T_1 \left( \frac{V_1}{V_3} \right)^{\gamma-1} = 298(7)^{1.4-1} \]

= 649.016K

\[ W_{12} = mRT_1 \ln \frac{V_2}{V_1}, W_{23} = 0 \]

\[ W_{31} = \frac{mR}{\gamma-1}(T_3 - T_1) \]

\[ Q_{in} = mCv(T_3 - T_2) \]

\[ \frac{W_{net}}{Q_{in}} = \frac{mRT_1 \ln \frac{V_2}{V_1} + O + \frac{mR}{\gamma-1}(T_3 - T_1)}{mR} \]

\[ = \frac{1}{0.4}(649 - 298) \]

= 0.339

\[ \frac{P_2}{P_1} = \frac{V_1}{V_2} = 7 \]

\[ \frac{P_3}{P_1} = \frac{P_2}{P_1} = \frac{(V_1 \gamma)}{V_3} = 7 \]

\[ \frac{V_1}{V_3} = \frac{1}{4} = 4 \]

\[ T_3 = T_1 \left( \frac{V_1}{V_3} \right)^{\gamma-1} = 298(4)^{0.4} \]

= 519.9K

\[ W_{net} = W_{12} + W_{23} + W_{31} \]

\[ Q_{in} \]

\[ Q_{net} = \frac{mRT_1 \ln \frac{V_2}{V_1} + mR(T_3 - T_2) + \frac{mR}{\gamma-1}(T_3 - T_2)}{mR} \]

\[ = \frac{1}{\gamma-1}(T_3 - T_2) \]

= 0.253

(8.5)

\[ \frac{R \gamma}{\gamma - 1} = 3.5R, C_v = \frac{R}{\gamma - 1} = 2.5R \]

\[ mCp(T_3 - T_1) = 1750mR \]

\[ = mCv(T_2 - T_1) + \frac{mRT_2 \ln \frac{P_2}{P_3}}{\gamma-1} \]

\[ = 2032.66mR \]

\[ \frac{P_2}{P_3} = \frac{T_2}{T_1} \]

\[ \eta = 1 - \frac{Q_o}{Q_{in}} = 1 - \frac{1750mR}{2034.66mR} \]

= 0.14

(250)
\[
\begin{align*}
R &= C_p - C_v = 1.25 - 0.75 \\
&= 0.5 \text{kJ/kg.K} \\
Q_{12} &= W_{12} = mR \ln \frac{V_2}{V_1} \\
&= 1 \times 0.5 \times \ln \frac{1}{8} \frac{V_1}{V_1} \\
&= -322.313 \text{kJ} \\
\gamma &= \frac{C_p}{C_v} = 1.25/0.75 \\
&= 1.666 \\
V_1 &= \frac{mRT_1}{P_1} = \frac{1 \times 0.5 \times 310}{100} \\
&= 1.55 \text{m}^3 \\
P_2 &= \frac{mRT_2}{V_2} = \frac{1 \times 0.5 \times 310}{\frac{1}{8} \times 1.55} \\
&= 800 \text{kN/m}^2 \\
T_3 &= T_1 \left( \frac{P_3}{P_1} \right)^{\gamma-1} = 310 \left( \frac{800}{100} \right)^{1.66 - 1} \\
&= 712 \text{K} \\
\end{align*}
\]

\[
\begin{align*}
Q_{23} &= mC_p(T_3 - T_2) \\
&= 1 \times 1.25(712 - 310) \\
&= 502.5 \text{kJ} \\
V_3 &= \frac{V_2 T_3}{T_2} = \frac{1}{8} \frac{V_1 \times T_3}{T_2} \\
&= \frac{1}{8} \times 1.55 \times 712 \\
&= \frac{310}{8} \\
&= 0.445 \text{m}^3 \\
W_{23} &= P_2 (V_3 - V_2) \\
&= 800(0.445 - 0.193) \\
&= 201 \text{kJ} \\
\Delta U_{23} &= Q_{23} - W_{23} \\
&= 502.5 - 201 = 301.5 \text{kJ} \\
W_{31} &= -\Delta U_{31} \\
&= -mC_v(T_1 - T_3) \\
&= -1 \times 0.75(310 - 712) \\
&= 301.5 \text{kJ} \\
\sum W &= -322313 + 201 + 30 \\
&= 1802 \text{kJ}
\end{align*}
\]
\( R = 0.287 \text{kJ/kg.K}, \quad \gamma = 1.4 \)

\[
V_2 = V_1 \cdot \frac{T_2}{T_1} = 10^{-3} \times \frac{473}{288}
\]

\[
= 1.64 \times 10^{-3} \text{m}^3
\]

\[
V_3 = V_2 \cdot \frac{T_3}{T_2}^{\frac{1}{\gamma - 1}}
\]

\[
= 1.64 \times 10^{-3} \left( \frac{373}{473} \right)^{0.4}
\]

\[
= 2.973 \times 10^{-3} \text{m}^3
\]

\[
m = \frac{PV}{RT} = \frac{500 \times 0.001}{0.287 \times 288}
\]

\[
= 0.006 \text{kg}
\]

\[
C_v = \frac{R}{\gamma - 1} = \frac{0.287}{0.4}
\]

\[
= 0.718 \text{kJ/kg.K}
\]

\[
C_p = \frac{R \gamma}{\gamma - 1} = \frac{0.287 \times 1.4}{0.4}
\]

\[
= 1.005 \text{kJ/kg.K}
\]

\[
Q_{12} = mC_p \Delta T
\]

\[
= 0.006 \times 1.005(473 - 288)
\]

\[
= 1.12 \text{kJ}
\]
\[ P_2 = P_1 \left( \frac{V_1}{V_2} \right)^\gamma = 0.97 \times (18)^{1.4} \]
\[ = 56 \text{bar} = P_3 \]
\[ T_2 = T_1 \left( \frac{V_1}{V_2} \right)^{\gamma-1} \]
\[ = 333 \times (18)^{0.4} = 1060 \text{K} \]
\[ T_3 = T_2 + \Delta T \]
\[ = 1060 + 1220 = 2280 \text{K} \]
\[ \frac{V_3}{T_3} = \frac{V_2}{T_2} \Rightarrow \frac{V_3}{V_2} = \frac{T_3}{T_2} \]
\[ = \frac{2280}{1060} = 2.15 \]
\[ \frac{V_4}{V_3} = \frac{18}{2.15} = 8.35 \]
\[ P_4 = P_3 \left( \frac{V_3}{V_4} \right)^\gamma = 56 \left( \frac{1}{2.15} \right)^{1.4} \]
\[ = 2.87 \text{bar} \]
\[ T_4 = T_1 \left( \frac{P_4}{P_1} \right) = 333 \left( \frac{2.87}{0.97} \right) \]
\[ = 985 \text{K} \]
\[ C_v = \frac{C_p}{\gamma} = \frac{1.005}{1.4} \]
\[ = 0.718 \text{kJ/kg.K} \]
\[ q_{\text{in}} = C_p \Delta T = 1.005 \times 1220 \]
\[ = 1226 \text{kJ/kg} \]
\[ q_o = C_v \Delta T = 0.718 \times 652 \]
\[ = 468 \text{kJ/kg} \]
\[ w_{\text{net}} = q_{\text{in}} - q_o = 1226 - 468 \]
\[ = 758 \text{kJ/kg} \]
\[ P_2 = P_1 \left( \frac{V_1}{V_2} \right)^y = 1.1 \left( \frac{0.07}{0.01} \right)^{1.4} = 16.8 \text{ bar} \]

\[ P_3 = P_2 \left( \frac{V_3}{V_2} \right)^y = 16.8 \left( \frac{0.01}{0.07} \right)^{1.25} = 1.47 \text{ bar} \]

\[ W_{12} = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{110 \times 0.07 - 1680 \times 0.01}{1.4 - 1} = -22.8 \text{ kJ} \]

\[ W_{23} = \frac{P_2 V_2 - P_3 V_3}{n - 1} = \frac{1680 \times 0.01 - 147 \times 0.07}{1.25 - 1} = 26 \text{ kJ} \]

\[ \sum Q = \sum W \]

\[ Q_{12} + Q_{23} + Q_{31} = W_{12} + W_{23} + W_{31} \]

\[ O + Q_{23} + (-4.22) = -22.8 + 26 + 0 \]

\[ Q_{23} = 7.42 \text{ kJ} \]

\[ \Delta U_{12} = Q_{12} - W_{12} \]

\[ = 0 - (-22.8) = 22.8 \text{ kJ} \]

\[ \Delta U_{23} = Q_{23} - W_{23} \]

\[ = 7.42 - 26 = -18.58 \text{ kJ} \]

\[ \Delta U_{31} = Q_{31} - W_{31} \]

\[ = -4.22 - 0 = -4.22 \text{ kJ} \]
\( V_1 = V_4 = \frac{mRT_1}{P_1}, \quad V_3 = V_2 = \frac{mRT_3}{P_3} \)

\[
V_1 = \frac{V_4}{V_2} = \frac{mRT_1}{mRT_3} = \frac{P_3T_1}{P_1T_3} = \frac{0.5 \times 1000}{3 \times 300} = 0.55
\]

\[
Q_{12} = W_{12} = mRT_1 \ln \frac{V_2}{V_1} = 0.5 \times 4.124 \times 100 \ln \frac{1}{0.55} = 1212 \text{kJ}
\]

\[
Q_{34} = W_{34} = mRT_3 \ln \frac{V_4}{V_3} = 0.5 \times 4.124 \times 300 \ln 0.55 = 363.6 \text{kJ}
\]

\[
W_{\text{net}} = W_{12} + W_{34} = 1212 + (-363.6) = 848.4 \text{kJ}
\]

\[
\eta = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{300}{1000} = 0.7
\]
(3) \[ V_1 = \frac{mRT_1}{P_1} = 1 \times 0.29 \times 448 \]
\[ = 0.075\text{m}^3 \]
\[ V_2 = 3V_1 = 3 \times 0.075 \]
\[ = 0.225\text{m}^3 \]
\[ V_3 = 6V_1 = 6 \times 0.075 \]
\[ = 0.45\text{m}^3 \]
\[ P_2 = P_1 \frac{V_1}{V_2} = 1730 \times \frac{1}{3} \]
\[ = 576.7\text{kN/m}^2 \]
\[ T_3 = T_2 \left( \frac{V_2}{V_3} \right)^{\gamma-1} \]
\[ = 448 \left( \frac{0.225}{0.45} \right)^{1.4-1} = 340\text{K} \]
\[ P_3 = P_2 \left( \frac{V_2}{V_3} \right)^{\gamma} = 576.7 \left( \frac{1}{2} \right)^{1.4} \]
\[ = 219\text{kN/m}^2 \]

\[ T_1 = \frac{T_2}{T_3} = \frac{V_4}{V_1} \]
\[ = \left( \frac{V_3}{V_2} \right)^{\gamma-1} \]
\[ \therefore \frac{V_4}{V_1} = \frac{V_3}{V_2} = 2 \]
\[ V_4 = 2V_1 = 2 \times 0.075 \]
\[ = 0.15\text{m}^3 \]
\[ P_4 = P_3 \frac{V_3}{V_2} = 219 \frac{0.45}{0.15} \]
\[ = 657\text{kN/m}^2 \]
\[ \eta_{th} = 1 - \frac{T_{min}}{T_{max}} = 1 - \frac{340}{448} \]
\[ = 0.24 \]
\[ W = mR \ln \frac{V_2}{V_1} (T_1 - T_2) \]
\[ = 1 \times 0.29 \times \ln 3 (448 - 340) \]
\[ = 34.4\text{kJ} \]
\[
m = \frac{P_v}{RT} = \frac{5100 \times 0.032}{0.287 \times 1273} = 0.457 \text{kg}
\]
\[
P_2 = \frac{P_1 V_1}{V_2} = \frac{51 \times 0.032}{0.08} = 20.4 \text{bar}
\]
\[
P_3 = P_2 \left(\frac{T_3}{T_2}\right)^{\gamma-1} = 20.4 \left(\frac{541}{1273}\right)^{1.4/0.4} = 1.02 \text{bar}
\]
\[
V_4 = V_1 \left(\frac{T_1}{T_4}\right)^{1-1} = 0.032 \left(\frac{1273}{541}\right)^{0.4} = 0.256 \text{m}^3
\]
\[
P_4 = P_1 \left(\frac{T_4}{T_1}\right)^{\gamma-1} = 51 \left(\frac{541}{1273}\right)^{1.4/0.4} = 2.55 \text{bar}
\]
\[
Q_{in} = mRT_2 \ln \left(\frac{P_1}{P_2}\right) = 0.457 \times 0.287 \times 1273 \ln \frac{51}{20.4} = 152.9 \text{kJ}
\]
\[
Q_0 = mRT_3 \ln \frac{P_4}{P_3} = 0.457 \times 0.287 \times 541 \ln \frac{2.55}{1.02} = 63.45 \text{kJ}
\]
\[
\sum Q = Qin - Q_0 = 152.9 - 63.45 = 89.45 \text{kJ}
\]
\[
Q_{12} = W_{12} = 152.9 \text{kJ}
\]
\[
C_v = \frac{R}{\gamma - 1} = \frac{0.287}{1.4 - 1} = 0.718 \text{kJ/kg.K}
\]
\[
W_{23} = (U_2 - U_3) = mC_v(T_2 - T_3) = 0.457 \times 0.718(1273 - 541) = 240 \text{kJ}
\]
\[
Q_{34} = W_{34} = -63.45 \text{kJ}
\]
\[
W_{41} = -\Delta U_{41} = mC_v(T_4 - T_1) = 0.457 \times 0.718(541 - 1273) = -240.2 \text{kJ}
\]
\[
\sum W = 152.9 + 240.2 - 63.45 - 240.2 = 89.45 \text{kJ}
\]
\( \eta_c = 1 - \frac{T_{\text{min}}}{T_{\text{min}}} \Rightarrow 0.55 = 1 - \frac{T_{\text{min}}}{673} \)

\( T_{\text{min}} = 303 \text{K} \)

\( \frac{V_3}{V_2} = \left( \frac{T_2}{T_3} \right)^{\gamma - 1} = \left( \frac{673}{303} \right)^{1.4 - 1} = 7.1 \)

\( \frac{V_3}{V_1} = \left( \frac{V_3}{V_2} \right) \frac{V_2}{V_1} = 7.1 \times 2.8 = 19.9 \)

\( \eta_c = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{300}{700} = 0.57 \)

\( v_1 = \frac{RT_1}{P_1} = \frac{0.287 \times 700}{650} = 0.3 \text{ m}^3 \)

\( v_2 = 2v_1 = 2 \times 0.31 = 0.62 \text{ m}^3 \)

\( q_{12} = w_{12} = P_1 V_1 \ln \frac{V_2}{V_1} = 650 \times 0.31 \ln 2 = 139.66 \text{kJ} \)

\( w_{\text{net}} = \eta_c \times q_{\text{in}} = 0.57 \times 139.66 = 79.6 \text{kJ/kg} \)
(8.15)  \( \gamma = 1.399 \)

\[
T_2 = T_1 \left( \frac{V_2}{V_1} \right)^{\gamma-1} = 295(16)^{1.399-1} = 891.8K
\]

\[
\eta_c = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{Q_o}{Q_{\text{in}}}
\]

\[
1 - \frac{295}{891.8} = 1 - \frac{Q_o}{53}
\]

\[ Q_o = 17.53kJ \]

\[ W = Q_{\text{in}} - Q_o = 53 - 17.53 = 35.65kJ \]

(8.16)

\[ \eta_c = \frac{W}{Q_{\text{in}}} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{288}{533} = 0.46 \]

\[ W = Q_{\text{in}} \times \eta_c = 88 \times 0.46 = 40.4kW \]

\[ Q_o = Q_{\text{in}} - W = 88 - 40.4 = 47.6kW \]

(8.17)

\[ R = 0.29kJ/kg.K \]

\[ T_{\text{max}} = T_2 \frac{P_2 V_2}{R} = \frac{1500 \times 0.075}{0.29} = 388K \]

\[
\ln \frac{V_2}{V_1} = \frac{20}{0.29 \times 388} = 1.18
\]

\[ v_1 = 0.063m^3/kg \]

\[ \eta_c = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{280}{388} = 0.28 \]

\[ w = \eta \times q_{\text{in}} = 0.28 \times 20 = 5.6kJ/kg \]
\[
\eta_{th} = 1 - \frac{Q_o}{Q_{in}} = 1 - \frac{334}{418} = 0.2
\]
\[
\eta_{th} = 1 - \frac{T_{\min}}{T_{\max}}
\]
\[
0.2 = 1 - \frac{T_{\min}}{T_{\max}} = 1 - \frac{T_{\min}}{400} \Rightarrow T_{\min} = 320K
\]
(8.21)

\[ \eta = \frac{T_{\text{max}} - T_{\text{min}}}{T_{\text{max}}} \]

\[ \eta_a = \frac{(T_{\text{max}} + \Delta T) - T_{\text{min}}}{(T_{\text{max}} + \Delta T)} = \frac{T_{\text{max}} - T_{\text{min}} + \Delta T}{T_{\text{max}} + \Delta T} \quad \text{............(a)} \]

\[ \eta_b = \frac{T_{\text{max}} - (T_{\text{min}} - \Delta T)}{T_{\text{max}}} = \frac{T_{\text{max}} - T_{\text{min}} + \Delta T}{(T_{\text{max}})} \quad \text{............(b)} \]

\[ \eta_b > \eta_a \]

(8.22)

\[ \eta_{HE} = \frac{W}{Q_{in}} = \frac{450}{1000} = 0.45 \]

\[ \eta_{HE} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{300}{450} = 0.33 \]
(8.23)

\[ \text{a) } \eta = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} \]
\[ 0.4 = 1 - \frac{280}{T_{\text{max}}} \]
\[ T_{\text{max}} = 466.6K \]
\[ 0.5 = 1 - \frac{280}{T_{\text{max}}} \]

\[ \Delta T = T_{\text{max}} - T_{\text{max}} \]
\[ = 560 - 466.6 = 93.4K \]

\[ \Delta T = T_{\text{max}} - T_{\text{min}} \]
\[ = 466.6 - 280 = 186.66K \]

(8.24)

\[ (\text{COP})_{\text{ref}} = \frac{Q_{\text{in}}}{Q_{o} - Q_{\text{in}}} = 0.5 \frac{T_{\text{min}}}{T_{\text{max}} - T_{\text{min}}} \]
\[ = \frac{600}{Q_{o} - 600} = 0.5 \frac{200}{400 - 200} \]
\[ Q_{o} = 1800kJ \]
\[
\eta_{HE} = 1 - \frac{T_{min}}{T_{max}} = 1 - \frac{15}{273} = 0.661
\]

\[
W_{HE} = \eta_{HE} \times Q_{in_1} = 0.661 Q_{in_1} = W_{ref}
\]

\[
(COP)_{HP} = (COP)_{ref} + 1
\]

\[
\frac{1}{\eta_{HE}} = \frac{(Q_{in})_{ref}}{W_{ref}} + 1
\]

\[
1 = \frac{Q_{in_2}}{Q_{in_1}} + 1
\]

\[
\frac{0.661}{Q_{in_1}} = 3.1
\]

\[
Q_{in_1} = 30\,kJ
\]

\[
W = Q_{in} - Q_{o} = 117.6 - 30 = 87.6\,kJ
\]

\[
(COP)_{HP} = \frac{Q_{in}}{W} = \frac{T_{min}}{T_{max} - T_{min}}
\]

\[
= \frac{270}{87.6 - 30} = \frac{T_{min}}{306 - T_{min}}
\]

\[
T_{min} = 2.31K
\]
The power (450 kW) is supplied by a gas-fired boiler to a condensing water-fired boiler with a condensing efficiency of 83.27%. (43000 kJ/kg) at a mass flow rate of 0.015 kg/s. The condenser pressure is 0.015 kg/s. (220 K) and the maximum heating capacity is 450 kW. When the condenser pressure is 43000 kJ/kg, the heating capacity is 450 kW.

\[ Q_{in} = \frac{T_{min}}{0.015 \times 43000} = \frac{450}{645} = 0.698 \text{ kW} \]

\[ \eta_c = 1 - \frac{T_{min}}{T_{max}} = 1 - \frac{220}{306} = 0.735 \]

\[ \eta_{HE} = \frac{W}{Q_{in}} = \frac{450}{645} = 0.698 \text{ kW} \]

\[ \eta_c > \eta_{HE}, (\text{COP})_{ref} < (\text{COP})_{ref} \]

\[ (\text{COP})_c = \frac{T_{min}}{T_{max} - T_{min}} \]

\[ = \frac{220}{306 - 220} = 2.6 \]

\[ (\dot{W})_{HE} = \eta_c \times Q_{in} \]

\[ = 0.735 \times 645 = 474.4 \text{ kW} \]

\[ (\dot{Q}_o)_{HE} = (\dot{Q}_{in})_{ref} \]

\[ = \dot{Q}_{in} - \dot{W}_{HE} \]

\[ = 645 - 474.07 = 170.9 \text{ kW} \]

\[ \eta_c > \eta_{HE} \]

\[ (\text{COP})_{ref} = \frac{(Q_{in})_{ref}}{\dot{W}} \]

\[ = \frac{170.9}{474.07} = 0.361 \]

\[ \therefore (\text{COP})_c > (\text{COP})_{ref} \]

