1A $p = \frac{F}{A} \Rightarrow F = pA$

$F = (p_{Atm} + \rho g h) A = (515840\,Pa)\left[\pi (1.43)^2\right]$

$\underline{F = 331.4\,N}$

1B

$n = 1$ mol

$W = +4500\,J$

$T_i = 300\,K$ $\qquad T_f = ?$

$p_i = 1.6$ atm $= 162080\,Pa$ $\qquad p_f = ?$

$\gamma = 5/3$ (ideal gas - mono-atomic)

process is adiabatic so

$$W = \frac{1}{\gamma - 1}(p_f V_f - p_i V_i) =$$

$$W = \frac{1}{\frac{5}{3} - 1}(p_f V_f - p_i V_i)$$

$$p_i V_i = nRT_i \Rightarrow V_i = \frac{nRT_i}{p_i} = \frac{(1)(8.31)(300)}{162080}$$

$$V_i = 0.01538\,(m^3)$$

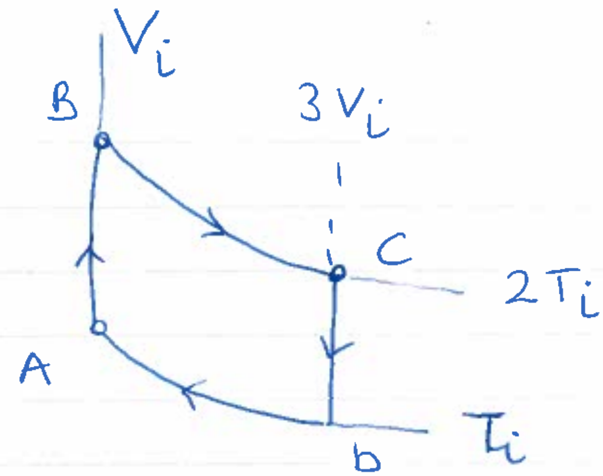
$$\underline{V_i = 15.38\,l}$$

$$4500 = \frac{1}{\frac{2}{3}}(p_f V_f - 162080 \cdot 0.01538)$$

$$3000 = p_f V_f - 2493$$

$$p_f V_f = 5493\,(J)$$

Q2 Stirling Engine



A Total work $= W_{AB} + W_{BC} + W_{CD} + W_{DA}$

$W_{AB} = W_{CD} = 0$ isovolumetric transformati

$$W_{BC} + W_{DA} = -nRT_B \ln \frac{V_C}{V_B} - nRT_D \ln \frac{V_A}{V_D}$$

$$= -nR(2T_i) \ln \frac{3V_i}{V_i} - nRT_i \ln \frac{V_i}{3V_i}$$

$$= -2nRT_i \ln 3 - nRT_i \ln \frac{1}{3}$$

$$= -nR(\ln 3)T_i \left[2 - 1\right] = -(\ln 3)nRT_i$$

(6) $W_{total} = -nRT_i \ln 3$

Heat transferred to the gas (positive)

$$Q_{AB} + Q_{BC} = nC_v(T_B - T_A) + nRT_B \ln \frac{V_C}{V_B}$$

$$= nC_v(2T_i - T_i) + nR(2T_i) \ln 3$$

$$= nT_i\left(C_v + 2(\ln 3)R\right)$$

(7) $C_v = \frac{3}{2}R \Rightarrow Q_h = nT_iR\left(\frac{3}{2} + 2\ln 3\right)$

$p_f V_f = 5493 (J)$

$nRT_f = 5493 \ (J)$

$$T_f = \frac{5493}{8.31} (K) = 661 \ K$$

On the other hand $\quad \underline{p_i V_i^{\gamma} = p_f V_f^{\gamma} = const}$

$$p_i \left(\frac{nRT_i}{p_i} \right)^{\gamma} = p_f \left(\frac{nRT_f}{p_f} \right)^{\gamma}$$

$$\frac{p_i}{p_i^{\gamma}} T_i^{\gamma} = \frac{p_f}{p_f^{\gamma}} T_f^{\gamma}$$

$$p_i^{1-\gamma} T_i^{\gamma} = p_f^{1-\gamma} T_f^{\gamma}$$

$$p_f = p_i \left(\frac{T_i}{T_f} \right)^{\frac{\gamma}{1-\gamma}}$$

$$p_f = 162080 \left(\frac{300}{661} \right)^{-5/3}$$

$$p_f = 1168013 \ Pa$$

ANS $\quad T_f = 661K, \ p_f = 1168013 Pa$

Q3

$M = 0.044\ kg/mole$ $\qquad$ $v \in (630, 632)\ m/s$

$T = 27^\circ C = 300K$ $\qquad$ $v = 631\ m/s;\ dv = 2\ m/s$

a) $$P_{631} = 4\pi\left[\frac{1}{2\pi}\frac{0.044}{(8.31)(300)}\right]^{3/2}(631)^2 e^{-\frac{0.044\cdot 631^2}{2(8.31)300}}[2]$$