Therefore, the efficiency of the system is improved.
\( (COP)_{ref} = \frac{Q_{in}}{W} = \frac{T_{min}}{T_{max} - T_{min}} \)
\[ \frac{Q_{in}}{5 \times 60} = \frac{288}{311 - 255} \]
\[ \dot{Q}_{in} = 3756.52 \text{kJ/min} \]

\( \eta_C = 1 - \frac{T_{min}}{T_{max}} = 0.25 \Rightarrow T_{min} = 0.75 \)
\[ \text{COP} = \frac{Q_{in}}{W_{in}} = \frac{T_{min}}{T_{max} - T_{min}} = \frac{1}{T_{max} - T_{min}} = \frac{1}{0.75 - 1} = 3 \]
\[ W_{in} = \frac{200}{3} = 66.66 \text{kJ} \]
\[ \Delta s = \frac{Q}{T_{min}} = \frac{200}{278} = 0.72 \text{kJ/kg} \]

\( (COP)_{HP} = \frac{1}{\eta} = \frac{1}{0.20} = 5 \)
\[ (COP)_{HP} = (COP)_{ref} + 1 \]
\[ 5 = (COP)_{ref} + 1 \]
\[ (COP)_{ref} = 5 - 1 = 4 \]
\[
\frac{T_1}{T_4} = \frac{T_2}{T_3} = \frac{V_4}{V_1} = \frac{V_3}{V_2} = (\frac{T_1}{T_4})^{y-1} = (\frac{V_3}{V_2})^{y-1} \\
\therefore \frac{V_4}{V_1} = \frac{V_3}{V_2} = \frac{1}{(\frac{T_1}{T_4})^{y-1}} \\
= (\frac{533}{294})^{1.4-1} = 4.42
\]

\[
\frac{V_3}{V_4} = \frac{V_1}{V_2} = (\frac{T_1}{T_4})^{y-1} = (\frac{V_3}{V_2})^{y-1} \\
\frac{V_3}{V_4} = \frac{V_1}{V_2} = (\frac{T_1}{T_4})^{y-1} = (\frac{V_3}{V_2})^{y-1} \\
= 15. \frac{1}{4.42} = 3.39 \\
\eta = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{294}{533} = 0.45
\]

\[
\frac{Q_{\text{in}}}{\eta} = 750 = 2143 \text{kJ} \\
\frac{Q_{\text{o}}}{\eta} = W_{\text{net}} - Q_{\text{in}} = 750 - 2143 = -1393 \text{kJ}
\]

\[
\eta_{c} = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{300}{550} = 0.455 \\
\frac{Q_{\text{in}}}{\eta} = \frac{W_{\text{net}}}{0.455} = 1648 \text{kJ} \\
\frac{Q_{\text{o}}}{\eta} = W_{\text{net}} - Q_{\text{in}} = 750 - 1648 = -898 \text{kJ}
\]
\( C_p = 0.293 \text{kJ/kg. K}, \quad C_v = 0.209 \text{kJ/kg. K} \)

\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right) = \frac{6}{5} T_1
\]

\[
q_{12} = C_v \Delta T = 0.209 \left( \frac{6}{5} T_1 - T_1 \right)
= 0.042 T_1
\]

\[
T_3 = T_2 \left( \frac{V_3}{V_2} \right) = \frac{6}{5} T_1 \left( \frac{4}{V_1} \right) = \frac{3}{2} T_1
\]

\[
q_{23} = C_p \Delta T = 0.293 \left( \frac{3T_1}{10} \right)
= 0.088 T_1
\]

\[
T_4 = T_3 \left( \frac{P_4}{P_3} \right) = \frac{3}{2} T_1 \left( \frac{P_1}{5 T_1} \right) = \frac{5}{4} T_1
\]

\[
q_{34} = C_v \Delta T = 0.209 \left( \frac{5}{4} T_1 - \frac{3}{2} T_1 \right)
= -0.05 T_1
\]

\[
q_{41} = C_v \Delta T = 0.293 \left( T_1 - \frac{5}{4} T_1 \right)
= -0.07 T_1
\]

\[
q_{in} = q_{12} + q_{23} = 0.13 T_1
\]

\[
q_o = q_{34} + q_{41} = 0.12 T_1
\]

\[
w = q_{in} - q_o = 0.01 T_1
\]

\[
\eta = \frac{w}{q_{in}} = \frac{0.01 T_1}{0.13 T_1} = 0.077
\]

\[
\eta_C = 1 - \frac{T_1}{T_3} = \frac{T_1}{\frac{3}{2} T_1}
= 1 - 0.66 = 0.34
\]

\[
\frac{0.077}{0.34} = 0.226
\]
(8.1) 

\[ R = 0.287 \text{kJ/kg} \] 

(144.6 \text{kJ/kg} \text{ 166.3kJ/kg})

(8.2) 

\[ y = 32.58kJ \text{ 1.285} \]

(8.3) 

\[ (50\%) \]

(8.4) 

\[ (-24.12\text{kJ} \text{ 55.9kJ} \text{ 1.427}) \]
\( \text{8.5} \)

(15°C) 

\[ \log(PV^{1.4} = C) \]

\[ \text{R} = 0.287 \text{kJ/kg. K} \]

\[ \text{346.6kJ/kg , 346.7kJ/kg} \]

\( \text{8.6} \)

\[ \log(3.45\text{kN/m}^2) \]

\[ \text{R} = 0.29 \text{kJ/kg. K} \]

\[ \gamma = 1.4 \]

\[ \text{34.4kJ, 24.1%, 577.6kPa, 1733kPa, 657kPa} \]

\( \text{8.7} \)

\[ \text{R} = 0.29 \text{kJ/kg. K} \]

\[ \gamma = 1.4 \]

\[ \text{(34.4kJ, 24.1%, 577.6kPa, 1733kPa, 657kPa)} \]
(8.8)

\( \gamma = 1.4, \quad \text{Cp} = 1.005 \text{kJ/kg}. \text{K} \) 

\( \gamma \) : 

\( \gamma \) is the specific heat ratio of air.

(8.9)

\( \gamma = 1.4, \quad \text{Cp} = 1.005 \text{kJ/kg}. \text{K} \) 

(8.10)

\( \gamma = 1.4, \quad R = 0.278 \text{kJ/kg}. \text{K} \text{bar} \)
(8.11) ﻓﻴﻪ ﺍﻟﻤﺎﺀ ﺣﺭﺍﺭﺓ ﻤﻨﺭ ﺍﻟﻤﺎﻙ ﺛﺩﻱ ﻣﻘﺩﺍﺭ ﺛﺩﺤﺍﺭﺓ ﻥﺩﺭ ﻟﺍﺭ ﺛﺩﻭﺩ ﻭﺍﺭ ﺛﺩﺤﺍﺭﺓ ﻝ распространен ﺍﻟﻤﺎﺀ ﺩﺭﺠﺔ ﻥﺩﺭ ﺍﻟﻤﺎﻙ ﺛﺩﺤﺍﺭﺓ ﺛﺩﺤﺍﺭﺓ ﺛﺩﺤﺍﺭﺓ ﺍﻟﻜﺫﺭﺒﺎﺌﻴﺔ ﺍﻟﻁﺎﻗﺔ ﻟﺘﻭﻟﻴﺩ ﻣﺤﻁﺔ

(30000kW, 50000kW, 480K)

(8.12) ﻓﻴﻪ ﺍﻟﻤﺎﺀ ﺣﺭﺍﺭﺓ ﻤﻨﺭ ﺍﻟﻤﺎﻙ ﺛﺩﺤﺍﺭﺓ ﻣﺤﻁﺔ ﻣﺤﻁﺔ ﺍﻟﻤﺎﻙ ﺛﺩﺤﺍﺭﺓ ﺍﻟﻤﺎﻙ ﺛﺩﺤﺍﺭﺓ 

(175.46kJ, -0.2009kJ/K, 0.2009kJ/K, 118.58kJ, 56.88kJ)

(8.13) ﻓﻴﻪ ﺍﻟﻤﺎﺀ ﺣﺭﺍﺭﺓ ﻤﻨﺭ ﺍﻟﻤﺎﻙ ﺛﺩﺤﺍﺭﺓ ﻣﺤﻁﺔ 

(-0.135kJ/K, 0.135kJ/K, 38.7kJ)
\[ T_1 \text{ to } T_2 \text{:} Q_1 \text{ (heat at temperature } T_1 \text{ to } T_2 \text{)} \]

\[ T_3 \text{ to } T_4 \text{:} Q_2 \text{ (heat at temperature } T_3 \text{ to } T_4 \text{)} \]

\[ T_5 \text{ to } T_6 \text{:} Q_3 \text{ (heat at temperature } T_5 \text{ to } T_6 \text{)} \]

\[ T_7 \text{ to } T_8 \text{:} Q_4 \text{ (heat at temperature } T_7 \text{ to } T_8 \text{)} \]

\[ \text{Heat supplied to } \text{the system:} \quad Q = 72\text{kJ} \]

\[ \text{Heat transferred to water:} \quad Q = 75.6\text{kJ} \]

\[ Q_1 = 8.14\text{kJ} \]

\[ Q_2 = 8.15\text{kJ} \]

\[ Q_3 = 8.16\text{kJ} \]

\[ Q_4 = 8.17\text{kJ} \]

\[ T_1 = 60^\circ\text{C} \]

\[ T_2 = 30^\circ\text{C} \]

\[ T_3 = 120\text{kJ} \]

\[ T_4 = 27\text{kJ} \]

\[ T_5 = 72\text{kJ} \]

\[ T_6 = 75.6\text{kJ} \]

\[ T_7 = 20\text{kJ} \]

\[ T_8 = 1.534\text{kJ/h} \]

\[ T_9 = 7.67\text{kJ} \]

\[ T_{10} = 272 \]
(8.17)

تُعَرَّض لها الغلاف الأعلى لتصريف ليومي يمكنها أن تكون مخصصة لائزلاج أنبوب حرمك القبلي لم تكن في الحالة التي تم الإشارة إليها في تَعلِم في حالة بصرية حمضي في 300C (500C) سُطوف النفايات الممازنة في الغلاف الأعلى لتصريف ليومي يمكنها أن تكون مخصصة لائزلاج أنبوب حرمك القبلي لم تكن في الحالة التي تم الإشارة إليها في تَعلِم في حالة بصرية حمضي في 300C . كُن في حالة بصرية حمضي في 300C .

\[ R = 0.278 \text{kJ/kg} \quad K, \quad \gamma = 1.4 \]

(1.917bar , 2.5kJ/kg) : 

(8.18)

الحمم أو التدفق الغرفة . (50C) كانت تُستَرد (0.97bar) كان في الحالة التي تم الإشارة إليها في تَعلِم في حالة بصرية حمضي في 300C . دُوَّر إلى أن كان 930kJ/kg) سُطوف النفايات الممازنة لم يكن (\( \frac{1}{3} \))

: لُجِلَت وُجِدَت . دُوَّر إلى أن كان 930kJ/kg) سُطوف النفايات الممازنة لم يكن (\( \frac{1}{3} \))

\[ C_v = 0.717 \text{kJ/kg} \quad K, \quad \gamma = 1.4 \]

(8.19)

إذا فُرِض تدفق محور الحوصل لائزلاج أنبوب حرمك القبلي لم تكن في الحالة التي تم الإشارة إليها في تَعلِم في حالة بصرية حمضي في 300C . (4 0C) كانت تُستَرد (0.1kJ/kg.K)

: نِفَت . (1.5 bar) كان 30(2.2k/kg) كان 30(2.2k/kg) كان 30(2.2k/kg)

: لُجِلَت وُجِدَت . كان 30(2.2k/kg) كان 30(2.2k/kg) كان 30(2.2k/kg)

\[ R = 0.278 \text{kJ/kg} \quad K, \quad \gamma = 1.4 \]

(-0.1kJ/kg , 1.05bar,12.08) : 

(8.20)

إذا فُرِض تدفق محور الحوصل لائزلاج أنبوب حرمك القبلي لم تكن في الحالة التي تم الإشارة إليها في تَعلِم في حالة بصرية حمضي في 300C . (100C) كان 30(2.2k/kg) كان 30(2.2k/kg) كان 30(2.2k/kg)

\[ 7.075, \quad 8.075, \quad 70.75kW, \quad 80.75kW : \] 

(273)
(8.21) 

\[
\text{いただける } V = (27^\circ C) \text{ および } 1727^\circ C \text{ における } d \text{ および } \gamma \text{ に対する } G \text{ の } (200kJ/kg) \text{ の } \gamma \text{ である }
\]

\[
\gamma \text{ および } (C_p = 1.006kJ/kg \cdot K) \text{ および } (\gamma = 1.4) \text{ における } L_d \text{ および } d \text{ の } \frac{1}{2} \text{ (MN/m²) \text{ における } } T (\text{ K}) \text{ 。}
\]

\[
\text{および } (30kJ/kg, 162.6, 114.75, 108.4MN/m²) \text{ である 。}
\]

(8.22) 

\[
\text{أعنف (1000^\circ C) における } T \text{ には } 300 \text{ および } 27^\circ C \text{ における } T \text{ である 。}
\]

\[
(21600kJ/hr) \text{ における } K_l \text{ および } K_c \text{ における } (5kJW) \text{ における } P \text{ である 。}
\]

\[
\text{したがって } G \text{ における } L_k \text{ である 。}
\]

(83\%, 70\%) : 

(8.23) 

\[
\text{أعنف } P_e \text{ における } L_k \text{ および } 25^\circ C \text{ における } P \text{ は } T \text{ である 。}
\]

\[
(2400kJ/min) \text{ における } P \text{ および } P_k \text{ における } (5^\circ C) \text{ における } K \text{ は } T \text{ である 。}
\]

\[
(25\%) \text{ における } P_e \text{ および } P_c \text{ における } (COP) \text{ における } L_k \text{ および } K \text{ は } T \text{ である 。}
\]

\[
\text{したがって } K_k \text{ および } K_c \text{ における } T \text{ である 。}
\]

(16.11kJW) : 

(8.24) 

\[
(20^\circ C) \text{ および } 600^\circ C \text{ における } P \text{ および } T \text{ は } d \text{ および } \gamma \text{ である 。}
\]

\[
(800kJ) \text{ における } P \text{ および } T \text{ は } d \text{ および } \gamma \text{ である 。}
\]

\[
(1) \text{ における } V \text{ および } d \text{ である 。}
\]

\[
(336kJ, 579.3kJ, 0.42, 505.75kJW) \text{ である 。}
\]
(8.25)

المادة في درجة حرارة 17°C في غرفة تشبه الغرفة (50%) الترويج لزيادة كفاءة المواد في الغرفة. (62.4 bar) في غرفة ذات درجة حرارة 8.25°C (1.04 bar)

تعد (1): A(T-S)A(P-V) COP ترتبط بدرجة حرارة (γ=1.4) COP=1.005kJ/kg K

.لإظهار لدينا كفاءة الإذابة للكتلة (0.712 580K)

(8.26)

باستخدام منصات زجاجية (50°C) A(800°C) يؤدي لزيادة كفاءة المواد في الغرفة بدرجة حرارة 10°C وتشمل المواد في الغرفة (80kJ) COP ترتبط بدرجة حرارة (50°C) COP

.تعد (1): ألا لنعل لزمنا لزمنا A(T-S)A(P-V) COP ترتبط بدرجة حرارة (50°C) COP ترتبط بدرجة حرارة (73.53kJ 245.1kJ)

(8.27)

الخصائص معززة (1000kJ) في غرفة لتهوية ظل في درجة حرارة 20°C وتشمل المواد في الغرفة (20°C) COP ترتبط بدرجة حرارة (400°C) COP ترتبط بدرجة حرارة (50°C) COP ترتبط بدرجة حرارة (600kJ) COP ترتبط بدرجة حرارة (20°C) COP ترتبط بدرجة حرارة (0.11) COP ترتبط بدرجة حرارة (275)
(8.28)


(8.29)

(8.30)

(8.31)
(8.32)


(8.33)


(8.34)


(277)
Entropy Equation (9.1)

温度 - 熵图 (T-S) 方程 (9.2)
\[(T-S) \text{ work done - (9.1) unit}\]

(2) \[\int q(T) \text{ d}T \text{ or } \int q(S) \text{ d}S \]

\[
q = \sum_{s_1}^{s_2} TdS = \int_{s_1}^{s_2} TdS \quad \text{...............(9.1)}
\]

\[
dq =TdS \quad \text{...............(9.2)}
\]

\[
dS = \frac{dq}{T} \quad \text{...............(9.3)}
\]

\[
\Delta S = \int \frac{dq}{T} \quad \text{...............(9.4)}
\]

\[\int dQ(T) \text{ or } \int dQ(S) \text{ or } \int dQ^k(T) \text{ or } \int dQ^k(S) \]

\[\text{kJ/kg.K} \text{ or } \text{kJ/kg.K} \text{ or } \text{kJ/kg.K} \text{ or } \text{kJ/kg.K} \]

(278)
التأثرين ﷲ ﺑﻠـﻠــﺤـﺎـﻟــﻴـﻥ ﻭـ(1)

: ﻓـ(9.2-a) ﻳَــﺖـﻳـﺭ

\[
\text{dq} = T \text{d}S \Rightarrow \int \text{dq} = T \int \text{d}S \hspace{1cm} (9.5)
\]

\[
\therefore q = T \Delta S_{12} = \text{area1234} \hspace{1cm} (9.6)
\]

: \( q = T \Delta S_{12} = T(S_2 - S_1) = \text{area1234} \hspace{1cm} (9.9) \)

\[
\int \text{dq} = T \int \text{d}S = \sum T \text{d}S = 1234 \hspace{1cm} (9.8)
\]

\[
\therefore q = T \Delta S_{12} = T(S_2 - S_1) = \text{area1234} \hspace{1cm} (9.9)
\]

\[
\text{ــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــــ~(279)
\[ \int \frac{dq}{T} = \int \left( \frac{dq}{T} \right)_A + \int \left( \frac{dq}{T} \right)_B = 0 \]

\[ \therefore \int \left( \frac{dq}{T} \right)_A = -\int \left( \frac{dq}{T} \right)_B \] (9.10)

\[ \int \left( \frac{dq}{T} \right)_A = -\int \left( \frac{dq}{T} \right)_C \] (9.11)

\[ \int \left( \frac{dq}{T} \right)_B = \int \left( \frac{dq}{T} \right)_C \] (9.12)
\[ \int \frac{dq}{T} \]

(Clausius Inequality)

\[ \eta_C = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{Q_o}{Q_{\text{in}}} \Rightarrow T_{\text{min}} = \frac{Q_o}{Q_{\text{in}}} T_{\text{max}} = \frac{Q_o}{Q_{\text{in}}} \]

\[ \text{LHOO } (Q_o) \text{ LHOOG} \]

\[ \frac{Q_{\text{in}}}{T_{\text{max}}} = -\frac{Q_o}{T_{\text{min}}} \Rightarrow \frac{Q_{\text{in}}}{T_{\text{max}}} + \frac{Q_o}{T_{\text{min}}} = 0 \]

\[ \therefore \sum \frac{dQ}{T} = 0 \quad \text{OR} \quad \int \frac{dQ}{T} = 0 \]

\[ \text{In the diagram, the area under the curve is limited to the region between the curves of the initial and final states.} \]

\[ (efgh) \text{ is a closed cycle.} \]

\[ \text{The energy change for the cycle is given by} \]

\[ \oint \frac{dQ}{T} = 0 \]

\[ \text{(Diagram)} \]

(281)
سأذكر أن الفيلتر لاري إراتو إن إصال (1854) كان يضمن...

... 입。


\[ \eta_C (IRR) < \eta_C (REV) \Rightarrow 1 - \frac{T_{\text{min}}}{T_{\text{max}}} < 1 - \frac{Q_o}{Q_{\text{in}}} \Rightarrow \frac{Q_{\text{in}}}{T_{\text{max}}} < \frac{Q_o}{T_{\text{min}}}. \]

: إذاً فإن \( Q_o \) لا يُعتبر.

\[ \sum \frac{dQ}{T} < 0 \text{ OR } \int \frac{dQ}{T} < 0 \] .......................... (9.14)

سأذكر أن الفيلتر لاري إراتو إن إصال (1854) كان يضمن...


\[ \int \frac{dq}{T} = 0 \] .......................... (9.15)

: إذاً فإن \( Q_o \) لا يُعتبر.
\[ 9.5 \] (1)

\[ 9.5 \] (2)

\[ \Delta S_{12} = (1 \rightarrow 2') \cdot \Delta S_{22'} = \frac{T_2}{T_2'} + \Delta S_{22'} \]

\[ 0 + C V \ln \frac{T_2}{T_2'} = \Delta S_{22'} \]
Isentropic Efficiency: (9.6)

\[ PV^\gamma = C \]

\[ T = \text{Const} \]

\[ S \]

\[ \Delta s = 0 \]
\[ q' - w = \Delta \mu = C_v (T_2 - T_1) \]
\[ w = -C_v (T_2 - T_1) \] ................................. (9.16)
\[ q' - w = \Delta h = C_p (T_2 - T_1) \]
\[ w = -C_p (T_2 - T_1) \] ................................. (9.17)

\[ \Delta T = \frac{q - q_o}{w} \]

**Diagram**

- **Diagram 1:** Diagram of a process involving energy transfer.
- **Diagram 2:** Graph representing thermodynamic properties.
- **Diagram 3:** Schematic of a system with labeled components.