b) v_{MP} at $T = 300K$

$$v_{MP} = \sqrt{\frac{2kT}{m}} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2(8.31)300}{0.044}} = 336.6\ \frac{m}{s}$$

c) $v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$, at what Temp $v_{rms} = 336.6$

$$\sqrt{\frac{3RT}{M}} = 336.6$$

$$T = 199.96 \simeq 200K$$

d) $\frac{dP}{dv} = 0$ when $P(v)$ reaches maximum.

$$\frac{dP}{dv} = 0 \Rightarrow \frac{d}{dv}\left(v^2 e^{-\frac{mv^2}{2kT}}\right) = 0$$

$$\left(2v - \frac{m}{kT}v^3\right)e^{-\frac{mv^2}{2kT}} = 0 \Rightarrow v\left(2 - \frac{m}{kT}v^2\right) = 0$$

$v = 0$ $\qquad$ or $\qquad$ $v^2 = \frac{2kT}{m}$

Q4

Using the isobaric process (table values for W, Q, ΔE_{int})

$$\left.\begin{aligned} \Delta E_{int} &= n C_V \Delta T \\ W &= -p\Delta V \\ Q &= n C_p \Delta T \end{aligned}\right\}$$

First Law of Thermodynamics

$$\Delta E_{int} = Q + W$$

$$\Delta E_{int} = Q + W$$

$$n C_V \Delta T = n C_p \Delta T - \underbrace{p \Delta V}$$

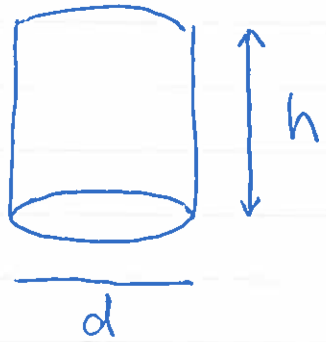
$$n C_V \Delta T = n C_p \Delta T - n R \Delta T$$

$$C_V = C_p - R$$

(A) $C_p = C_V + R$

(B) Discussed in lecture in details + (A3)

Q5



$d = h \Rightarrow 2r = h$

$m = 2\,kg \;,\; \rho = 8.94 \dfrac{kg}{cm^3}$

a) $Q_{Cu} + Q_{H_2O} = 0$

$$m_{Cu} C_{Cu} (T_f - T_{i_{Cu}}) + m_{H_2O} C_{H_2O} (T_{f_{H_2O}} - T_{i_{H_2O}}) = 0$$

$$(2\,kg)(385)(T_f - 850) + 5(4186)(T_f - 10) = 0$$

$$770 T_f - 654{,}500 + 20930 T_f - 209{,}300 = 0$$

$$21700\, T_f = 863800$$

$$\underline{T_f = 39.4\,°C}$$

ANS : Final temperature of this system is $39.4\,°C$

b) $P_i = \sigma A T_i^4$ $\qquad P_f = \sigma A T_f^4 \;;\; \underline{e = 1}$

$$\frac{P_i}{P_f} = \frac{T_i^4}{T_f^4} = \frac{(850+273)^4}{(39.4+273)^4} = \left(\frac{1123}{312.4}\right)^4 = (3.59)^4$$

$$\frac{P_i}{P_f} = 166.98 \simeq \underline{\underline{167}}$$

c Surface area SA

$$\Delta S = \beta S_i \Delta T = 2\alpha S_i \Delta T$$

$S_i = 2(\pi r^2) + 2\pi r h$; $2r = h$ so

$S_i = 2\pi r^2 + 2\pi r(2r) = 6\pi r^2$

to find S_i we need to figure out r

the cylinder's mass is $2\,kg$; $\rho = 8.94 \frac{g}{cm^3}$

since $\rho = \frac{m}{V} \Rightarrow V = \frac{m}{\rho} = \frac{2000\,g}{8.94\,g/cm^3}$

$V = 223.71\ cm^3$

Volume of the cylinder is $\pi r^2 h = \pi r^2 (2r) = \pi 2 r^3$

$223.71 = 2\pi r^3$

$r^3 = \frac{223.71}{2\pi} \Rightarrow r = \sqrt[3]{\frac{223.71}{2\pi}}$

$r = \sqrt[3]{35.60} = 3.289\,cm$

$S_i = 204\,cm^2 \Rightarrow \Delta S = 2(17\times10^{-6})\cdot(204)\cdot(-810.4)$

$\Delta S = 5.62\ cm^2$