(285)
(9.9) \(\Delta(9.8)

\[
\eta_N = \frac{(C_2)^2a}{2} = \frac{(C_2)^2a}{(C_2)^2s} = \frac{\Delta h_a}{\Delta T_s} = \frac{\Delta T_a}{\Delta T_s} \quad \text{(9.18)}
\]

\[
\eta_D = \frac{P_{2a} - P_1}{P_{2s} - P_1} \quad \text{(9.19)}
\]

\[
\eta_T = \frac{w_a}{w_s} = \frac{\Delta h_a}{\Delta h_s} = \frac{\Delta T_a}{\Delta T_s} \quad \text{(9.20)}
\]

\[
\eta_C = \frac{w_s}{w_a} = \frac{\Delta h_s}{\Delta h_a} = \frac{\Delta T_s}{\Delta T_a} \quad \text{(9.21)}
\]


\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\gamma - 1} = 1110 \times \left( \frac{0.1035}{4.14} \right)^{0.286} = 747 \text{K} \]

\[ \eta_{IS} = \frac{\Delta T_a}{\Delta T_s} = \frac{\Delta T_a}{T_{2s} - T_1} \]

\[ \Delta T_a = 0.9 \times (1110 - 747) = 3267 \text{K} \]

\[ \Delta T_a = t_2 - t_1 = 125 - 15 = 110 \text{°C} \]

\[ w = \Delta h = C_p \Delta T = 1.005 \times 110 = 110.5 \text{kJ/kg} \]

\[ T_{2s} = T_1 \left( \frac{P_2}{P_1} \right)^{\gamma - 1} = 288 \left( \frac{2.38}{1} \right)^{0.4} \]

\[ \eta = \frac{\Delta T_s}{\Delta T_a} = \frac{82}{110} = 0.745 \]

\[ \eta_{IS} = \frac{\eta}{\omega} = \frac{5.4}{6.83} = 0.79 \]
\[ T_{2s} = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{\gamma - 1}{\gamma}} = 288 \left( \frac{4.14}{1.01352} \right)^{0.286} = 430 \text{K} \]

\[ \Delta T_s = T_{2s} - T_1 = 430 - 288 = 142 \text{K} \]

\[ w_s = C_p \Delta T_s = 1.005 \times 142 = 143 \text{KJ/Kg} \]

\[ \eta_{isc} = \frac{w_s}{w_a} \Rightarrow w_{ac} = \frac{143}{0.85} = 168 \text{kJ/kg} \]

\[ w_{ac} = w_{at} \]

\[ 168 = C_p(T_3 - T_4) = 1.005(1033 - T_4) \]

\[ T_4 = 866 \text{K} \]
\[ \gamma = 1.4 \quad C_p = 1.005 \text{ kJ/kg.K} \]

\[ T_{2S} = T_1 \left( \frac{P_2}{P_1} \right) ^{\frac{\gamma-1}{\gamma}} = 288 \times \left( \frac{6}{1.4} \right) ^{\frac{1.4-1}{1.4}} = 481 \text{K} \]

\[ \eta_{is} = \frac{\Delta T_s}{\Delta T_a} \Rightarrow 0.85 = \frac{481 - 288}{T_2 - 288} \]

\[ T_2 = 515 \text{K} \]

\[ T_{4S} = T_3 \left( \frac{P_4}{P_3} \right) ^{\frac{\gamma-1}{\gamma}} = 1000 \times \left( \frac{1}{6} \right) ^{\frac{1.4-1}{1.4}} = 599 \text{K} \]

\[ \eta_{isT} = \frac{\Delta T_a}{\Delta T_s} \Rightarrow 0.9 = \frac{1000 - T_4}{1000 - 599} \]

\[ T_4 = 639 \text{K} \]

\[ w_C = -C_p(T_1 - T_s) = -1.005 \times (515 - 288) = -288 \text{kJ/kg} \]

\[ w_T = -C_p(T_4 - T_s) = -1.005 \times (639 - 1000) = 363 \text{kJ/kg} \]

\[ w_{net} = w_C + w_T = -288 + 363 = 135 \text{kJ/kg} \]

\[ q_{23} = C_p(T_3 - T_2) = 1.005 \times (1000 - 515) = 487 \text{kJ/kg} \]

\[ \eta_{cycle} = \frac{w_{net}}{q_{23}} = \frac{135}{487} = 0.277 \]

\[ \text{kJ/kg} = \frac{\text{kW}}{\text{kg/s}} \quad \text{kW/kg.s} \]

\[ \text{kW..per..kg/s} \]
The pressure at 15°C is 1 bar, and the pressure at 650°C is 6 bar.

When the pressure is 1 bar and the temperature is 15°C, the gas enters. For example, a gas with a specific heat capacity of 1.005 kJ/kg·K enters. The gas is heated to 650°C, and the gas enters.

\[
\eta_{isC} = \frac{\Delta T_s}{\Delta T} = \frac{0.88}{T_2 - 288} = \frac{923 - T_4}{923 - 552} = 0.9
\]

\[
T_2 = 507 K
\]

\[
T_4 = 589 K
\]

\[
w_C = Cp(T_2 - T_1) = 1.005 \times (219) = 220 kJ/kg
\]

\[
w_T = Cp(T_4 - T_3) = 1.005 \times 334 = 336 kJ/kg
\]

\[
q_{in} = Cp(T_3 - T_2) = 1.005 \times 416 = 418 kJ/kg
\]

\[
q_o = Cp(T_4 - T_1) = 1.005 \times 301 = 303 kJ/kg
\]

\[
w_{net} = w_C + w_T = -220 + 336 = 116 kJ/kg
\]

\[
\eta = \frac{w_{net}}{q_{in}} = \frac{116}{418} = 0.277
\]

\[
\eta_{isT} = \frac{\Delta T_s}{\Delta T} = \frac{0.9}{T_2 - 288} = \frac{923 - T_4}{923 - 552} = 0.9
\]

\[
T_2 = 507 K
\]

\[
T_4 = 589 K
\]

\[
w_C = Cp(T_2 - T_1) = 1.005 \times (219) = 220 kJ/kg
\]

\[
w_T = Cp(T_4 - T_3) = 1.005 \times 334 = 336 kJ/kg
\]

\[
q_{in} = Cp(T_3 - T_2) = 1.005 \times 416 = 418 kJ/kg
\]

\[
q_o = Cp(T_4 - T_1) = 1.005 \times 301 = 303 kJ/kg
\]

\[
w_{net} = w_C + w_T = -220 + 336 = 116 kJ/kg
\]

\[
\eta = \frac{w_{net}}{q_{in}} = \frac{116}{418} = 0.277
\]

\[
\eta_{isT} = \frac{\Delta T_s}{\Delta T} = \frac{0.9}{T_2 - 288} = \frac{923 - T_4}{923 - 552} = 0.9
\]

\[
T_2 = 507 K
\]

\[
T_4 = 589 K
\]

\[
w_C = Cp(T_2 - T_1) = 1.005 \times (219) = 220 kJ/kg
\]

\[
w_T = Cp(T_4 - T_3) = 1.005 \times 334 = 336 kJ/kg
\]

\[
q_{in} = Cp(T_3 - T_2) = 1.005 \times 416 = 418 kJ/kg
\]

\[
q_o = Cp(T_4 - T_1) = 1.005 \times 301 = 303 kJ/kg
\]

\[
w_{net} = w_C + w_T = -220 + 336 = 116 kJ/kg
\]

\[
\eta = \frac{w_{net}}{q_{in}} = \frac{116}{418} = 0.277
\]
\[ \begin{align*} 
P_2 &= T_1 \left( \frac{P_2}{P_1} \right)^{\gamma-1} = 450 \left( \frac{300}{180} \right)^{\frac{1.667-1}{1.667}} = 3677\text{K}\ , 
C_{2s} &= \sqrt{2C_p(T_1-T_{2s})} 
&= \left[ 2 \times 5.19(450-367) \times 10^3 \right]^{\frac{1}{2}} = 928\text{ m/s}\ , 
C_{2a} &= \sqrt{2C_p(T_1-T_2)} 
&= \left[ 2 \times 5.19(450-373) \times 10^3 \right]^{\frac{1}{2}} = 894\text{ m/s}\ , 
\Delta s_{12} &= S_2 - S_1 
&= C_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} 
&= 5.19 \ln \frac{373}{450} - 2.078 \ln \frac{180}{300} = 0.088\text{kJ/kg.K}\ , 
kJ = 10^3 J = 10^3 \text{N.m} 
&= 10^3 \text{kg.m/s}^2\cdot\text{m} 
&= 10^3 \text{kg.m}^2/\text{s}^2 
kJ/\text{kg} = \frac{10^3 \text{kg.m}^2/\text{s}^2}{\text{kg}} = 10^3 \text{m}^2/\text{s}^2 
\end{align*} \]
\( T_{2S} = T_1 \left( \frac{P_2}{P_1} \right)^{\gamma-1} = 310(12)^{1\frac{4-1}{1.4}} \)

\( = 630.96K \)

\( T_{4S} = T_3 \left( \frac{P_4}{P_1} \right)^{\gamma-1} = 1566(12)^{0.286} \)

\( = 769.4K \)

\( w_{12S} = C_p(T_1 - T_{2S}) = 1.004(310 - 630.96) = -322.3kJ/kg \)

\( w_{34S} = C_p(T_3 - T_{4S}) = 1.004(1566 - 769.4) = 799.8kJ/kg \)

\( w_{\text{net}} = w_{34S} + (w_{12S}) = 796.1 + (-320.5) = 475.6kJ/kg \)

\( q_{2S3} = C_p(T_3 - T_{2S}) = 1.004(1566 - 630.96) = -938.8kJ/kg \)

\( \eta_{th} = \frac{w_{\text{net}}}{q_{2S3}} = \frac{475.6}{938.8} = 0.506 \)

\( \eta_c = \frac{T_{2S} - T_1}{T_{2a} - T_1} \)

\[ \Rightarrow 0.84 = \frac{630.96 - 310}{T_{2a} - 310} \]
(9.8) T_2 = \frac{P_2}{5P_1} = \frac{5.100}{500} = 0.01 \text{ kN/m}^2

\dot{W}_c = mC_p(T_1 - T_2)
= 10 \times 1.005(293 - 494) = -2020 \text{kW}

\gamma = 1.4 \quad \dot{C}_p = 1.005 \text{ kJ/kg.K}

(9.10)

\begin{align*}
T_{2s} &= T_1 \left(\frac{P_2}{P_1}\right)^{\gamma - 1} = 293(5)^{1.4} = 464 K \\
\eta_{is} &= \frac{\Delta T_s}{\Delta T_a} = \frac{T_2 - T_1}{T_2 - T_1} \\
0.85 &= \frac{464 - 293}{T_2 - 293}
\end{align*}

(9.11)

\gamma = 1.4 \quad \dot{C}_p = 1.005 \text{ kJ/kg.K}

\begin{align*}
R &= \frac{P_1}{\rho T} = \frac{93}{1.3 \times 288} = 0.248 \text{ kJ/kg.K} \\
C_p &= \frac{R_y}{\gamma - 1} = \frac{0.248 \times 1.38}{1.38 - 1} = 0.902 \text{ kJ/kg.K} \\
T_{2s} &= T_1 \left(\frac{P_2}{P_1}\right)^{\gamma - 1} = 288\left(\frac{200}{93}\right)^{1.38 - 1} = 353 K
\end{align*}

\begin{align*}
\eta_{is} &= \frac{\Delta T_s}{\Delta T_a} = \frac{T_{2s} - T_1}{\Delta T_a} \\
\Delta T_a &= \frac{T_{2s} - T_1}{0.82} = \frac{353 - 288}{0.82} = 82.0 K \\
\dot{W}_c &= mC_p\Delta T_a \\
&= 0.17 \times 0.902 \times 79.3 \\
&= 12.16 \text{kW}
\end{align*}
|

9.7

\[ \Delta S_{12} = \int_{1}^{2} \frac{dq}{T} = \int_{1}^{2} \frac{C_v dT}{T} = C_v \ln \frac{T_2}{T_1} \]  

(9.22)

9.10

Iso-choric process

\[ \Delta S_{12} = C_v \ln \frac{T_2}{T_1} \]  

(9.22)

9.11

Iso-baric process

\[ \Delta S_{12} = C_p \ln \frac{T_2}{T_1} \]  

(9.22)
 Isothermal Process

\[ \Delta S_{12} = \int \frac{dq}{T} = \int \frac{Pdv}{T} = \int \frac{RTdv}{vT} \]

\[ \therefore P = \frac{RT}{v} \]

\[ \therefore \Delta S_{12} = R \int \frac{dv}{v} = R \ln \frac{v_2}{v_1} \]..........................(9.24)

OR:

\[ \Delta S_{12} = \frac{q}{T} = \frac{RT \ln \frac{v_2}{v_1}}{T} = R \ln \frac{v_2}{v_1} \]..........................(9.25)

Adiabatic Process

\[ \Delta S_{12} = \int \frac{dq}{T} = 0 \]..........................(9.26)
Polytropic Process

(9.13) Šrückat... (9.14) Šrückat...

\[ \int \frac{dq}{T} = \int \frac{du}{T} + \int \frac{pdv}{T} = \int \frac{du}{T} + \int \frac{RTdv}{V} \]

\[ \Delta s_{12} = \int \frac{CvdT}{T} + R \int \frac{dv}{V} \]

\[ = C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1} \]

\[ \frac{\Delta S}{\Delta T} = \frac{\ln \frac{V_T}{V_N}}{T_N} \]
\[ \Delta s_{12} = C_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1} \]

\[ C_v = C_p - R \]

\[ \Delta s_{12} = (C_p \ln \frac{T_2}{T_1} - R \ln \frac{v_2}{v_1}) + R \ln \frac{v_2}{v_1} \]

\[ = C_p \ln \frac{T_2}{T_1} - R \ln \frac{v_2}{v_1} \]

\[ = C_p \ln \frac{T_2}{T_1} - R \ln \frac{p_2}{p_1} \]

\[ \Delta s_{12} = C_v \ln \frac{T_2}{T_1} + R \ln \frac{v_2}{v_1} \]

\[ R = C_p - C_v \]

\[ \Delta s_{12} = C_v \ln \frac{T_2}{T_1} (C_p \ln \frac{v_2}{v_1} - C_v \ln \frac{v_2}{v_1}) \]

\[ = C_p \ln \frac{v_2}{v_1} + C_v (\ln \frac{T_2}{T_1} - \ln \frac{v_2}{v_1}) \]

\[ = C_p \ln \frac{v_2}{v_1} + C_v \ln \frac{T_2}{T_1} \frac{v_1}{v_2} \]

\[ = C_p \ln \frac{v_2}{v_1} + C_v \ln \frac{p_2}{p_1} \]

\[ q = \frac{\gamma - n}{\gamma - 1} \cdot dw \]

\[ \int \frac{dq}{T} = \frac{\gamma - n}{\gamma - 1} \int \frac{p dv}{T} \]

\[ \Delta s_{12} = \frac{\gamma - n}{\gamma - 1} \cdot R \int \frac{dv}{v} \]

\[ = \frac{\gamma - n}{\gamma - 1} \cdot R \ln \frac{v_2}{v_1} = \frac{\gamma - n}{\gamma - 1} \cdot C_v (\gamma - 1) \ln \frac{v_2}{v_1} \]

\[ \Delta s_{12} = C_v (\gamma - n) \ln \frac{v_2}{v_1} \]

\[ \frac{p}{T} = \frac{R}{v} \]

\[ q = \frac{\gamma - n}{\gamma - 1} \cdot dw \]

\[ \int \frac{dq}{T} = \frac{\gamma - n}{\gamma - 1} \int \frac{p dv}{T} \]

\[ \Delta s_{12} = \frac{\gamma - n}{\gamma - 1} \cdot R \int \frac{dv}{v} \]

\[ = \frac{\gamma - n}{\gamma - 1} \cdot R \ln \frac{v_2}{v_1} = \frac{\gamma - n}{\gamma - 1} \cdot C_v (\gamma - 1) \ln \frac{v_2}{v_1} \]

\[ \Delta s_{12} = C_v (\gamma - n) \ln \frac{v_2}{v_1} \]

\[ \frac{p}{T} = \frac{R}{v} \]
\[
\begin{align*}
\frac{T_2}{T_1} &= \left(\frac{V_1}{V_2}\right)^{n-1} = \left(\frac{p_2}{p_1}\right)^{n-1} \\
\frac{1}{T_1} &= \left(\frac{V_1}{V_2}\right) = \left(\frac{p_2}{p_1}\right)^n \\
\frac{v_2}{v_1} &= \left(\frac{T_1}{T_2}\right)^{n-1} = \left(\frac{p_1}{p_2}\right)^n .........................(9.30)
\end{align*}
\]

<table>
<thead>
<tr>
<th>\text{1st Law of Thermodynamics}</th>
<th>\text{2nd Law of Thermodynamics}</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\Delta s_{12} = Cv(\gamma - n)\ln\frac{v_2}{v_1}]</td>
<td>[\Delta s_{12} = Cv(\gamma - n)\ln\frac{v_2}{v_1}]</td>
</tr>
<tr>
<td>[= Cv(\gamma - n)\ln\left(\frac{p_1}{p_2}\right)^n]</td>
<td>[= Cv(\gamma - n)\ln\left(\frac{p_1}{p_2}\right)^n]</td>
</tr>
</tbody>
</table>
| \[= Cv\frac{\gamma - n}{n}\ln\frac{p_1}{p_2} \] | \[= Cv\frac{\gamma - n}{n-1}\ln\frac{T_1}{T_2} \] | \[\Delta s_{12} = (\Delta s_{12})_{\text{heat transfer}} + (\Delta s_{12})_{\text{IRR}} \] 
\[= \int_1^2 \frac{dq}{T} + (\Delta s_{12})_{\text{IRR}} \] 
\[\Delta s_{12} > \int_1^2 \frac{dq}{T} \] \[\]
(T-S) (P-V) \( \text{C.O.P} \) (9.15) (9.8)

\[
\eta_{c,th} = \frac{W}{Q_{in}} = \frac{\text{area}(1 \rightarrow 2 \rightarrow 3 \rightarrow 4)}{\text{area}(1 \rightarrow 2 \rightarrow 6 \rightarrow 5)} = \frac{(T_{\max} - T_{\min})(S_2 - S_1)}{T_{\max}(S_2 - S_1)} = 1 - \frac{T_{\min}}{T_{\max}} \quad \text{(9.33)}
\]

\[
\text{C.O.P} = \frac{T_{\min}(S_4 - S_1)}{(T_{\max} - T_{\min})(S_4 - S_1)} = \frac{T_{\min}}{T_{\max} - T_{\min}} \quad \text{(9.34)}
\]
\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{n-1} = 823 \left( \frac{1.05}{6.3} \right)^{1.3-1} = 545K \]

\[ \Delta s_{12} = R \ln \frac{P_1}{P_2} - C_p \ln \frac{T_1}{T_2} = 0.287 \ln \frac{6.3}{1.05} - 1.005 \ln \frac{823}{545} = 0.1kJ/kg.K \]

\[ \Delta s_{12} = R \ln \frac{\nu_2}{\nu_1} = 0.287 ln \frac{2\nu_1}{\nu_1} = 0.199kJ/kg.K \]

\[ \Delta S_{12} = mR \ln \frac{P_1}{P_2} = 0.5 \times 0.287 \times \ln \frac{1}{5.2} = -0.237kJ/K \]
9.15

\[ R = \frac{\sum \frac{R}{M}}{28} = 0.297 \text{kJ/kg.K} \]

\[ m = \frac{PV}{RT} = 0.036 \text{kg} \]

\[ \Delta S_{12} = -mR \ln \frac{P_2}{P_1} \]

\[ = -0.0368 \times \frac{0.29}{1.05} \ln 4.2 \]

\[ = -0.01516 \text{kJ/kg} \]

\[ Q_{12} = T \Delta S_{12} \]

\[ = 288(-0.01516) = -4.37 \text{kJ} \]

\[ W_{12} = Q_{12} = -4.37 \text{kJ} \]

\[ V_2 = \frac{mRT_2}{P_2} = 0.007 \text{m}^3 \]

\[ W = mRT \ln \frac{V_2}{V_1} = -4.37 \text{kJ} \]

\[ \Delta S_{12} = \frac{Q_{12}}{T} \]

\[ = \frac{-4.37}{288} = -0.01516 \text{kJ/kg} \]

9.16

\[ \text{Exit: } (1.05 \text{bar}) \]

\[ \text{Entry: } (0.03 \text{m}^3) \]

\[ M = 28 \text{ kg/kmol} \]

\[ \text{Initial: } 1 \text{ kg} \]

\[ \text{Final: } 300 \text{ K} \]

\[ \text{Initial: } 2.5 \text{ bar} \]

\[ \text{Final: } 310 \text{ K} \]

\[ \text{CP} = 1.005 \text{ kJ/kg.K}, \text{ Cv} = 0.718 \text{ kJ/kg.K} \]

\[ \Delta S_{12} = C_P \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \]

\[ = 1.005 \ln \frac{310}{300} - R \ln \frac{2.5}{1} \]

\[ = -0.2 \]

\[ = -0.23 \text{ kJ/kg.K} \]

\[ \Delta U = mC_P \Delta T \]

\[ = 1 \times 0.718(310 - 300) = 718 \text{kJ} \]

\[ Q = \Delta U + W \]

\[ = 7.18 + (-10) = -2.82 \text{kJ} \]

\[ \Delta S = \frac{Q}{T} = \frac{2.82}{300} = 0.0094 \text{kJ/K} \]

(301)
\[ (9.17) \]

\[ \text{R} = 0.287 \text{kJ/kg.K}, \quad \text{Cv} = 0.718 \text{kJ/kg.K} \]

\[ m = \frac{P_1 V_1}{RT_1} = \frac{105 \times 0.02}{0.287 \times 288} = 0.0254 \text{kg} \]

\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right) = 288 \left( \frac{4.2}{1.05} \right) = 1152 \text{K} \]

\[ Q_{12} - W_{12} = \Delta U_{12} = m \text{Cv}(T_2 - T_1) = 0.0254 \times 0.718 \times (1152 - 288) = 15.75 \text{kJ} \]

\[ Q_{23} = m \text{Cp}(T_3 - T_2) = 0.0254 \times 1.005(288 - 1152) = -22.05 \text{kJ} \]

\[ Q_{31} = Q_{12} + Q_{23} = 15.75 - 22.05 = -6.3 \text{kJ} = Q_0 \]

\[ \Delta S_{31} = m \text{Cp} \ln \frac{T_3}{T_1} - m \text{R} \ln \frac{P_2}{P_1} = -0.0254 \times 0.287 \times \ln \frac{4.2}{1.05} = -0.01 \text{kJ/K} \]
\( R = 0.29 \text{ kJ/kg.K} \)

1 \( \Rightarrow \) 2'

\[ T_{2'} = T_1 \left( \frac{V_1}{V_2} \right)^{\gamma^{-1}} \]

\[ = 288 \left( \frac{1}{4} \right)^{\gamma^{-1}} = 501.1 \text{K} \]

\[ w' = \frac{R(T_1 - T_2)}{\gamma^{-1}} \]

\[ = -\frac{0.287(501.1 - 288)}{1.4 - 1} \]

\[ = -152.9 \text{kJ/kg} \]

\( \Delta S_{12'} = 0 \)

1 \( \Rightarrow \) 2

\[ T_2 = 501.1 + 6.6 = 507.7 \text{K} \]

\[ w = -\Delta u_{12} = -C_v(T_2 - T_1) \]

\[ = -\frac{R(T_2 - T_1)}{\gamma - 1} \]

\[ = -\frac{0.29(507.7 - 288)}{1.4 - 1} \]

\[ = -157.6 \text{kJ/kg} \]

\[ \Delta s_{2'2} = C_v \ln \frac{T_2}{T_{2'}} = \frac{R}{\gamma - 1} \ln \frac{T_2}{T_{2'}} \]

\[ = 0.0093 \text{kJ/kg.K} \]
\( \text{R} = 0.287 \text{kJ/kg.K} \)

\[
m = \frac{PV}{RT} = \frac{105 \times 0.02}{0.287 \times 288} = 0.0254 \text{kg}
\]

\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right) = 288 \left( \frac{4.2}{1.05} \right) = 1152 \text{K}
\]

\[
Q_{12} = mC_v(T_2 - T_1) = 0.0254 \times 0.718(1152 - 288) = 15.75 \text{kJ}
\]

\[
Q_{23} = mC_p(T_3 - T_2) = 0.0254 \times 1.005(288 - 115.2) = -22.05 \text{kJ}
\]

\[
\sum Q = Q_{12} + Q_{23} = 15.75 - 22.05 = -6.3 \text{kJ}
\]

\[
\Delta S_{12} = mC_v \ln \frac{T_2}{T_1} = 0.0254 \times 0.718 \ln \frac{1152}{288} = 0.0253 \text{kJ/kg}
\]

\[
\Delta S_{23} = mC_p \ln \frac{T_3}{T_2} = 0.0254 \times 1.005 \ln \frac{288}{115} = 0.0354 \text{kJ/kg}
\]

\[
\Delta S_{31} = 0.0354 - 0.0253 = 0.0101 \text{kJ/K.}
\]
\( C_p = 1.041 \text{kJ/kg.K} \), \( C_v = 0.743 \text{kJ/kg.K} \)

\[
R = C_p - C_v = 1.041 - 0.743 = 0.298 \text{kJ/kg.K}
\]

\[
m = \frac{P_1 V_1}{RT} = \frac{140 \times 0.14}{0.298 \times 298} = 0.221 \text{kg}
\]

\[
V_2 = V_1 \left( \frac{P_1}{P_2} \right)^{\frac{1}{n}} = 0.14 \left( \frac{140}{1400} \right)^{\frac{1}{1.25}}
\]

\[
= 0.022 \text{m}^3
\]

\[
\Delta s_{12} = C_p \ln \frac{V_2}{V_1} + C_v \ln \frac{P_2}{P_1} = 1.041 \ln \frac{0.0222}{0.14} + 0.743 \ln \frac{1400}{140}
\]

\[
= -0.205 \text{kJ/kg.K}
\]

\[
\Delta S_{12} = m \Delta s_{12} = 0.221 \times (-0.205) = -0.0453 \text{kJ/K}
\]

\[
W_{12} = \frac{P_1 V_1 - P_2 V_2}{n - 1} = \frac{140 \times 0.14 - 1400 \times 0.0222}{1.25 - 1} = -46.0 \text{kJ}
\]

\[
Q_{12} = \frac{\gamma - n}{\gamma - 1} \cdot W_{12} = \frac{1.4 - 1.25}{1.4 - 1} \times (-46) = -17.25 \text{kJ}
\]
\( \Delta s_{12} = 0 \)

\[
T_1 = \frac{P_1 V_1}{mR} = \frac{100 \times 0.3}{0.5 \times 0.189} = 317.46 \text{K}
\]

\[
T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1} = 317.46 \left(\frac{V_1}{0.25V_1}\right)^{0.306} = 485.2 \text{K}
\]

\[
P_2 = P_1 \left(\frac{V_1}{V_2}\right)^\gamma = 100 \left(\frac{V_1}{0.25V_1}\right)^{1.306} = 611.35 \text{kJ/m}^2
\]

\[
V_3 = \frac{mRT_3}{P_3} = \frac{0.5 \times 0.189 \times 317.46}{611.35} = 0.05 \text{m}^3
\]

\[
\Delta S_{23} = mC_p \ln \frac{T_3}{T_2} = m \cdot \frac{\gamma}{\gamma-1} \ln \frac{T_3}{T_2} = 0.5 \frac{0.189 \times 1.366}{1.306 - 1} \times \ln \frac{317.46}{485.2} = 0.171 \text{kJ/kg}
\]

\[\text{(9.22)}\]

\[\text{Cp}=1.01 \text{kJ/kg.K}, \ R=0.287 \text{kJ/kg.K}\]

\[
m = \frac{P_1 V_1}{RT_1} = \frac{100 \times 0.02}{0.287 \times 293} = 0.0238 \text{kg}
\]

\[
C_v = C_p - R = 1.01 - 0.287 = 0.723 \text{kJ/kg.K}
\]

\[
T_2 = T_1 \left(\frac{P_2}{P_1}\right) = 293 \left(\frac{5}{1}\right) = 1465 \text{K}
\]

\[
\Delta S_{12} = mC_v \ln \left(\frac{P_2}{P_1}\right) = 0.0238 \times 0.723 \ln \left(\frac{5}{1}\right) = 0.0277 \text{kJ/K}
\]

\[\Delta S_{31} = \Delta S_{12} + \Delta S_{23} = -0.011 \text{kJ/K} \]

\[\text{(306)}\]
\[ R = 0.287 \text{kJ/kg.K} \quad \text{and} \quad C_v = 0.718 \text{kJ/kg.K} \]

\[ m = \frac{P_1 V_1}{R T_1} = \frac{103 \times 0.056}{0.287} = 0.0647 \text{kg} \]

\[ T_2 = \frac{P_2 T_1}{P_1} = \frac{1.72 \times 311}{1.03} = 520 \text{K} \]

\[ \Delta U_{12} = m C_v (T_2 - T_1) = 0.0647 \times 0.718 \times 209 = 9.7 \text{kJ} = Q_{12} \]

\[ T_3 = \frac{V_3 T_2}{V_2} = \frac{0.126 \times 520}{0.056} = 1170 \text{K} \]

\[ Q_{23} = m C_p (T_3 - T_2) = 0.0647 \times 1.005(650) = 42.23 \text{kJ} \]

\[ W_{23} = P (V_3 - V_2) = 172(0.126 - 0.056) = 12.05 \text{kJ} \]

\[ \Delta U_{23} = Q_{23} - W_{23} = 42.23 - 12.05 = 30.18 \text{kJ} \]

\[ \sum U = \Delta U_{12} + \Delta U_{23} = 9.7 + 30.18 = 39.88 \text{kJ} \]

\[ \Delta S_{12} = m C_v \ln \frac{T_2}{T_1} = 0.0647 \times 0.718 \ln \frac{520}{311} = 0.0238 \text{kJ/K} \]

\[ \Delta S_{23} = m C_p \ln \frac{T_3}{T_2} = 0.0647 \times 1.005 \ln \frac{1170}{520} = 0.0527 \text{kJ/K} \]

\[ \sum \Delta S = \Delta S_{12} + \Delta S_{23} = 0.0238 + 0.0527 = 0.0765 \text{kJ/K} \]
\[ \Delta S_{12} = \Delta S_{23} \]
\[ mC_p \ln \frac{T_2}{T_1} = mC_v (\frac{n-\gamma}{n-1}) \ln \frac{T_3}{T_2} \]
\[ mC_p \ln \frac{T_2}{T_1} = mC_v (\frac{\gamma-n}{n-1}) \ln \frac{T_2}{T_1} \]
\[ C_p = C_v (\frac{\gamma-n}{n-1}) \]
\[ \gamma = \left( \frac{\gamma-n}{n-1} \right) \]
\[ n = \frac{2\gamma}{\gamma + 1} = \frac{2C_p}{C_p + C_v} = \frac{2C_p}{C_p + C_v} = \frac{2C_p}{C_p + C_v} \]

\[ R = 0.287 \text{ kJ/kg.K} \]

\[ \eta = \frac{T_{\text{min}}}{T_{\text{max}}} = \frac{293}{673} = 0.565 \]

\[ \Delta S_{12} = mR \ln \frac{V_2}{V_1} \]
\[ \ln \frac{V_2}{V_1} = \frac{\Delta S_{12}}{mR} = \frac{0.1}{0.5 \times 0.287} = 0.697 \]
\[ V_2 = V_1 e^{0.697} = 2 \]

\[ W_T = mR \ln \frac{V_2}{V_1} (T_1 - T_3) \]
\[ = 0.5 \times 0.287 \times 0.697 (673 - 293) = 38.6 \text{ kJ} \]

\[ Q_{\text{in}} = mRT \ln \frac{V_2}{V_1} \]
\[ = 0.5 \times 0.287 \times 673 \times 0.697 = 67.3 \text{ kg} \]
\[ W_T = \eta Q_{\text{in}} = 0.565 \times 67.3 = 38 \text{ kg} \]
\[
\begin{align*}
q_{12} &= q_o = RT_1 \ln \frac{V_2}{V_1} \\
&= 0.287 \times 560 \ln \frac{1}{2} \\
&= -11.4 \text{kJ/kg}
\end{align*}
\]

\[
\frac{P_2}{P_1} = \frac{V_1}{V_2} = 2
\]

\[
T_3 = T_1 \left( \frac{P_2}{P_1} \right)^{\gamma-1} \\
= 560(2)^{0.287} = 683.2 \text{K}
\]

\[
q_{23} = q_{in} \\
= 1 \times (683.2 - 560) \\
= 123.2 \text{kJ/kg}
\]

\[
\begin{align*}
\eta_{\text{cycle}} &= 1 - \frac{q_o}{q_{in}} = 1 - \frac{111.4}{123.2} \times 0.1 \\
\eta_c &= 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{560}{683.2} = 0.18 \\
\Delta s_{12} &= R \ln \frac{V_2}{V_1} \\
&= 0.287 \ln \frac{1}{2} = -0.199 \text{kJ/kg.K} \\
\Delta s_{12} &= C_p \ln \frac{T_2}{T_1} \\
&= 1 \times \left( \frac{683.2}{560} \right) = 0.198 \text{kJ/kg.K} \\
\Delta s_{31} &= 0
\end{align*}
\]
\[
\gamma = 1.4, \quad R = 0.288 \text{ kJ/kg.K}
\]

\[
\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} = \left(\frac{28}{2}\right)^{\frac{1}{1.3}} = 7.62
\]

\[
\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{28}{2}\right)^{\frac{0.3}{1.3}} = 1.838
\]

\[
\Delta S_{12} = mC_v \left(\frac{n-\gamma}{n-1}\right) \ln \frac{T_2}{T_1} = \frac{mR(n-\gamma)}{(\gamma-1)(n-1)} \ln \frac{T_2}{T_1}
\]

\[
= \frac{1.2 \times 0.288 \times (1.3 - 1.4)}{(1.4 - 1)(1.3 - 1)} \times \ln 1.838
\]

\[
= -0.175 \text{ kJ/K}
\]

\[
V_2 = V_1 \left(\frac{P_1}{P_2}\right)^{\frac{1}{n}}
\]

\[
= 0.5 \times \left(\frac{2}{28}\right)^{\frac{1}{1.4}} = 0.07 \text{ m}^3
\]

\[
W_{12} = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{200 \times 0.5 - 2800 \times 0.07}{1.3 - 1} = -279 \text{ kJ} = Q_o
\]

\[
T_2 = \frac{P_2V_2}{mR} = \frac{2800 \times 0.07}{1.2 \times 0.288} = 531.5 \text{ K}
\]

\[
W_{23} = Q_{23} = mR \ln \frac{V_3}{V_2} = mR \ln \frac{V_1}{V_2}
\]

\[
= 1.2 \times 0.288 \times 531.5 \times \ln \frac{0.5}{0.07}
\]

\[
= 373.06 \text{ kJ}
\]

\[
Q_{in} = 373.06 \text{ kJ}
\]

\[
\eta = \frac{Q_{in} - Q_o}{Q_{in}} = \frac{373.06 - 279}{373.06} = 0.25
\]
(9.28)
\[ t_m = \frac{m_1C_1t_1 + m_2C_2t_2}{m_1C_1 + m_2C_2} = 35.2K \]
\[ \Delta S_{\text{Fe}} = mC\ln\frac{T_m}{T_1} = -0.053K/J/K \]
\[ \Delta S_{\text{Cu}} = mC\ln\frac{T_m}{T_2} = 0.059K/J/K \]
\[ \Delta S_{T} = -0.053 + 0.059 = 0.006K/J/K \]

(9.29)
\[ \Delta S = \frac{Q}{T} = \frac{W}{T} = \frac{P_1V_1\ln\frac{V_2}{V_1}}{T} \]
\[ = \frac{700 \times 0.014}{423} \ln\frac{0.084}{0.014} = 0.0416K/J/K \]

(9.30)
\[ V_1 = \frac{mRT_1}{P_1} = \frac{1.5 \times 0.296 \times 280}{100} = 1.24m^3 \]
\[ T_2 = T_1\left(\frac{V_1}{V_2}\right)^{n-1} = 280\left(\frac{1.24}{0.2076}\right)^{1.3-1} = 479.1K \]
\[ W_{12} = \frac{mR(T_1 - T_2)}{n-1} = \frac{1.5 \times 0.296(-199)}{1.3 - 1} = -295KJ \]
\[ Q = \gamma - \frac{W}{\gamma - 1} = \frac{1.4 - 1.3}{1.4 - 1} \times (-295) = -73.75KJ \]
\[ \Delta S = \frac{Q}{T} = \frac{-73.75}{280} = -0.26K/J/K \]

Cp=1.035 kJ/kg.K, R=0.2966 kJ/kg.K
\[ Cv = Cp - R = 1.035 - 0.296 = 0.739K/J/kg.K \]
\[ \gamma = \frac{Cp}{Cv} = 1.4 \]
\[ Q = \gamma - nW \]
\[ \frac{1.4 - 1.3}{1.4 - 1} \times (-295) = -73.75KJ \]
\[ \Delta S = \frac{Q}{T} = \frac{-73.75}{280} = -0.26K/J/K \]
\[
\begin{align*}
T_2 &= T_1 \left( \frac{P_2}{P_1} \right) = 303 \left( \frac{1.3}{0.95} \right) = 414 \text{K} \\
Q_{12} &= mC_v \Delta T_{12} \\
&= 0.05 \times 0.74(414 - 303) = 4.1 \text{kJ} \\
\Delta S_{12} &= mC_v \ln \frac{T_2}{T_1} \\
&= 0.05 \times 0.74 \ln \frac{414}{303} = 0.011 \text{kJ/K} \\
\end{align*}
\]

\[
\begin{align*}
T_3 &= T_1 \left( \frac{P_3}{P_1} \right)^{\frac{n}{n-1}} = 300 \left( \frac{600}{200} \right)^{0.15} = 346.2 \text{K} \\
Q_o &= Q_{23} = mC_p \Delta T \\
&= 4 \times 1.55(346.2 - 900) = -3433.4 \text{kJ} \\
\Delta S_{12} &= mC_v \ln \frac{T_2}{T_1} = 4 \times 1.25 \ln \frac{900}{300} = 5.5 \text{kJ/K} \\
\Delta S_{23} &= mC_p \ln \frac{T_3}{T_2} = 4 \times 1.55 \ln \frac{346.2}{900} = -6 \text{kJ/K} \\
\gamma &= C_p / C_v = 1.55 / 1.25 = 1.24 \\
\Delta S_{31} &= mC_v \frac{n - \gamma}{n - 1} \ln \frac{T_1}{T_3} \\
&= 4 \times 1.25(-0.6) \ln \frac{300}{346.2} = 0.43 \text{kJ/K} \\
\end{align*}
\]
\[
C_p = 1.006 \text{kJ/kg.K} \quad \text{and} \quad C_v = 0.717 \text{kJ/kg.K}
\]

\[
R = C_p - C_v = 1.006 - 0.717 = 0.289 \text{kJ/kg.K}
\]

\[
V_1 = \frac{mRT_1}{P_1} = \frac{0.3 \times 0.289 \times 308}{350} = 0.0763 \text{m}^3
\]

\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right) = 308 \left( \frac{700}{350} \right) = 616 \text{K}
\]

\[
\Delta s_{12} = C_v \ln \left( \frac{P_2}{P_1} \right) = 0.717 \ln \left( \frac{700}{350} \right) = 0.496 \text{kJ/kg.K} \quad \Rightarrow \Delta s_{12} \cdot m = 0.496.03 = 1.488 \text{kJ/kg.K}
\]

\[
\text{and (1) } \Delta s_{23} = C_p \ln \left( \frac{T_3}{T_2} \right)
\]

\[
\text{and (2) } \Delta s_{23} = C_p \ln \left( \frac{T_3}{T_2} \right) + R \ln \left( \frac{V_3}{V_2} \right)
\]
\[
R = \frac{C_p - C_v}{-1} = 1.041 - 0.743
\]
\[
= \frac{0.298 \times 1000}{298} \times 0.14 = 0.298 \times 0.14
\]
\[
m = \frac{P_1 V_1}{R T_1} = \frac{140 \times 0.0221}{0.298 \times 0.14} = 0.221 \text{ kg}
\]
\[
V_2 = V_1 \left( \frac{P_1}{P_2} \right)^{\frac{1}{n}} = 0.14 \left( \frac{140}{1400} \right)^{1.25} = 0.022 \text{ m}^3
\]
\[
\Delta s_{12} = C_p \ln \frac{V_2}{V_1} + C_v \ln \frac{P_2}{P_1} = 1.041 \ln \frac{0.0222}{0.14} + 0.743 \ln \frac{1400}{140}
\]
\[
= -0.205 \text{ kJ/kg.K}
\]
\[
\Delta S_{12} = \Delta s \times m = -0.205 \times 0.221 = -0.0453 \text{ kJ/K}
\]
\[
W = \frac{P_1 V_1 - P_2 V_2}{n - 1} = \frac{140 \times 0.14 - 1400 \times 0.0222}{1.25 - 1} = -46 \text{ kJ}
\]
\[
\gamma = \frac{C_p}{C_v} = \frac{1.041}{0.743} = 1.4
\]
\[
\frac{\gamma - n}{\gamma - 1} W = \frac{1.4 - 1.25}{1.4 - 1} \times (-46) = -17.25 \text{ kJ}
\]
\[
T_2 = T_1 \left( \frac{V_1}{V_2} \right)^{n-1} = 298(6.3)^{1.25-1} = 472 \text{ K}
\]
\[
\frac{472 + 298}{2} = 385 \text{ K}
\]
\[
\Delta S = \frac{Q}{T} = \frac{-17.25}{385} = -0.0448 \text{ kJ/K}
\]
\[
\Delta s_1 = C_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}
\]
\[
\Delta s_2 = C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}
\]
\[
\Delta s_3 = C_v (\gamma - n) \ln \frac{V_2}{V_1}
\]
\[
\Delta s_4 = C_v \frac{\gamma - n}{n - 1} \ln \frac{T_1}{T_2}
\]
\[
\Delta s_5 = C_v \frac{\gamma - n}{n} \ln \frac{P_1}{P_2}
\]
\[
\Delta s = -0.205 \text{ kJ/kg.K}
\]
\( \Delta S_{12} = \Delta S_{23} \)

\[
mCp \ln \frac{T_2}{T_1} = mCv \ln \frac{T_1}{T_2} \left( \frac{n - \gamma}{n - 1} \right)
\]

\[
\frac{n - \gamma}{n - 1} = \frac{Cp \ln \frac{T_2}{T_1}}{Cv \ln \frac{T_1}{T_2}} = \frac{-Cp \ln \frac{T_1}{T_2}}{Cv \ln \frac{T_1}{T_2}} = -\gamma
\]

\[
\frac{n - 1.4}{n - 1} = -1.4 \quad n = 1.17
\]
\( R = 0.029 \text{ kJ/kg.K} \quad \hat{C}_p = 0.532 \text{ kJ/kg.K} \)

1 \( \Rightarrow \) 2

\[ T_2 = T_1 \left( \frac{V_2}{V_1} \right) = 300 \times 2 \]
\[ = 600 \text{K} \]

\[ Q_{12} = mC_p(T_2 - T_1) \]
\[ = 1 \times 0.532 \times 300 = 159.6 \text{kJ} \]

\[ W_{12} = mR \Delta T_{12} \]
\[ = 1 \times 0.029 \times 300 = 37.2 \text{kJ} \]

\[ \Delta U_{12} = Q_{12} - W_{12} \]
\[ = 159.6 - 37.2 = 122.4 \text{kJ} \]

\[ \Delta S_{12} = mC_p \ln \frac{T_2}{T_1} \]
\[ = 1 \times 0.532 \ln \frac{600}{300} = 0.369 \text{kJ/K} \]

2 \( \Rightarrow \) 3

\[ \Delta S_{23} = -\Delta S_{12} = -0.369 \text{kJ/K} \]

\[ Q_{23} = T_2 \Delta S_{23} \]
\[ = 600 \times (-0.369) \]
\[ = -221.4 \text{kJ} = W_{23} \]

3 \( \Rightarrow \) 4

\[ Q_{23} = mR T_2 \ln \frac{V_3}{V_2} \]
\[ 221.4 = 1 \times 0.029 \times 600 \ln \frac{V_3}{V_2} \]

\[ \therefore \frac{V_3}{V_2} = 19.5 \]
\( \gamma = 1.4 \) \( \bar{U} R = 0.287 \text{ kJ/kg.K} \)

**A**

\[
\nu_1 = \frac{RT_1}{P_1} = \frac{0.287 \times 288}{100} = 0.827 \text{ m}^3 / \text{kg}
\]

\[
\nu_2 = \frac{RT_2}{P_2} = \frac{0.287 \times 288}{100} = 0.030 \text{ m}^3 / \text{kg}
\]

\[q = w = RT \ln \left( \frac{v_2}{v_1} \right) = 0.287 \times 288 \ln \frac{0.030}{0.827} = -263.47 \text{ kJ/kg} \]

\[\Delta s = R \ln \frac{v_2}{v_1} + Cv \ln \frac{T_2}{T_1} = 0.287 \ln \frac{0.03}{0.827} + 0 = -0.915 \text{ kJ/kg.K} \]

**B**

\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{n-1}{n}} = 288 \left( \frac{27.59}{1} \right)^{\frac{0.3}{1.3}} = 619.2 \text{ K}
\]

\[
\Delta U = Cv(T_2 - T_1) = \frac{R}{\gamma - 1}(T_2 - T_1) = \frac{0.287}{0.402} (619.2 - 288) = 237.61 \text{ kJ/kg} \]

\[
\Delta s = Cv \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} = \frac{0.4 \times 0.287 \times 619.2}{288} - 0.287 \ln \frac{27.59}{1} = -0.186 \text{ kJ/kg.K} \]

\[w = \frac{P_1 \nu_1 - P_2 \nu_2}{n-1} = \frac{R(T_1 - T_2)}{n-1} = \frac{0.287(-331.2)}{1.3 - 1} = -316.84 \text{ kJ/kg} \]

\[q = w + \Delta u = -316.84 + 237.61 = -79.23 \text{ kJ/kg} \]
\[ T_2 = T_1 \left( \frac{V_1}{V_2} \right)^{\gamma^{-1}} \]
\[ = 323(8)^{0.4} = 743K \]

\[ T_4 = T_3 \left( \frac{V_3}{V_4} \right)^{\gamma^{-1}} = 1173(\frac{1}{8})^{0.4} = 511K \]

\[ q_{23} - w_{23} = \mu_3 - \mu_2 \]
\[ = C_v(T_3 - T_2) \]
\[ = 308.7 \text{kJ/kg} \]

\[ q_{41} = C_v(T_1 - T_4) \]
\[ = 0.718(323 - 511) = -135 \text{kJ/kg} \]

\[ w_{\text{net}} = q_{\text{in}} + q_o = 308.7 + (-135) \]
\[ = 173.7 \text{kJ/kg} \]

\[ \eta = \frac{W_{\text{net}}}{q_{\text{in}}} = \frac{173.7}{308.7} = 0.563 \]

\[ \eta_c = 1 - \frac{T_{\text{min}}}{T_{\text{max}}} = 1 - \frac{323}{1173} = 0.725 \]

\[ \Delta s_{23} = C_v \ln \frac{T_3}{T_2} = 0.718 \ln \frac{1173}{743} \]
\[ = 0.328 \text{kJ/kg.K} \]

\[ \Delta s_{41} = C_v \ln \frac{T_1}{T_4} = 0.718 \ln \frac{323}{511} \]
\[ = 0.329 \text{kJ/kg.K} \]
\[ T_2 = T_1 \left( \frac{V_1}{V_2} \right)^{\gamma - 1} 313(17)^{0.4} \]
\[ = 972 K \]
\[ T_3 = T_2 \left( \frac{V_3}{V_2} \right) = 972(2) \]
\[ = 1944 K \]
\[ C_p = \frac{R \gamma}{\gamma - 1} = 0.287 \times 1.4 \]
\[ = 1.004 \text{kJ/kg.K} \]
\[ q_{23} = P_2 (v_3 - v_2) + (\mu_3 - \mu_2) \]
\[ = h_3 - h_2 = C_p(T_3 - T_2) \]
\[ = 1.004(1944 - 972) \]
\[ = 975.9 \text{kJ/kg} = q_{in} \]
\[ C_v = \frac{R}{\gamma - 1} = 0.287 \times 0.4 \]
\[ = 0.717 \text{kJ/kg.K} \]
\[ q_{41} = w_{41} + (\mu_1 - \mu_4) \]
\[ = C_v(T_1 - T_4) \]
\[ = 0.717(313 - 826) \]
\[ = -367.8 \text{kJ/kg} \]

\[ W_{net} = q_{in} + q_o \]
\[ = 975.9 + (-367.8) \]
\[ = 608.1 \text{kJ/kg} \]
\[ \eta = \frac{W_{net}}{q_{in}} = \frac{608.1}{975.9} = 0.623 \]
\[ \eta_c = 1 - \frac{T_{min}}{T_{max}} = 1 - \frac{313}{1944} = 0.84 \]
\[ \Delta s_{23} = C_p \ln \frac{T_3}{T_2} \]
\[ = 1.004 \ln \frac{1944}{972} = 0.696 \text{kJ/kg.K} \]
\[ \Delta s_{23} = \Delta s_{41} \]
\[ = -0.696 \text{kJ/kg.K} \]
(9.1) 

\[ T = 240\, ^\circ C \] 

\[ \Delta T = 115\, ^\circ C \] 

\[ \Delta T = 240\, ^\circ C \] 

\[ \Delta T = 115\, ^\circ C \] 

\[ \Delta T = 90\, kJ \] 

\[ \Delta T = 148.77\, kJ \] 

\[ \Delta T = 518.13\, kJ \] 

\[ \Delta T = 459.36\, kJ \] 

(9.2) 

\[ T = 22\, ^\circ C \] 

\[ \Delta T = 1\, bar \] 

\[ \Delta T = 40\, ^\circ C \] 

\[ \Delta T = 8.56\, kJ \] 

\[ \Delta T = 40.5\, kJ \] 

\[ \Delta T = 45.86\, kJ \] 

(9.3) 

\[ T = 40\, ^\circ C \] 

\[ \Delta T = 0.3\, kg \] 

\[ \Delta T = 1\, bar \] 

\[ \Delta T = 30\% \] 

\[ \Delta T = 7.588\, kJ/K \] 

\[ \Delta T = 0.01136\, kJ/K \] 

\[ \Delta T = 0.108\, kJ/K \] 

\[ \Delta T = -0.11936\, kJ/K \] 

\[ \Delta T = 0.0965\, m^3 \]
(9.4)

\[ \text{ massa } = 2 \text{ kg} \]

\( \text{ حجم } \text{ ازدياد } \text{ الحرارة } \text{ الثالثة} \)

\( \text{ بعد ضغط } \text{ ذلك } \text{ الحجم } \text{ يعود } \text{ حتى الحرارة } \text{ الثالثة.} \)

(9.5)

\( \text{ في } 0.5 \text{ m}^3 \) (0.09m³) في (0.12m³) في (27 °C) في (0.2 kg) نجارة (1) في (15) (2) (1) و(1)

\[ \text{ في } (0.614, 0.091 \text{kJ/kg.K}) \]

(9.6)

\( \text{ كتلة غاز } 0.2 \text{ kg} \)

\( \text{ في } 0.12 \text{ m}^3 \) (0.5m³) في (0.2kg) في (15) (3) (1) و(1)

\[ \text{ في } (0.309 \text{kJ/K}, 0.7855 \text{kJ/K}, 118.56 \text{kJ}, 89.05 \text{kJ}, 89.05 \text{kJ}, 118.56 \text{kJ}) \]

(9.7)

\( \text{ كتلة أكسجين } 0.2 \text{ kg} \)

\( \text{ في } 0.12 \text{ m}^3 \) (0.5m³) في (0.2kg) في (15) (3) (1) و(1)

\[ \text{ في } (0.309 \text{kJ/K}, 0.7855 \text{kJ/K}, 118.56 \text{kJ}, 89.05 \text{kJ}, 89.05 \text{kJ}, 118.56 \text{kJ}) \]
(9.8) 

$$\text{نماذج البخار} \quad T (27^\circ C) \quad (327^\circ C) \quad \text{مشتقة} \quad \text{علي} \quad \text{إرقة} \quad \text{التي} \quad \text{يستخدم} \quad \text{نماذج البخار} \quad 1 \text{kt}

: \eta \text{ه} (T-S) \quad (P-V) \quad \text{عوامل} \quad \text{بيئة} \quad 0.35 \text{bar} \quad \text{ساع} \quad 7 \text{bar}

4 \text{ذكاء} \quad 3 \text{مشتقة} \quad 2 \text{مشتقة} \quad \text{نماذج البخار} \quad \text{تبيّن} \quad \text{إذا} \quad \text{وجّه} \quad \text{ب} \quad 1 \text{kg}

\text{ضغط} \quad 327^\circ C \quad \text{و} \quad 27^\circ C.

(9.9) 

$$

$$

\text{نماذج البخار} \quad (300 \text{K}) \quad \text{نماذج} \quad 1 \text{bar} \quad \text{نماذج} \quad 1 \text{kg}

: \eta \text{ه} (T-S) \quad (P-V) \quad \text{عوامل} \quad \text{بيئة} \quad 0.35 \text{bar} \quad \text{ساع} \quad 0.62 \text{bar}

(19.2 \text{kJ}, \quad 49.08 \text{kJ}, \quad 0.002 \text{kJ/K}, \quad 0.62 \text{bar}, \quad 1.4 \text{m}^3)

\text{(9.10)}

$$

$$

\text{نماذج البخار} \quad 5 \text{bar} \quad \text{نماذج} \quad \text{بيئة} \quad 1 \text{bar} \quad \text{ساع} \quad 1 \text{kg}

: \eta \text{ه} (T-S) \quad (P-V) \quad \text{عوامل} \quad \text{بيئة} \quad 0.35 \text{bar} \quad \text{ساع} \quad 1 \text{kg}

(0.09 \text{kJ/K}, \quad 4.72 \text{kg/m}^3, \quad -32.3 \text{kJ}, \quad 25.55 \text{kJ}, \quad 32.33 \text{kJ}, \quad 0.212 \text{m}^3, \quad 0.106 \text{m}^3)

\text{(9.11)}

$$

$$

\text{نماذج البخار} \quad V_2=2.15 \text{m}^3 \quad \text{نماذج} \quad t_1=15^\circ C \quad \text{نماذج} \quad P_1=1 \text{ bar} \quad \text{ساع} \quad 2 \text{مشتقة} \quad (1) \text{نماذج البخار} \quad 1 \text{kg}

: \eta \text{ه} (T-S) \quad (P-V) \quad \text{عوامل} \quad \text{بيئة} \quad 10.7 \text{m}^3

\text{نماذج البخار} \quad 1 \text{kg} \quad \text{ساع} \quad 10.7 \text{m}^3

(322)
(9.12)

\[ T_1 \to \text{isentropic journey} \to T_2 \]

\[ PV_n = C_1 \]

\[ T_3 \to \text{isothermal journey} \to T_1 \]

\[ \gamma = 1.67 \]

\[ R = 0.287 \text{kJ/kg.K} \]

(9.13)

\[ R = 0.1883 \text{kJ/kg.K} \]

(9.14)

\[ R = 0.287 \text{kJ/kg.K} \]

(9.15)

\[ R = 0.287 \text{kJ/kg.K} \]
(9.16) 
\[ P = \frac{V}{N} = \frac{1}{N} \]

\[ T = \frac{S}{N} \]

\[ (\text{pressure} \text{ change} \text{ from} \text{ dry} \text{ air}) \]

\[ \text{Cp} = 1.005 \text{kJ/kg.K}, \quad \text{Cv} = 0.717 \text{kJ/kg.K} \]

\[ \gamma = 1.4 \]

\[ R = 0.292 \text{kJ/kg.K} \]

\[ (0.41 \text{kJ/K}, \quad 0.214 \text{m}^3, \quad 881.19 \text{K}, \quad 293.73 \text{K}) \]

(324)
Element, Compound and Mixture

The Atomic and Relative Atomic Mass (Atomic Weight)

<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic Mass</th>
<th>Relative Atomic Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>32.06</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>12.011</td>
<td>12</td>
</tr>
<tr>
<td>H</td>
<td>1.008</td>
<td>1</td>
</tr>
</tbody>
</table>

(N,H,O) $\approx$ (H, C, S) whereas Hg $(\approx)$ (N, H, O).

The Molecule and Relative Molecular Mass (Molecular Weight)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Mass</th>
<th>Relative Molecular Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$O</td>
<td>18.015</td>
<td>18</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>44.01</td>
<td>44</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>16.04</td>
<td>16</td>
</tr>
<tr>
<td>H$_2$</td>
<td>2.0177</td>
<td>2</td>
</tr>
<tr>
<td>N$_2$</td>
<td>28.015</td>
<td>28</td>
</tr>
</tbody>
</table>

(325)
(Molecule) يُفسرُ الجزيئات التي تُسمى الذرَّة اثنتاً على أنها تُحتوي على الأنيون، والمركبات الأعنصرة فيها (CH4, H2O, CO2, CO, N2, H2, O2) ...(S, C) على
الوضوء يُحيط بالذرة (2H2O) تُضاف مركب (CO, CO2, H2O) لد.
(02) الفحمي (H2) يُخلو الضروري لجح يحض (H2 + O2 → H2O) ويُرش الذرة
عن طريق العناصر ببعض وجوه الجزيئات كالأي (S, C).
(02) جزء واحد من الذرة اثنتاً على أنها تُحتوي على الأنيون، والمركبات الأعنصرة فيها (CO, CO2, H2O) (كما يُ ويم تعودتعات (الiOS) لجح لذة.
(4CO2) الأكسجين (CO2) د.اً على (M) الذي يُعليه الرئيسي، ويُمكن أن يكون مركب (S, C)
(2H2O) ماء (H2O) مكون من جزيئات تعودتعات (12.1 +4.1=16) أين (س) (CH4) (كما يُ ويم تعودتعات (الiOS) لجح لذة.
(44) (CO2) (12.1 +16.1=44) أين (س) (CH4) (كما يُ ويم تعودتعات (الiOS) لجح لذة.

### جدول (10.1)

| كيبيدات | لَعِفَ | (M) قيمتهائ
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H2O=18</td>
<td>CO=28</td>
<td>S=32</td>
</tr>
</tbody>
</table>

(10.1) يُعد (M) قيمتهائ (س) (CH4) (كما يُ ويم تعودتعات (الiOS) لجح لذة.

(M) يُقيد (الiOS) لجح لذة (10.4)

(326)
Avocadro’s Hypothesis and Number

1 kmole \( O_2 = 32 \text{ kg } O_2 \)  
1 kmole \( H_2 = 2 \text{ kg } H_2 \)  
1 kmole \( C = 12 \text{ kg } C \)  
1 kmole \( H_2O = 18 \text{ kg } H_2O \)  
1 kmole \( N_2 = 28 \text{ kg } N_2 \)  
1 kmole \( CO_2 = 44 \text{ kg } CO_2 \)  

\( 1 \text{ kmole } C + 1 \text{ kmole } O_2 \rightarrow 1 \text{ kmole } CO_2 \)

\( 1 \text{ Vol } C + 1 \text{ Vol } O_2 \rightarrow 1 \text{ Vol } CO_2 \)

Gaseous Mixtures

\[ \frac{V_i}{N_i} = \frac{V_T}{N_T} \Rightarrow \frac{V_i}{V_T} = \frac{N_i}{N_T} \]
Properties of Ideal Gaseous Mixture

Dalton’s Law

\[ P = P_1 + P_2 + P_3 + \ldots \]

Gibbs-Dalton’s Law

Mixture & Partial Pressure

\[ V, T = \text{Const.} \]

(10.7) ... (10.8)
The document contains scientific text discussing the concept of partial pressure, specifically Dalton's Law of Partial Pressure. The text includes mathematical expressions and equations to describe the relationship between total pressure and the partial pressures of different gases in a mixture. Here are the key points and equations from the text:

- Dalton’s Law of Partial Pressure: The total pressure of a gas mixture is equal to the sum of the partial pressures of all the gases in the mixture.
  \[ P_T = P_1 + P_2 + P_3 + \ldots \]
  \[ m_T = m_1 + m_2 + m_3 + \ldots \]
  \[ W_1 = \frac{m_1}{m_T}, \quad W_2 = \frac{m_2}{m_T}, \quad W_3 = \frac{m_3}{m_T} \]
  \[ W_1 + W_2 + W_3 = 1 \]

- The total pressure is also related to the total volume, temperature, and the total number of moles of the gas mixture.
  \[ V = \frac{m_1R_T}{V} + \frac{m_2R_T}{V} + \frac{m_3R_T}{V} \]
  \[ m_T = m_1 + m_2 + m_3 \]
  \[ R_T = \frac{m_1R_1 + m_2R_2 + m_3R_3}{m_T} \]

- The total number of moles of the gas mixture can be calculated using the ideal gas law:
  \[ N = \frac{m}{M}, \quad R = \frac{M}{M} \]
  \[ PV = mRT = NMRT = N \cdot \frac{R}{M}T = NRT \]

- The partial pressure of each gas is calculated by multiplying the total pressure by its mole fraction:
  \[ P_1 = W_1 \cdot P_T, \quad P_2 = W_2 \cdot P_T, \quad P_3 = W_3 \cdot P_T \]

The text also includes additional mathematical expressions and equations, but the key points are summarized above. The document appears to be a detailed explanation of the behavior of gases in mixtures, focusing on the application of Dalton’s Law.
Molar Volume & Universal Gas Constant

\[ V = \frac{NRT}{P} \]

\[ V = \frac{RT}{N} = \frac{8.314 \times 273.15}{101.325} = 22.4 \, \text{m}^3/\text{kmol} \]

\[ V_{\text{mol}} = \frac{RT}{P} = \frac{\text{MRT}}{P} \]

\[ M_1 R_1 T = M_2 R_2 T = M_3 R_3 T = \text{MRT} \]

\[ P \]

\[ M_1 R_1 = M_2 R_2 = M_3 R_3 = \text{MR} = \overline{R} = 8.314 \, \text{kJ}/\text{kmol.K} \]

\[ (S. \, T. \, P.) \]
Mole Ratio or Mole Fraction (10.11)

\[ P_T V_T = N_T \overline{RT} \Rightarrow \frac{V_T}{N_T} = \frac{\overline{RT}}{P} \]
لاعترف بالعوامل (10.3) في ظل ظل أول للفصل أكرار لثاني للفصل.

\[ P_1 V_1 = N_1 RT \Rightarrow \frac{V_1}{N_1} = \frac{RT}{P} \Rightarrow \therefore \frac{V_1}{N_1} = \frac{V_T}{N_T} \] (10.12)

2) بفضل جذور ظل أول للفصل للفصل أكرار للفصل.

\[ VT = V_1 + V_2 + V_3 \] (10.13)

\[ P_1 V_T = N_1 RT \] (10.14)

\[ P_2 V_1 = N_1 RT \] (10.15)

\[ \therefore \frac{V_1}{VT} = \frac{P_1}{P_T} \] (10.14)

(i) لدعماً في (10.14) في (10.12) نحن يجب أن نأكيد للفصل أكرار للفصل.

\[ X_i = \frac{V_i}{V_T} = \frac{N_i}{N_T} = \frac{P_i}{P_T} \] (10.15)

\[ X_1 + X_2 + X_3 = 1 \]
Average Relative Molecular Mass of a Gas Mixture

\[ M_T = \frac{m_T}{N_T} = \frac{m_1 + m_2 + m_3}{N_T} = \frac{M_1 N_1 + M_2 N_2 + M_3 N_3}{N_T} = M_1 X_1 + M_2 X_2 + M_3 X_3 = \sum M_i X_i \ldots \ldots \ldots (10.16) \]

\[ W_i = \frac{m_i}{m_T} = \frac{M_i N_i}{M_T N_T} = \frac{M_i X_i N_T}{M_T N_T} = \sum M_i X_i \ldots \ldots \ldots (10.17) \]

The Density of Gas Mixture

\[ \rho_T = \frac{M_T}{V_{mol}} \left[ \frac{\text{kg}}{\text{kmol}} \times \frac{\text{kmol}}{\text{m}^3} = \frac{\text{kg}}{\text{m}^3} \right] \]

Volumetric and Weight Analysis

The mixture is composed of 2 g of water, 15 g of dry air, 15 g of dry CO₂, and 20 g of dry CO₂. The total volume of the mixture is 10% (21%) L and the total mass of the mixture is 50 g. According to the balance, 79% is dry air, 21% is dry CO₂.

\[ W_i = \frac{m_i}{m_T}, \quad \Rightarrow \quad W_1 + W_2 + W_3 = 1 \]

\[ X_i = \frac{V_i}{V_T} = \frac{N_i}{N_T}, \quad \Rightarrow \quad X_1 + X_2 + X_3 = 1 \]

\[ W_i = \frac{M_i X_i}{\sum M_i X_i} \]

\[ \text{(333)} \]
\[ W_1 = \frac{m_i}{m_T} \]

\[ W_{H_2} = \frac{5}{15} = 0.333, \quad W_{O_2} = \frac{3}{15} = 0.2, \quad W_{CO_2} = \frac{7}{15} = 0.467 \]

\[ \text{(10.2) 예제} \]

\[ N_i = \frac{m_i}{M_i} \Rightarrow N_{N_2} = \frac{0.75}{28} = 0.02696 \]

\[ N_{O_2} = \frac{0.23}{32} = 0.00723 \]

\[ NT = 0.03419 \]

\[ X_i = \frac{N_i}{N_T} \Rightarrow X_{N_2} = \frac{0.02696}{0.03419} = 0.7809 \]

\[ X_{O_2} = \frac{0.00723}{0.03419} = 0.2115 \]

\[ \text{(10.3) 예제} \]

\[ W_i = \frac{m_i}{m_T} = \frac{\sum MiX_i}{m_T} \Rightarrow W_{N_2} = \frac{28 \times 0.79}{28 \times 0.79 + 32 \times 0.21} = 0.767 \]

\[ W_{O_2} = \frac{32 \times 0.21}{28 \times 0.79 + 32 \times 0.21} = 0.233 \]

\[ \text{(10.4) 예제} \]

\[ M_T = \frac{m_T}{N_T} = \frac{m_1 + m_2 + m_3}{N_T} = \frac{M_1N_1 + M_2N_2 + M_3N_3}{N_T} \]

\[ M = \frac{28 \times 78.05 + 32 \times 21 + 39.9 \times 0.95}{78.05 + 21 + 0.95} = 28.95 \text{ kg/kmol} \]

(334)
Internal Energy, Enthalpy, Specific Heat and Entropy of Mixture

Extensive Properties

Internal Energy, Enthalpy, Specific Heat and Entropy of Mixture

Extensive Properties


The internal energy, enthalpy, specific heat and entropy of a mixture are described in terms of the internal energy, enthalpy, specific heat and entropy of its components.

\[ U_T = U_1 + U_2 + U_3 \]  
\[ \mu_T m_T = \mu_1 m_1 + \mu_2 m_2 + \mu_3 m_3 \]  
\[ \frac{\mu_T}{T} = \frac{W_1}{T} + \frac{W_2}{T} + \frac{W_3}{T} \]  
\[ Cv = W_1 Cv_1 + W_2 Cv_2 + W_3 Cv_3 \]  
\[ H_T = H_1 + H_2 + H_3 \]  
\[ h_T m_T = h_1 m_1 + h_2 m_2 + h_3 m_3 \]  
\[ \frac{h_T}{T} = \frac{W_1}{T} + \frac{W_2}{T} + \frac{W_3}{T} \]  
\[ CP_T = W_1 CP_1 + W_2 CP_2 + W_3 CP_3 \]
\[ s_T = s_1 + s_2 + s_3 \] .................................(10.25)

\[ s_T m_T = s_1 m_1 + s_2 m_2 + s_3 m_3 \]

\[ s_T = \frac{s_1 m_1 + s_2 m_2 + s_3 m_3}{m_T} = W_1 s_1 + W_2 s_2 + W_3 s_3 \] .......(10.26)

\[ \frac{Q}{M} = R \enspace \text{or} \enspace \frac{Q}{M} = \gamma \]

\[ \gamma = \frac{C_p}{C_v} \] or \[ \gamma = \frac{C_p}{C_v - 8.314} \] .................................(10.27)

\[ M_{cv} = C_v \]
\[ M_{cp} = C_p \]

Molar Heat Capacity

\[ \gamma = \frac{C_p}{C_v} \] or \[ \gamma = \frac{C_p}{C_v - 8.314} \] .................................(10.28)
الغاز المستخدم (Cvav.) في التحليل المعين للأقدام المذكورة في الجزء المعين (N1) كليًا، ويتم استخدام الأوزان المذكورة في جزء المعين في الأوزان لكل جزء من المعين (Cv1, Cv2, Cv3, …) لتحديد درجة الحرارة في كل جزء من المعين.

\[
N_T \cdot C_v_T = N_1 \cdot C_v_1 + N_2 \cdot C_v_2 + N_3 \cdot C_v_3 = \sum N_i \cdot C_v_i \tag{10.30}
\]

\[
C_v_T = \frac{\sum N_i \cdot C_v_i}{N_T} = \frac{\sum N_i}{N_T} \cdot C_v_i = \sum X_i \cdot C_v_i \tag{10.31}
\]

\[
N_T \cdot C_p_T = N_1 \cdot C_p_1 + N_2 \cdot C_p_2 + N_3 \cdot C_p_3 = \sum N_i \cdot C_p_i \tag{10.32}
\]

\[
C_p_T = \frac{\sum N_i \cdot C_p_i}{N_T} = \frac{\sum N_i}{N_T} \cdot C_p_i = \sum X_i \cdot C_p_i \tag{10.33}
\]

10.5):

(.52%N2) (4%CO2) (3%CH4) (12%H2) (29%CO)

<table>
<thead>
<tr>
<th>M</th>
<th>CO</th>
<th>H2</th>
<th>CH4</th>
<th>CO2</th>
<th>N2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>28</td>
<td>2</td>
<td>16</td>
<td>44</td>
<td>28</td>
</tr>
<tr>
<td>CP</td>
<td>29.27</td>
<td>28.89</td>
<td>35.8</td>
<td>37.22</td>
<td>29.14</td>
</tr>
</tbody>
</table>
\[ \begin{align*}
C_p(T) &= \sum X_i C_{p_i} \\
&= 0.29 \times 29.27 + 0.12 \times 28.89 + 0.03 \times 35.8 + 0.04 \times 37.22 + 0.52 \times 29.14 \\
&= 29.676 \text{kJ/kg.K} \\
C_v(T) &= C_p(T) - R = 29.676 - 8.314 = 21.362 \text{kJ/kmol.K} \\
M &= \sum M_i X_i \\
&= 28 \times 0.29 + 2 \times 0.12 + 16 \times 0.03 + 44 \times 0.04 + 28 \times 0.52 \\
&= 25.2 \text{kg/kmol} \\
c_p(T) &= \frac{C_p(T)}{M} = \frac{29.676}{25.2} = 1.178 \text{kJ/kg.K} \\
c_v(T) &= \frac{C_p(T)}{M} = \frac{21.362}{25.2} = 0.847 \text{kJ/kg.K}
\end{align*} \]

(10.17)

**Entorpy Change Due to Mixing of Perfect Gases**

\[ \sum (X_i C_{p_i}) = \sum (X_i C_{v_i}) \]

\[ \sum (X_i T) = \sum (X_i P) \]

(10.4) (10.5)

\[ (P, T = \text{Const.}) \]

(338)
Mixture of Perfect Gases at Different Initial Pressures and Temperatures

\[ \Delta S_i = C_v \ln \frac{T}{T_i} + R \ln \frac{V}{V_i} = C_p \ln \frac{T}{T_i} - R \ln \frac{P}{P_i} \]
\[ \therefore T = T_i \]
\[ \therefore \Delta s_i = R \ln \frac{V}{V_i} = R \ln \frac{P}{P_i} \]
\[ \Delta s = \sum \Delta s_i > 0 \]
\[ \Delta s = C_v \ln \frac{T}{T_i} + R \ln \frac{V}{V_i} \]
\[ = \frac{\gamma - n}{\gamma - 1} R \ln \frac{V}{V_i} \]
\[ = C_v \frac{n - \gamma}{n - 1} \ln \frac{T}{T_i} \]
\[
T_T = \frac{m_1C_vT_1 + m_2C_vT_2 + m_3C_vT_3}{m_TC_T} \\
= \frac{W_1C_vT_1 + W_2C_vT_2 + W_3C_vT_3}{C_vT}
\]

(10.39)

\[
t_T = \frac{m_wC_wt_w + m_sC_st_s + m_aC_at_a}{m_wC_w + m_sC_s + m_aC_a} \\
= \frac{0.8 \times 4.2 \times 15 + 0.25 \times 0.23 \times 15 + 0.2 \times Ca \times 100}{0.8 \times 4.2 + 0.25 \times 0.234 + 0.2Ca}
\]

\[
19.24 = \frac{4.98C90C160}{4.2kJ/kg.K}
\]

Ca = 0.88kJ/kg.K

(10.7)

\[
t_T = \frac{m_c t_1 + m_c t_2}{m_c + m_c} = \frac{160 \times c \times 150 + 90 \times c \times 98.4}{160 \times c + 90 \times c} = 131.424^\circ C
\]

(10.8)
لم يكن في معرفتي $(0.55)$ أن يكون كمية أول ي смысл أن هناك شكلية ليز التي تجذب للسائل $1$ بار) يمثل $100\text{m}^3$ نصف كمية $15^\circ\text{C})$

\[
m_{\text{NH}_3} = \frac{PV}{RT} = \frac{100 \times 0.55}{8.314 \times \frac{17}{288}} = 390\text{kg}
\]
MCO₂ = 44Kg/kmol, R = 0.185 kJ/kg.K

\[ R = \frac{\overline{R}}{M} = \frac{8.314}{44} = 0.185 \text{kJ/kg.K} \]

\[ m = \frac{P V}{R T} = \frac{110 \times 10^2 \times 0.015}{0.185 \times 291} = 3.064 \text{kJ} \]

\[ V_{\text{mol}} = \frac{R T}{P} = \frac{8.314 \times 291}{110 \times 10^2} = 0.22 \text{m}^3/\text{kmol} \]

\[ \rho = \frac{m}{v} = \frac{3.064}{0.015} = 204.27 \text{kg/m}^3 \]

\[ N = \frac{V}{V_{\text{mol}}} = \frac{0.015}{0.22} = 0.0682 \text{kmol} \]

\[ N_{H₂} = \frac{m_{H₂}}{M_{H₂}} = \frac{1}{2} = 0.5 \]

\[ N_{O₂} = \frac{m_{O₂}}{M_{O₂}} = \frac{m_{O₂}}{32} \]

\[ \frac{N_{H₂}}{N_{O₂}} = \frac{2}{1} = \frac{0.5}{m_{O₂}} \]

\[ \frac{m_{O₂}}{32} \]

\[ N_T = N_{O₂} + NH₂ \]

\[ = 0.5 + \frac{8}{32} = 0.75 \]

\[ V = \frac{NRT}{P} = \frac{0.75 \times 8.314 \times 288}{100} = 17.96 \text{m}^3 \]
\( \text{Cp} \text{ H}_2 = 14.31 \text{ kJ/kg.K} \quad \text{Cp}_{\text{CO}} = 1.042 \text{ kJ/kg.K} \)

(1)

\[
\begin{align*}
R_{\text{CO}} &= \frac{\overline{R}}{M} = \frac{8.314}{12 + 16} = 0.297 \text{kJ/kg.K} \\
R_{\text{H}_2} &= \frac{\overline{R}}{M} = \frac{8.314}{2} = 4.157 \text{kJ/kg.K} \\
R &= \sum \frac{m_i R_i}{m} = 1 \times 0.297 + 0.8 \times 4.157 \\
&= 2.015 \text{kJ/kg.K} \\
C_p &= \sum \frac{m_i C_{pi}}{m} = 1 \times 1.042 + 0.8 \times 14.31 \\
&= 6.938 \text{kJ/kg.K} \\
C_v &= C_p - R = 6.938 - 2.015 \\
&= 4.923 \text{kJ/kg.K}
\end{align*}
\]

(2)

\[
\begin{align*}
V &= \frac{mRT}{P} = \frac{1.8 \times 2.015 \times 291}{200} \\
&= 5.277 \text{m}^3 \\
v &= \frac{V}{m} = \frac{5.277}{1.8} = 2.931 \text{m}^3/\text{kg} \\
N_{\text{CO}} &= \frac{m}{M} = \frac{1}{28} = 0.0357 \text{Mol} \\
N_{\text{H}_2} &= \frac{m}{M} = \frac{0.8}{2} = 0.4 \text{Mol} \\
N &= \sum N_i = 0.0357 + 0.4 \\
&= 0.4357 \text{Mol} \\
P_{\text{CO}} &= \frac{N_{\text{CO}}}{N} \times 200 = 200 \times \frac{0.0347}{0.4357} = 16.4 \text{kPa} \\
P_{\text{H}_2} &= \frac{N_{\text{H}_2}}{N} \times 200 = 200 \times \frac{0.4}{0.4357} = 183.6 \text{kPa}
\end{align*}
\]
\[
\text{M} \text{O}_2 = 32, \text{M} \text{N}_2 = 28, \text{M} \text{CO}_2 = 44
\]

\[
\text{Ni} = \frac{\text{mi}}{\text{Mi}}
\]

\[
\text{No}_2 = \frac{8}{32} = 0.25 \text{kmol}
\]

\[
\text{NN}_2 = \frac{7}{28} = 0.25 \text{kmol}
\]

\[
\text{Nco}_2 = \frac{\text{mco}_2}{44} = \text{kmol}
\]

\[
\text{N}_T = \text{No}_2 + \text{NN}_2 + \text{Nco}_2
\]

\[
1 \text{kmol} = 0.25 + 0.25 + \frac{\text{mco}_2}{44}
\]

\[
\text{mco}_2 = 22 \text{kg}
\]

\[
\text{Nco}_2 = \frac{22}{44} = 0.5 \text{kmol}
\]

\[
(2) \text{Po}_2 = \frac{\text{p \text{No}_2}}{\text{N}} = 416 \frac{0.25}{1} = 104 \text{kN/m}^2
\]

\[
\text{PN}_2 = \frac{\text{p \text{NN}_2}}{\text{N}} = 416 \frac{0.25}{1} = 104 \text{kN/m}^2
\]

\[
\text{Pco}_2 = \frac{\text{p \text{Nco}_2}}{\text{N}} = 416 \frac{0.5}{1} = 208 \text{kN/m}^2
\]

\[
(3) V = \frac{\frac{\text{NRT}}{P}}{416} = 6.7 \text{m}^3
\]

\[
m = \text{mco}_2 + \text{mH}_2 + \text{mco}_2
\]

\[
= 8 + 7 + 22 = 37 \text{kg}
\]

\[
\rho = \frac{m}{V} = \frac{37}{6.7} = 5.5 \text{kg/m}^3
\]

\[
(4) V = \text{Vo}_2 = \text{V}_2 = \text{Vco}_2
\]

\[
= 6.7 \text{m}^3
\]

\[
\text{P} = \frac{\text{NRT}}{V} = \frac{1 \times 8.314 \times 501}{6.7}
\]

\[
= 625.9 \text{kN/m}^2
\]
\[ 10.13 \]

\[ \text{Given: (7 mol Air) \( \hat{\text{N}} \) (3 mol CO) \( \hat{\text{N}} \) (3 mol N}_2 \) (2 mol He) \text{ and} \]
\[ \text{\( \hat{\text{N}} \) (2 mol CO) \( \hat{\text{N}} \) (3 mol N}_2 \) (2 mol He) \]
\[ \text{\( \text{Air} \text{ mixture} \)} \]
\[ \text{\( \text{N}_2 = 79 \%) \text{ \( \text{CO} \)} = 3 \% \text{ \( \text{He} \)} = 2 \% \text{ \( \text{Air} \)} = 10 \% \text{ (2 mol Air)} \]

\[ \begin{array}{|c|c|c|c|}
\hline
\text{He} & \text{N}_2 & \text{CO} & \text{O}_2 \\
\hline
\text{C}_p \ (\text{kJ/kg.K}) & 2.22 & 1.046 & 1.046 & 0.92 \\
\text{C}_v \ (\text{kJ/kg.K}) & 0.17 & 0.754 & 0.754 & 0.67 \\
\text{M} \ (\text{kg/kmol}) & 4 & 28 & 28 & 32 \\
\hline
\end{array} \]

\[ \text{\( N_{N_2} = 3 + 7 \times 0.79 = 8.53 \text{Mol} \)} \]
\[ \text{\( N_{O_2} = 7 \times 0.21 = 1.47 \text{Mol} \)} \]
\[ \text{\( N = \text{NH}_e + N_{N_2} + N_{CO} + N_{air} \)} \]
\[ = 2 + 3 + 4 + 7 = 16 \text{Mol} \]

or
\[ \text{\( N = \text{NH}_e + N_{N_2} + N_{CO} + N_{O_2} \)} \]
\[ = 2 + 8.53 + 4 + 1.47 = 16 \text{Mol} \]

\[ \text{\( X_{He} = \frac{\text{NH}_e}{N} = \frac{2}{16} = 0.125 \)} \]
\[ \text{\( X_{N_2} = \frac{N_{N_2}}{N} = \frac{8.53}{16} = 0.533 \)} \]
\[ \text{\( X_{CO} = \frac{N_{CO}}{N} = \frac{4}{16} = 0.25 \)} \]
\[ \text{\( X_{O_2} = \frac{N_{O_2}}{N} = \frac{1.47}{16} = 0.092 \)} \]

\[ \text{\( M = XM_{He} + XM_{N_2} + XM_{CO} + XM_{O_2} \)} \]
\[ = 0.125 \times 4 + 0.533 \times 28 + 0.25 \times 28 \\
+ 0.092 \times 32 = 25.368 \text{kg/kmol} \]

\[ \text{or} \]
\[ R = \frac{\bar{R}}{M} = \frac{8.314}{25.368} \]
\[ = 0.327 \text{kJ/kg.K} \]

\[ \text{\( \gamma = \frac{C_p}{C_v} = \frac{1.053}{0.726} = 1.45 \)} \]
(10.14)

\[ M_m = \sum \frac{V_i}{V} M \]
\[ = 0.8 \times 2 + 0.2 \times 28 = 7.2 \]
\[ N_m = \frac{mm}{Mm} = \frac{mm}{7.2} \]
\[ N_{H_2} = N_m \times \frac{V_{H_2}}{V_T} = \frac{mm}{7.2} \times 0.8 \]
\[ = \frac{mm}{9} \]
\[ N_{H_2} = 0.8 \times 1 = 0.8 \]
\[ N_{H_2} = 0.8 - \frac{mm}{9} \]

(50% CO) \( \bar{U} \) (50% H) \( \bar{A} \) (mol) \( \bar{U} \)

\[ 0.8 - \frac{mm}{9} = 0.5 \]
\[ m_m = (0.8 - 0.5) \times 9 = 2.7 \text{ kg} \]
\[ \frac{mm}{28} = \frac{m_{co}}{7.2} \]
\[ m_{co} = \frac{2.7 \times 28}{7.2} = 10.5 \text{ kg} \]

(10.15)

(1 bar)

(1) \( \bar{U} \) (79% \( \text{N}_2 \)) (21% \( \text{O}_2 \)) \( \bar{A} \) (15°C)

(3) \( \bar{R}_m \), \( \bar{M}_m \)

\[ \bar{N}_i = \frac{V_i}{V} \bar{N} \]
\[ \bar{N}_{o2} = 0.21 \times 3.5 = 0.735 \text{ kmol} \]
\[ \bar{N}_{\text{N}_2} = 0.79 \times 3.5 = 2.765 \text{ kmol} \]
\[ m = N \bar{M} \]
\[ m_{o2} = 1.44 = 44 \text{ kg} \]
\[ m_{o2} = 0.735 \times 32 = 23.55 \text{ kg} \]
\[ m_{N_2} = 2.765 \times 28 = 77.5 \text{ kg} \]
\[ m_m = 23.55 + 77.5 = 145.05 \text{ kg} \]

\[ \%C = \frac{12}{145.05} = 8.27\% \]
\[ \bar{N}_m = \bar{N}_{o2} + \bar{N}_{o2} + \bar{N}_{N_2} = 4.5 \text{ kmol} \]
\[ \bar{M}_m = \sum \frac{N_i}{N} \bar{M}_i \]
\[ = \frac{1}{4.5} \times 44 + \frac{0.735}{4.5} \times 32 + \frac{2.765}{4.5} \times 28 \]
\[ = 32.2 \text{ kg/kmol} \]

(346)
\[ \text{MO}_2 = 32, \text{M N}_2 = 28, \text{M Ar} = 40, \text{M CO}_2 = 44. \]

\[ R_i = \frac{R}{M_i} \]
\[ R_{O_2} = \frac{8.314}{32} = 0.259 \text{kJ/kg.K} \]
\[ R_{N_2} = \frac{8.314}{28} = 0.2468 \text{kJ/kg.K} \]
\[ R_{Ar} = \frac{8.314}{40} = 0.208 \text{kJ/kg.K} \]
\[ R_{co_2} = \frac{8.314}{44} = 0.1889 \text{kJ/kg.K} \]

\[ \text{PV} = mRT = T\sum miR_i \]
\[ R = \sum \frac{mi}{m} R_i = 0.2314 \times 0.2598 + 0.7553 \times 0.296 \]
\[ + 0.0128 \times 0.208 + 0.0005 \times 0.1889 \]
\[ = 0.287 \text{kJ/kg.K} \]

\[ \frac{R}{M} = \frac{8.314}{0.2871} = 28.96 \text{kg/kmol} \]

\[ X_{N_2} = \frac{0.02696}{0.03452} = 78.09\% \]
\[ X_{Ar} = \frac{0.00032}{0.03452} = 0.93\% \]
\[ X_{CO_2} = \frac{0.00001}{0.03452} = 0.03\% \]
\[ P_{O_2} = 0.2095 \times 1 = 0.2095 \text{bar} \]
\[ P_{N_2} = 0.7809 \times 1 = 0.7809 \text{bar} \]
\[ P_{Ar} = 0.0093 \times 1 = 0.0093 \text{bar} \]
\[ P_{CO_2} = 0.0003 \times 1 = 0.0003 \text{bar} \]
\[ 10.18 \]

\[
\text{M CO}=28 \ , \text{M N}_2=28 \ , \text{M O}_2=32.
\]

\[
m_{\text{O}_2} = \frac{23.3}{100} \times 1 = 0.233\text{kg}
\]
\[
m_{\text{N}_2} = \frac{76.7}{100} \times 1 = 0.767\text{kg}
\]
\[
\text{N}_i = \frac{m_i}{M_i}
\]
\[
\text{N}_{\text{O}_2} = \frac{0.233}{32} = 0.0073\text{kmol}
\]
\[
\text{N}_{\text{N}_2} = \frac{0.767}{28} = 0.0274\text{kmol}
\]
\[
\text{N}_{\text{co}} = \frac{0.45}{28} = 0.01\text{kmol}
\]

\[
P_i = \frac{\text{NRT}}{V}
\]
\[
P_{\text{O}_2} = \frac{0.0073 \times 8.314 \times 288}{0.4}
\]
\[
= 43.59\text{kN/m}^2
\]
\[
P_{\text{N}_2} = \frac{0.0274 \times 8.314 \times 288}{0.4}
\]
\[
= 164\text{kN/m}^2
\]
\[
P_{\text{co}} = \frac{0.0161 \times 8.314 \times 288}{0.4}
\]
\[
= 96.2\text{kN/m}^2
\]
\[
P = \sum P_i = 43.59 + 164 + 96.2
\]
\[
= 303.8\text{kN/m}^2
\]
\((10.19)\)

\[\text{去哪儿 of \((4\text{kg }\text{O}_2) \) \(\text{与 } 7\text{kg CO} \) \(\text{在 } 15^\circ\text{C} \) \(\text{压力 } 0.3\text{m}^3 \text{)} \text{对 } \text{产生 } (0.3\text{m}^3) \text{ \(\text{氮气} \)) \text{由于} \text{扩大 } \text{的压力 } \text{与 } \text{温度 } \text{增加 } \text{如果 } \text{去哪里} \text{的} \text{温度} \]

\[\text{Messages} \]

\[
\begin{align*}
\text{Ni} &= \frac{m_i}{M_i} \\
N_{\text{O}_2} &= \frac{4}{32} = 0.125\text{kg/kmol} \\
N_{\text{CO}} &= \frac{7}{28} = 0.250\text{kg/kmol} \\
N &= 0.125 + 0.250 = 0.375\text{kg/kmol} \\
P_1 &= \frac{NRT_i}{V} = \frac{0.375 \times 8.314 \times 288}{0.3} = 29.93\text{bar} \\
P_2 &= P_1\left(\frac{T_2}{T_1}\right) = 29.93\left(\frac{313}{288}\right) = 32.53\text{bar} \\
\text{or} \\
\text{M} &= \frac{\sum \frac{V_i}{V}}{N}M_i = 0.333 \times 32 + 0.667 \times 28 = 29.33\text{kg/kmol} \\
\text{or} \\
\text{M} &= \frac{m}{N} = \frac{7 + 4}{0.375} = 29.33 \\
R &= \frac{\overline{R}}{M} = \frac{8.314}{29.33} = 0.283\text{kJ/kg.K} \\
\end{align*}
\]
\[ (10.20) \]

\[
\begin{align*}
&\text{93%CH}_4, 29\%\text{ CO, 12}\%\text{ H}_2: \text{يبدو} \text{ كي} \\
&\text{80}\%\text{ H}_2, 20\%\text{ CO}.
\end{align*}
\]

\[
\begin{array}{c|c|c|c|c|c}
\text{H}_2 & \text{CO} & \text{CH}_4 & \text{N}_2 & \text{CO}_2 \\
\hline
28.89 & 29.27 & 35.8 & 29.13 & 37.22
\end{array}
\]

\[
C_p \ (\text{kJ/kg.K}) = \sum \frac{V_i}{V} \cdot C_{pi}
\]

\[
= 0.12 \times 28.89 + 0.29 \times 29.27 + 0.03 \times 35.8 + 0.04 \times 29.13 + 0.52 \times 29.14 \\
= 29.676 \text{kJ/kmol}
\]

\[
C_v = C_p - R = 29.676 - 8.314 = 21.362 \text{kJ/kmol.K}
\]

\[
M = \sum \frac{V_i}{V} \cdot M_i = 0.29 \times 28 + 0.12 \times 2 + 0.03 \times 16 + 0.044 + 0.52 \times 28 = 25.2 \text{kg/kmol}
\]

\[
c_p = \frac{C_p}{M} = \frac{29.676}{25.2} = 1.178 \text{kJ/kg.k}, \quad c_v = \frac{C_v}{M} = \frac{21.362}{25.2} = 0.847 \text{kJ/kg.k}
\]

\[
(10.21)
\]

50\% \text{ CO, 50}\% \text{ H}_2.

\[
\text{Nh}_2 = 0.8 - 0.8\text{Nd} = 0.8 - 0.8 \times 0.375 = 0.8 - 0.3 = 0.5 \text{ kg}
\]

\[
\text{Md} = \text{Nd} \cdot \frac{V_{co}}{V} \cdot \text{M} + \text{Nd} \cdot \frac{V_{H_2}}{V} \cdot \text{M}_{H_2}
\]

\[
= 0.375 \times 0.2 \times 28 + 0.375 \times 0.8 \times 2 = 2.7 \text{ kg}
\]
\begin{align*}
\text{M CH}_4 &= 16, \text{ M H}_2 = 2 \\
V_{H_2} &= 0.12 \times 0.5 = 0.06 \text{ m}^3/\text{s} \\
V_{CH_4} &= 0.6 \times 0.5 = 0.3 \text{ m}^3/\text{s} \\
m_{CH_4} &= \frac{PV}{RT} = \frac{150 \times 0.3}{8.314} \times \frac{305}{16} \\
&= 0.284 \text{ kg/s} \\
m_{CH_4} &= \frac{PV}{RT} = \frac{150 \times 0.06}{8.314} \times \frac{305}{2} \\
&= 0.0071 \text{ kg/s} \\
m_{O_2} &= 0.2839 \times 1.5 + 0.0071 \times 10 \\
&= 0.4968 \text{ kg/s} \\
N_i &= \frac{m_i}{M_i} \\
N_{O_2} &= \frac{0.4968}{32} = 0.0155 \\
N_{N_2} &= \frac{0.4968 \times 79}{32} = 0.0584 \\
N &= \sum N_i = 0.0739 \\
V &= \frac{NRT}{P} = \frac{0.0739 \times 8.314 \times 3.0}{150} \\
&= 1.27 \text{ m}^3/\text{s} \\
\end{align*}

\begin{align*}
\text{mi} &= N_i M_i \\
m_{N_2} &= 0.78 \times 21 = 16.18 \text{ kg} \\
m_{CO_2} &= 0.12 \times 44 = 5.28 \text{ kg} \\
m_{O_2} &= 0.1 \times 32 = 3.2 \text{ kg} \\
m_T &= 30.32 \text{ kg} \\
Wi &= \frac{m_i}{m_T} \\
W_{N_2} &= \frac{21.84}{30.32} = 0.71 \\
W_{CO_2} &= \frac{5.28}{30.32} = 0.174 \\
W_{O_2} &= \frac{3.2}{30.32} = 0.105 \\
M &= \frac{m}{N} = \frac{30.32}{1} = 30.32 \\
R &= \frac{\bar{R}}{M} = \frac{8.314}{30.32} = 0.274 \text{ kJ/kg.K} \\
PV &= mRT \implies P = \frac{m}{RT} \implies P = \rho RT \\
\rho &= \frac{P}{RT} = \frac{100}{0.274 \times 823} = 0.443 \text{ kg/m}^3 \\
\end{align*}
\[ R = \frac{\bar{R}}{M} \]

\[ R_{O_2} = \frac{8.314}{32} = 0.26\text{kJ/kg.K} \]

\[ R_{N_2} = \frac{8.314}{28} = 0.297\text{kJ/kg.K} \]

\[ PV = mRT \]

\[ P \times 0.21 = m_{O_2} \times 0.26 \times T \]

\[ P \times 0.79 = m_{N_2} \times 0.297 \times T \]

\[
\begin{align*}
\frac{m_{O_2}}{m_{N_2}} &= \frac{0.21 \times 0.297}{0.79 \times 0.26} = 1 \\
\end{align*}
\]

\[ OR \]

\[ 76.6\% N_2, 23.3\% O_2 \]

\[ R_T = \frac{23.3 \times 0.26 + 76.7 \times 0.297}{23.3 + 76.7} \]

\[ = 0.287\text{kJ/kg.K} \]

\[ M_T = \frac{8.314}{0.287} = 29.0 \]

\[ c_v_T = \frac{23.3 \times 0.66 + 76.6 \times 0.753}{100} \]

\[ = 0.718\text{kJ/kg.K} \]

\[ c_p_T = c_v_T + R_T = 0.718 + 0.287 \]

\[ = 1.005\text{kJ/kg.K} \]

\[ \gamma_T = \frac{c_p_T}{c_v_T} = \frac{1.005}{0.718} = 1.4 \]
\[ \text{từ phòng } 0.7 \text{m}^3 \text{ chứa } 80\% \text{ của } H_2 \text{ và } 20\% \text{ của } O_2 \text{. \text{Sử dụng chất thải } H_2 \text{ và } O_2 \text{ để sản xuất } T \text{ với } 350 \text{ kN/m}^3 \text{ và tại } 38^\circ C.} \]

\[ C_{pH_2} = 14.4 \text{ kJ/kg.K, } C_{vH_2} = 10.4 \text{ kJ/kg.K,} \]
\[ C_{pO_2} = 0.92 \text{ kJ/kg.K, } C_{vO_2} = 0.67 \text{ kJ/kg.K.} \]

(1)

\[
\frac{m_{H_2}}{m} = \frac{m_{H_2} \cdot \frac{V_{H_2}}{V}}{\sum m_i \cdot \frac{V_i}{V}} = \frac{2 \times 0.8}{2 \times 0.8 + 32 \times 0.2} = 0.2 \\
\frac{m_{O_2}}{m} = \frac{m_{O_2} \cdot \frac{V_{O_2}}{V}}{\sum m_i \cdot \frac{V_i}{V}} = \frac{32 \times 0.8}{2 \times 0.8 + 32 \times 0.2} = 0.8 \\
C_p = \frac{\sum m_i C_{pi}}{\sum m_i} = \frac{m_{H_2} C_{pH_2} + m_{O_2} C_{pO_2}}{m} \\
\sum m_i = \frac{m_{H_2} C_{pH_2}}{m} + \frac{m_{O_2} C_{pO_2}}{m} \\
= \frac{m_{H_2} C_{pH_2}}{m} + \frac{m_{O_2} C_{pO_2}}{m} \\
= 0.2 \times 14.4 + 0.8 \times 0.92 \\
= 3.616 \text{ kJ/kg.K} \\
C_v = \frac{m_{H_2} C_{vH_2} + m_{O_2} C_{vO_2}}{m} \\
= 0.2 \times 10.4 + 0.8 \times 0.67 \\
= 2.616 \text{ kJ/kg.K} \\
\]

(2)

\[
R = C_p - C_v = 3.616 - 2.616 \\
= 1 \text{ kJ/kg.K} \\
\frac{PV}{RT} = \frac{350 \times 0.7}{1.311} = 0.787kg \\
\frac{m_{H_2}}{m} = 0.2 \Rightarrow m_{H_2} = 0.2m \\
= 0.2 \times 0.787 \\
= 0.157kg \\
\frac{m_{O_2}}{m} = 0.8 \Rightarrow m_{O_2} = 0.8m \\
= 0.8 \times 0.787 \\
= 0.629kg \\
\]

\[
Q = mC_p(T_2 - T_1) \\
= 0.787 \times 3.616 \times (393 - 311) \\
= 233.35kJ \\
\]

(353)
(10.26)

\[ (3 \text{ mol CO}) \times (5 \text{ mol H}_2) \times (2 \text{ mol O}_2) \]

\[ \text{at} 17^\circ \text{C} \text{ and 24 bar} \]

\[ \text{Assume} \, T \text{ and } P \text{ to be constant.} \]

\[ MO_2 = 32, \, M H_2 = 2, \, M CO = 28. \]

\[ \frac{V_{O_2}}{V} = \frac{N_{O_2}}{N} = \frac{2}{2 + 5 + 3} = 0.2 \]

\[ \frac{V_{H_2}}{V} = \frac{V_{H_2}}{N} = \frac{5}{10} = 0.5 \]

\[ \frac{V_{CO}}{V} = \frac{V_{CO}}{N} = \frac{3}{10} = 0.3 \]

\[ M = \frac{V_{O_2}}{V} M_{O_2} + \frac{V_{H_2}}{V} M_{H_2} + \frac{V_{CO}}{V} M_{CO} \]

\[ = 0.2 \times 32 + 0.5 \times 2 + 0.3 \times 28 \]

\[ = 15.8 \text{ kg/kmol} \]

\[ R = \frac{M}{\bar{R}} = \frac{15.8}{8.314} \]

\[ = 1.89 \text{ kJ/kg.K} \]

\[ P_{O_2} = P \frac{N_{O_2}}{N} = 24 \times 0.2 = 4.8 \text{ bar} \]

\[ P_{H_2} = P \frac{N_{H_2}}{N} = 24 \times 0.5 = 12 \text{ bar} \]

\[ P_{CO} = P \frac{N_{CO}}{V} = 24 \times 0.3 = 7.2 \text{ bar} \]

\[ W_i = \frac{\sum M_i X_i}{\sum M_i} \]

\[ W_{O_2} = \frac{N_{O_2} M_{O_2}}{2 \times 2 + 2 \times 5 + 28 \times 3} \]

\[ = 40.5\% \]

\[ W_{H_2} = \frac{N_{H_2} M_{H_2}}{2 \times 0.5 + 2 \times 0.5 + 28 \times 3} \]

\[ = 6.3\% \]

\[ W_{CO} = \frac{N_{CO} M_{CO}}{2 \times 0.3 + 2 \times 0.5 + 28 \times 3} \]

\[ = 53.1\% \]
(10.27)

\[(\text{Air}=7 \text{ Moles}) \hat{\text{UCO}}=4\text{Moles})\hat{\text{U}}(\text{N}_2=3\text{Moles}) \hat{\text{U}}\text{He}=2\text{Moles})\]

\[
\begin{array}{c|cccc}
\text{He} & \text{N}_2 & \text{CO} & \text{O}_2 \\
\hline
\text{M(kg/kmol)} & 4 & 28 & 28 & 32
\end{array}
\]

\[
\frac{\text{Ni}}{\text{N}} = \frac{\text{Vi}}{\text{V}}
\]

\[
\frac{\text{NH}_e}{\text{N}} = \frac{\text{NH}_e}{\text{V}} = \frac{2}{2 + 3 + 4 + 7} = 0.125
\]

\[
\frac{\text{N}_{\text{N}_2}}{\text{N}} = \frac{\text{VN}_2}{\text{V}} = \frac{3}{16} = 0.1875
\]

\[
\frac{\text{N}_{\text{CO}}}{\text{N}} = \frac{\text{VN}_2}{\text{V}} = \frac{4}{16} = 0.25
\]

\[
\frac{\text{N}_{\text{O}_2}}{\text{N}} = \frac{\text{VO}_2}{\text{V}} = \frac{7}{16} = 0.437
\]

\[
\text{mi} = \text{Mi}.\text{Ni}
\]

\[
\text{m}_{\text{He}} = 4.2 \times 10^{-3} = 0.008\text{kg}
\]

\[
\text{m}_{\text{N}_2} = 28.3 \times 10^{-3} = 0.084\text{kg}
\]

\[
\text{m}_{\text{CO}} = 28.4 \times 10^{-3} = 0.112\text{kg}
\]

\[
\text{m}_{\text{O}_2} = 32 \times 7 \times 10^{-3} = 0.224\text{kg}
\]

\[
\text{m} = \sum \text{mi} = 0.428\text{kg}
\]

\[
\text{Wi} = \frac{\text{mi}}{\text{M}_i}
\]

\[
\text{W}_{\text{He}} = \frac{0.008}{0.428} = 1.87\%
\]

\[
W_{\text{N}_2} = 19.626\% \ , \ W_{\text{CO}} = 26.17\% \ , \ W_{\text{O}_2} = 52.336\%
\]
\[
\text{(10.28)}
\]

\[
\text{عstarting with the decomposition} \quad 2 \text{H}_2 \text{O} \rightarrow \text{H}_2 + \text{O}_2 \quad \text{at} \quad 27^\circ \text{C} \quad \text{and 1.5 bar}
\]

\[
\text{pressure, the initial mass} \quad m = 2 \text{kg}
\]

\[
\text{is split into} \quad \text{H}_2 = 0.1 \text{kg} \quad \text{and} \quad \text{O}_2 = 1 \text{kg}
\]

\[
\text{The final gases are} \quad \text{CO} = 0.2 \times 2 = 0.4 \text{kg}, \quad \text{H}_2 = 0.1 \text{kg}, \quad \text{CO}_2 = 0.5 \text{kg}, \quad \text{O}_2 = 1 \text{kg}
\]

\[
\text{The initial molar fractions are} \quad \text{H}_2 = \frac{0.1}{2}, \quad \text{CO} = \frac{0.4}{28}, \quad \text{CO}_2 = \frac{0.5}{44}, \quad \text{O}_2 = \frac{1}{32}
\]

\[
\text{The final molar fractions are} \quad \text{H}_2 = \frac{0.1 \text{kg}}{0.1 \text{kg}} = 1, \quad \text{CO} = \frac{0.4 \text{kg}}{0.4 \text{kg}} = 1, \quad \text{CO}_2 = \frac{0.5 \text{kg}}{0.5 \text{kg}} = 1, \quad \text{O}_2 = \frac{1 \text{kg}}{1 \text{kg}} = 1
\]

\[
\begin{array}{cccc}
\text{CO} & \text{H}_2 & \text{CO}_2 & \text{O}_2 \\
\text{Cp(kJ/kg.K)} & 1.04 & 14.4 & 0.82 & 0.9 \\
\text{N} & 28 & 2 & 44 & 32
\end{array}
\]

\[
\text{The total number of moles is} \quad n = 0.1060 \text{kmole}
\]

\[
\text{The total volume is} \quad V = \frac{0.0143}{0.0169} = 0.134
\]

\[
\text{The total volume is} \quad V = \frac{0.05}{0.0169} = 0.468
\]

\[
\text{The total volume is} \quad V = \frac{0.011364}{0.0169} = 0.603
\]

\[
\text{The total volume is} \quad V = \frac{0.03125}{0.0169} = 0.29233
\]

\[
\text{The total molar volume is} \quad V = 1.583 \text{kJ/kg.k}
\]

\[
\text{The total molar volume is} \quad V = 1.1385 \text{kJ/kg.k}
\]

\[
\text{The total molar volume is} \quad V = 1.39
\]

\[
\text{The total molar volume is} \quad V = 3.9323 \text{bar}
\]

\[
\text{(356)}
\]
\[ P = P' = 7 \text{bar}, \quad P_{O_2} = P_{N_2} \]

\[ V_{O_2} = V_{N_2} = 0.7 \text{m}^3 \]

\[ R_{O_2} = \frac{R}{M} = \frac{8.314}{32} = 0.26 \text{kJ/kg.K} \]

\[ R_{N_2} = \frac{R}{M} = \frac{8.314}{28} = 0.297 \text{kJ/kg.K} \]

\[ T = 90 + 273 = 363 \text{K} \]

\[ P = \frac{PV}{RT} = \frac{350 \times 1.4}{0.26 \times 363} = 5.2 \text{kg} \]

\[ m_{O_2} = \frac{PV}{R} = \frac{350 \times 1.4}{0.297 \times 363} = 4.55 \text{kg} \]

\[ m_{N_2} = \frac{PV}{R} = \frac{350 \times 1.4}{0.297 \times 363} = 4.55 \text{kg} \]

\[ \Delta S = m_{O_2} R_{O_2} \ln \frac{P}{P_{O_2}} + m_{N_2} R_{N_2} \ln \frac{P}{P_{N_2}} \]

\[ = (5.2 \times 0.26 + 4.55 \times 0.297) \ln \frac{7}{3.5} \]

\[ = 1.87 \text{kJ/kg} \]
\[(10.30)\]

\[1000^{\circ}C \ N_2 = 0.765 \ N_2 + 0.115 \ O_2 + 0.12 \ CO_2\]

\[1 \ kg \ \text{at}\ [\text{Pv}^{1.25 \ C.}] \ \text{is} \ \frac{\text{\gamma}}{\text{s}} \ \text{less} \ \text{in} \ \text{the} \ \text{gas} \ \text{phase}\]

\[\text{co}_2 \ n_{\text{m}} \times 0.28 + 0.765 \times 28 \approx 30.36 \text{kg}\]

\[\text{Cp} = \sum \frac{m_i \cdot C_{\text{pi}}}{m_i} = \frac{5.28}{30.36} \times 1.235 + \frac{3.68}{30.36} \times 1.088 + \frac{21.42}{30.36} \times 1.172 = 1.173 \text{kJ/kg.K}\]

\[R = \sum \frac{m_i \cdot R}{m_i} \cdot \frac{1}{M} = \frac{5.28}{30.36} \times \frac{8.134}{44} + \frac{3.68}{30.36} \times \frac{8.134}{32} + \frac{21.42}{30.36} \times \frac{8.314}{28} = 0.2739 \text{kJ/kg.K}\]

\[C_v = \text{Cp} - R = 1.173 - 0.2739 = 0.899 \text{kJ/kg.K}\]

\[T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{n-1} = 1273 \left(\frac{1}{7}\right)^{0.25} = 783.2 \text{K}\]

\[w_{12} = \frac{R(T_1 - T_2)}{n - 1} = \frac{0.2739(1273 - 783.2)}{1.25 - 1} = 536.3 \text{kJ/kg.K}\]

\[q_{12} = w_{12} + C_v(T_2 - T_1) = 536.3 + 0.899(783.2 - 1273) = 96 \text{kJ/kg}\]

\[\Delta s_{12} = C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1} = 0.899 \ln \frac{783.2}{1273} + 0.2739 \ln \frac{7}{1} = 0.0963 \text{kJ/kg.K}\]

or

\[\Delta s_{12} = \frac{\gamma - n}{\gamma - 1} R \ln \frac{V_2}{V_1} = \frac{1.305 - 1.25}{0.305} \times 0.2739 \ln \frac{7}{1} = 0.0961 \text{kJ/kg.K}\]
\[ V = V_{\text{mol}} \cdot N = 8.674 \times 20 \times 10^{-3} = 0.173 \text{m}^3 \]

\[ m_{N_2} = 28 \times 16 \times 10^{-3} = 0.448 \text{kg} \]

\[ m_{O_2} = 32 \times 4 \times 10^{-3} = 0.128 \text{kg} \]

\[ m_r = 0.448 + 0.128 = 0.576 \text{kg} \]

\[ R = \frac{PV}{m_r} = \frac{300 \times 0.173}{0.576 \times 313} = 0.2887 \text{kJ/kg.K} \]

\[ T_2 = T_1 \left( \frac{V_1}{V_2} \right)^{n-1} = 313 \left( \frac{4}{1} \right)^{0.2} = 413 \text{K} \]

\[ W = \frac{mR(T_1 - T_2)}{n - 1} = \frac{0.576 \times 0.2887(313 - 413)}{1.2 - 1} = -83.1456 \text{kJ} \]

\[ Cp = \frac{\sum m_iC_{pi}}{\sum m_i} = \frac{m_{N_2}C_{pN_2} + m_{O_2}C_{pO_2}}{m_{N_2} + m_{O_2}} = \frac{0.448 \times 1.046 + 0.128 \times 0.92}{3.576} = 1.018 \text{kJ/kg.K} \]

\[ Cv = Cp - R = 1.018 - 0.2887 = 0.73 \text{kJ/kg.K} \]

\[ \gamma = \frac{Cp}{Cv} = \frac{1.018}{0.73} = 1.396 \]

\[ \Delta S_{12} = mCv \frac{n - \gamma}{n - 1} \ln \frac{T_2}{T_1} = \frac{0.576 \times 0.7293(1.2 - 1.396)}{1.2 - 1} \ln \frac{413}{313} = -0.114 \text{kJ/K} \]

\[ \text{(10.31)} \]
\[ \text{O}_2 (\text{g}) \text{ and } \text{CO}_2 (\text{g}) \]
(10.33)

\[ N_{CH_4} = 1, \quad N_{O_2} = 3 \]

\[ N_{N_2} = \frac{V_{N_2}}{V_{O_2}} = \frac{0.79}{0.21} = \frac{N_{N_2}}{3} \]

\[ N_{N_2} = 3 \times \frac{79}{21} = 11.286 \]

\[ N_T = 11.286 + 1 + 3 = 15.286 \]

\[ C_{p_m} = \sum \frac{N_i}{N} \cdot C_{pi} \]

\[ = \frac{1}{15.286} \times 35.797 + \frac{3}{15.286} \times 129.341 + \frac{11.286}{15.286} \times 29.14 \]

\[ = 29.624 \text{kJ/kmol.K} \]

\[ C_v = C_p - R = 29.624 - 8.314 \]

\[ = 21.31 \text{KJ/Kmol.k} \]

\[ M_f = \sum \frac{N_i}{N} \cdot M_i \]

\[ = \frac{1 \times 16 + 3 \times 32 + 11.286 \times 28}{15.286 + 15.286 + 15.286} = 28 \]

\[ c_p = \frac{C_p}{M} = \frac{29.624}{28} = 1.058 \text{kJ/kg.K} \]

\[ c_v = \frac{C_v}{M} = \frac{21.31}{28} = 0.761 \text{kJ/kg.K} \]

\[ R = \frac{\bar{R}}{M} = \frac{8314.4}{28} = 296.94 \text{kJ/kg.K} \]
\[
\text{سُوِّجَتْ} \ CO \ (1) \ \text{أَفَّنِنجُ (3)} \ + \ \text{أَفَّنِنجُ لِبْأَوْلِدِ} \ CO\text{أَلاَدْيَأَنْجُ} \ \text{أَفَّنِنجُ} \ \text{أَدْيَأَنْجُ} \ \text{أَفَّنِنجُ} \ \text{أَدْيَأَنْجُ} \ (15^\circ \text{C}) \ \text{أَلَّيْجُ} \ \text{لَنَرْفُ (4)} \ \text{أَرَحَ} \ \text{CO}
\]

: \ \text{لِعَلَّ1} \ \text{أَرَحَ} \ \text{لِعَلَّ3} \ \text{أَرَحَ} \ \text{لِعَلَّ7} \ \text{أَرَحَ} \ \text{أَتَّأَدْيَأَنْجُ} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ (1)}

.(1 \ \text{kg/min}) \ \text{أَذَيْجُ (CO)} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ (2)}

: \ \text{أَذَيْجُ (0.1 m2)} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ} \ \text{أَذَيْجُ (4)}

\text{Cp O}_2=0.9182 , \ \text{Cp N}_2=1.04 , \ \text{Cp CO}=1.041 \ \text{kJ/kg.K}
\[ \frac{m_{\text{air}}}{m_{\text{co}}} = 3, \quad \frac{m_{\text{co}}}{m} = 4 \]

\[ \therefore m_{\text{air}} = 0.75\text{kg} \]

\[ m_{\text{co}} = 0.25\text{kg} \]

\[ 0.233\text{O}_2, 0.767\text{N}_2 \]

\[ m_{\text{O}_2} = 0.233 \times 0.75 = 0.175\text{kg} \]

\[ m_{\text{N}_2} = 0.767 \times 0.75 = 0.575\text{g} \]

\[ \sum\Delta h_{\text{in}} = \sum\Delta h_{\text{out}} \]

\[ \Rightarrow 0.175 \times 0.9182 \times 305 + 0.575 \times 1.05 \times 305 + 0.25 \times 1.041 \times 288 \]

\[ = T(0.175 \times 0.9182 + 0 \times 575 \times 1.04 + 0.25 \times 1.041) \]

\[ 306.351 = 1.0189T \]

\[ \therefore T = 300.7\text{K} \]

<table>
<thead>
<tr>
<th>( \frac{P_i}{P} )</th>
<th>( \frac{N_i}{N} )</th>
<th>( \frac{N}{M} )</th>
<th>( \sum\Delta h_{\text{in}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{\text{O}_2} )</td>
<td>0.1565</td>
<td>0.175</td>
<td>0.00547</td>
</tr>
<tr>
<td>( P_{\text{N}_2} )</td>
<td>0.588</td>
<td>0.575</td>
<td>0.0205</td>
</tr>
<tr>
<td>( P_{\text{CO}} )</td>
<td>0.2556</td>
<td>0.25</td>
<td>0.00893</td>
</tr>
<tr>
<td>( N_i = 0.03494 )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \Delta s = \sum\Delta s_i \]

\[ m = 0.175, T_1 = 305\text{K} \]

\[ T_2 = 300 \times 7\text{K}, P_1 = 7 \times 0.21 = 1.47\text{bar}, P_2 = 0.156\text{bar} \]

\[ \therefore \Delta S_{\text{O}_2} = m(Cp_{\text{ln}} \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}) \]

\[ = m(Cp_{\text{ln}} \frac{T_2}{T_1} + R \ln \frac{P_1}{P_2}) \]

\[ = 0.175(0.9182 \ln \frac{3007}{305} + 8.314 \ln \frac{1.47}{0.156}) \]

\[ = 0.1\text{kJ/K} \]

\[ m = 0.598, T_1 = 305\text{K} \]

\[ T_2 = 300.7\text{K}, P_2 = 7 \times 0.79 = 5.53\text{bar}, \]

\[ P_1 = 0.588\text{bar} \]

\[ \therefore \Delta S_{\text{N}_2} = m(Cp_{\text{ln}} \frac{T_2}{T_1} + R \ln \frac{P_2}{P_1}) \]

\[ = 0.598(1.041\ln \frac{300.7}{305} + 8.314 \ln \frac{5.53}{0.588}) \]

\[ = 1.66\text{kJ/K} \]
\[ m = 0.25, T_1 = 288K \]
\[ T_2 = 300.7K, P_1 = 4\text{bar}, \]
\[ P_2 = 0.2556\text{bar} \]

\[ \therefore \Delta s_{co} = m(Cp \ln \frac{T_2}{T_1} + R \ln \frac{P_2}{P_1}) \]
\[ = 0.25(1.041\ln \frac{300.7}{305} + \frac{8.314}{28}\ln \frac{0.2556}{4}) \]
\[ = -0.2\text{kJ/K} \]

\[ (\Delta S)_{\text{total}} = \sum \Delta S_i = 1.55\text{kJ/K} \]

(4)

\[ \frac{m_{CO}}{m_T} = \frac{1}{4} \Rightarrow 1\text{kg(CO)} \]

\[ = 4\text{kg(mixture)} \]

\[ N = 4 \times 0.03494 = 0.13976 \text{kg CO/m}^2 \text{s} \]

\[ \dot{V} = \frac{NRT}{P} \]
\[ = \frac{4 \times 0.03494 \times 8.314 \times 300.7}{100} \]
\[ = 3.494 \text{m}^3/\text{min} \]

\[ \dot{V} = C \cdot A \]

\[ C = \frac{\dot{V}}{A} = \frac{3.494 \text{m}^3/\text{min}}{0.1 \text{m}^2} \]
\[ = 34.9 \text{m}^3/\text{min} \]
\[ = 0.58 \text{m/s} \]
$$\gamma = \frac{C_p}{C_v} = 1.3969$$


1 - الأولى

\[ m_1 = 0.5565 \text{Kg} \times T_1 = 305K \times T_2 \]
\[ = 300.9K \]
\[ V_1 = 0.3m^3, V_2 = 0.33m^3 \]
\[ \Delta S_1 = m(Cv \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}) \]
\[ \Delta S_1 = 0.5565(0.6586 \ln \frac{300.9}{305} \]
\[ + \frac{8.314}{32} \ln \frac{0.33}{0.3} \]
\[ = 0.009kJ/K \]

2 - الثانية

\[ m_2 = 0.8419 \text{Kg} \times T_1 = 288K \times T_2 \]
\[ = 300.9K \]
\[ V_1 = 0.03m^3, V_2 = 0.33m^3 \]
\[ \Delta S_2 = 0.8419(0.6586 \ln \frac{300.9}{288} \]
\[ + \frac{8.314}{32} \ln \frac{0.33}{0.03} \]
\[ = 0.075kJ/K \]

3 - الثالثة

\[ m_{N_2} = 1.8318Kg \times T_1 = 305K \times T_2 \]
\[ = 300.9K \]
\[ V_1 = 0.3m^3, V_2 = 0.33m^3 \]
\[ \Delta S = 1.8318(0.7436 \ln \frac{300.9}{288} \]
\[ + \frac{8.314}{28} \ln \frac{0.33}{0.03} \]
\[ = 1.342kJ/K \]
\[ (\Delta S)_{total} = \Delta S_1 + \Delta S_2 + \Delta S_3 \]
\[ = 1.1426kJ/Kg \]

\[ 10^\circ C \]

\[ U_2 - U_1 = mCv(T_2 - T_1) \]
\[ = (0.5565 + 0.8419 + 1.8318) \]
\[ \times 0.7068(10 - 27.7) \]
\[ = -40.4kJ \]

\[ \Delta H = mCp\Delta T \]
\[ = 3.23 \times 0.9873(10 - 27.7) \]
\[ = -56.4kJ \]
\[ \Delta \mu = \frac{\Delta U}{m} = \frac{-40.4}{3.23} = -12.5kJ \]
\[ \Delta h = \frac{\Delta H}{m} = \frac{-56.4}{3.23} = -17.45kJ \]
1.1) (5 مولات CO2) Ä (10 مولات N2) Ä (5 مولات O2) €(2 بار) نهر (23 °C)

<table>
<thead>
<tr>
<th></th>
<th>O2</th>
<th>N2</th>
<th>CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cv (kJ/kg.K)</td>
<td>0.65</td>
<td>0.727</td>
<td>0.639</td>
</tr>
<tr>
<td>M (kg/kmol)</td>
<td>32</td>
<td>28</td>
<td>44</td>
</tr>
</tbody>
</table>

(66.05kJ, 90.9kJ, 0.246م³) €

1.2) (150 °C) كـ (32 بار) (81% N2) كـ (5% O2) كـ (14% CO2)

MO2=32 kg/kmol, M CO2=44 kg/kmol, M N2=28 kg/kmol

(0.453م³, 3.24بار, 0.20بار, 0.56بار, 0.745, 0.053, 0.202) €

1.3) (30%O2) كـ (20 °C) 

(67.1%, 32.9%, 0.714بار, 0.306بار, 0.645 kJ/kg.K) €

(367)
(10.4)

\[
\begin{align*}
\text{ـ} & \quad 2 \text{ أس.} \quad \text{Om.} \quad \text{ـ} \\
\text{ـ} & \quad \text{ـ} \\
\end{align*}
\]

(10.5)

\[
\begin{align*}
\text{ـ} & \quad \text{ـ} \\
\text{ـ} & \quad \text{ـ} \\
\end{align*}
\]

(10.6)

\[
\begin{align*}
\text{ـ} & \quad \text{ـ} \\
\text{ـ} & \quad \text{ـ} \\
\end{align*}
\]
\[ (10.7) \]

\[ (10.8) \]

\[ (10.9) \]
\[(10.10)\]

\[\text{Gas mixture} (75\% \text{C}_4\text{H}_{10}) (15\% \text{N}_2) (10\% \text{H}_2) \text{ is fed to the reactor.}\]

\[\text{The mixture} (6.5\%) \text{ is fed to the reactor.}\]

\[\text{The mixture} (2\% \text{LJ}) \text{ is fed to the reactor.}\]

\[\text{Gas flow rate: } \text{O}_2 (1\text{m}^3/\text{s}), \text{N}_2 (1\text{m}^3/\text{s}) \text{ and } \text{H}_2 (1\text{m}^3/\text{s}) \text{ are fed to the reactor.}\]

\[\text{The gas flow rate: } \text{O}_2 (0.5\text{m}^3/\text{s}), \text{N}_2 (0.5\text{m}^3/\text{s}) \text{ and } \text{H}_2 (0.5\text{m}^3/\text{s}) \text{ are fed to the reactor.}\]

\[\text{The gas flow rate: } (\text{O}_2) 0.5\text{m}^3/\text{s}, (\text{N}_2) 0.5\text{m}^3/\text{s} \text{ and } (\text{H}_2) 0.5\text{m}^3/\text{s} \text{ are fed to the reactor.}\]

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\[\text{The gas flow rate: } (\text{O}_2) 0.5\text{m}^3/\text{s}, (\text{N}_2) 0.5\text{m}^3/\text{s} \text{ and } (\text{H}_2) 0.5\text{m}^3/\text{s} \text{ are fed to the reactor.}\]

\[\text{The gas flow rate: } (\text{O}_2) 0.5\text{m}^3/\text{s}, (\text{N}_2) 0.5\text{m}^3/\text{s} \text{ and } (\text{H}_2) 0.5\text{m}^3/\text{s} \text{ are fed to the reactor.}\]

\[\text{The gas flow rate: } (\text{O}_2) 0.5\text{m}^3/\text{s}, (\text{N}_2) 0.5\text{m}^3/\text{s} \text{ and } (\text{H}_2) 0.5\text{m}^3/\text{s} \text{ are fed to the reactor.}\]

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\[\text{The gas flow rate: } (\text{O}_2) 0.5\text{m}^3/\text{s}, (\text{N}_2) 0.5\text{m}^3/\text{s} \text{ and } (\text{H}_2) 0.5\text{m}^3/\text{s} \text{ are fed to the reactor.}\]
\(10.12\)

\[ \text{4.95 Mole O}_2 \text{ (1.65 Mole CO) } \text{23.2 Mole CO}_2 \text{ (1.65 Mole CO)} \]

\(\text{1.00} \text{ Mole KOH} \text{ (1000°C) } \text{1 bar} \)

: \(\% \text{ of KOH in KOH } \text{18\%} \text{)}\]

\(10.13\)

\[ \text{76.5 \% N}_2 \text{ (11.5\% O}_2 \text{ (12\% CO}_2 \text{ (1.65 Mole CO)} \text{23.2 Mole CO}_2 \text{ (1.65 Mole CO)} \]

\(\text{2.6 bar} \text{ (1 bar)} \)

: \(\% \text{ of KOH in KOH } \text{18\%} \text{)}\]

\(\text{CO}_2 \text{ (1.65 Mole CO)} \text{23.2 Mole CO}_2 \text{ (1.65 Mole CO)} \]

\[ \text{M (kg/kmol)} \text{ 44} \text{ 32} \text{ 28} \text{ 44} \]

\[ \text{Cp (kJ/kg.K)} \text{ 0.846} \text{ 0.918} \text{ 1.04} \]

\((-0.685\text{kJ/kg.K}, -3.45\text{kJ/kg}, 1.989\text{bar}, 0.299\text{bar}, 0.321\text{bar})\)
\[ \text{(10.14)} \]

\[
\begin{array}{ccc}
\text{O}_2 & \text{N}_2 & \text{CH}_4 \\
\text{Cp (kJ/kg.K)} & 0.92 & 1.04 & 2.23 \\
\text{M (kg/kmol)} & 32 & 28 & 16 \\
\end{array}
\]

\{(0.721, 0.22, 0.05, -37.15kJ)\}

\[
\text{(10.15)} \]

\[
\begin{array}{ccc}
\text{CO}_2 & \text{O}_2 & \text{N}_2 \\
\text{Cp (kJ/kg.K)} & 0.846 & 0.92 & 0.743 \\
\text{M (kg/kmol)} & 44 & 32 & 28 \\
\end{array}
\]

\{(0.445kg, 0.046kg, 0.5kg, 1.428, 1.232kg, 0.128kg, 1.408kg)\}

(372)
References

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