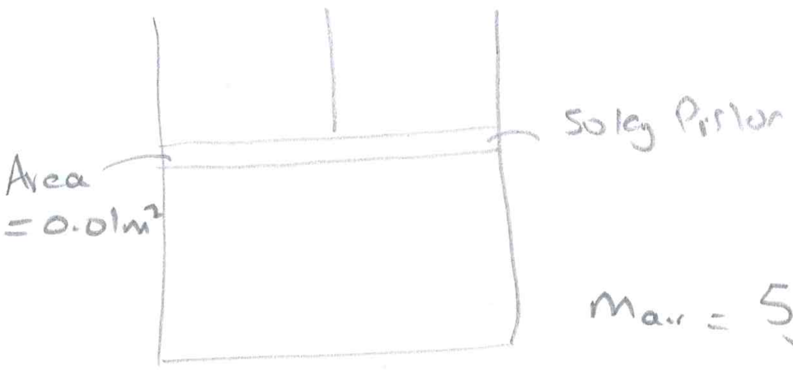
Problem 1

Exam 2 2017

CHEN



$m_{air} = 5g = 0.005\,kg$

$V_1 = 5L = 0.005\,m^3$

$V_2 = 0.002\,m^3$

$$P_T = P_0 + \frac{m_{pist} * g}{A_{pist}} = 100 + \frac{50 * 9.81}{0.01 * 10^3}$$

$$= 149.05\,kPa$$

$$W = \int_{V_1}^{V_2} P\,dV = 149.05\,[0.002 - 0.005]$$

$$= -0.447\,kJ$$

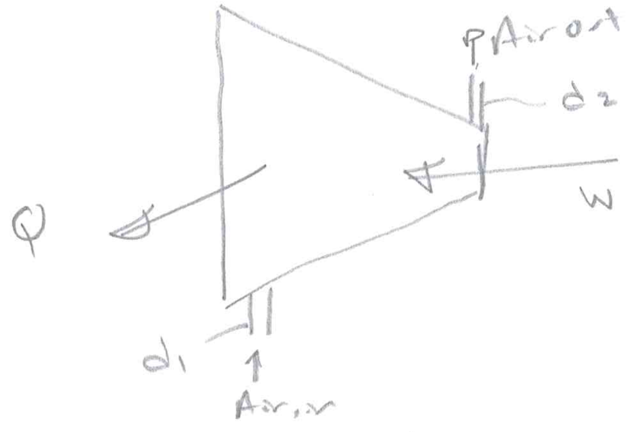
but $\Delta U = Q - W$

$$\Rightarrow -260 * 0.005 = Q - (-0.447)$$

$$\boxed{Q = -1.747\,kJ}$$

Problem 2

velocity = 90 m/s
P_2 = 8 bar
v_2 = 0.14 m³/kg



$\dot{m} = \frac{12}{60} = 0.2$ kg/s

vel_1 = 12 m/s
P_1 = 1 bar
v_1 = 0.5 m³/kg

$\Delta PE = 0$
$\Delta h = -150$ kJ/kg
$\Delta KE = \frac{12^2 - 90^2}{2 \times 1000}$

$Q = \frac{700}{60} = -11.67$ kW

$\Rightarrow W = 0.2 \left[-150 + \frac{12^2 - 90^2}{2 \times 1000} \right] + (-11.67)$

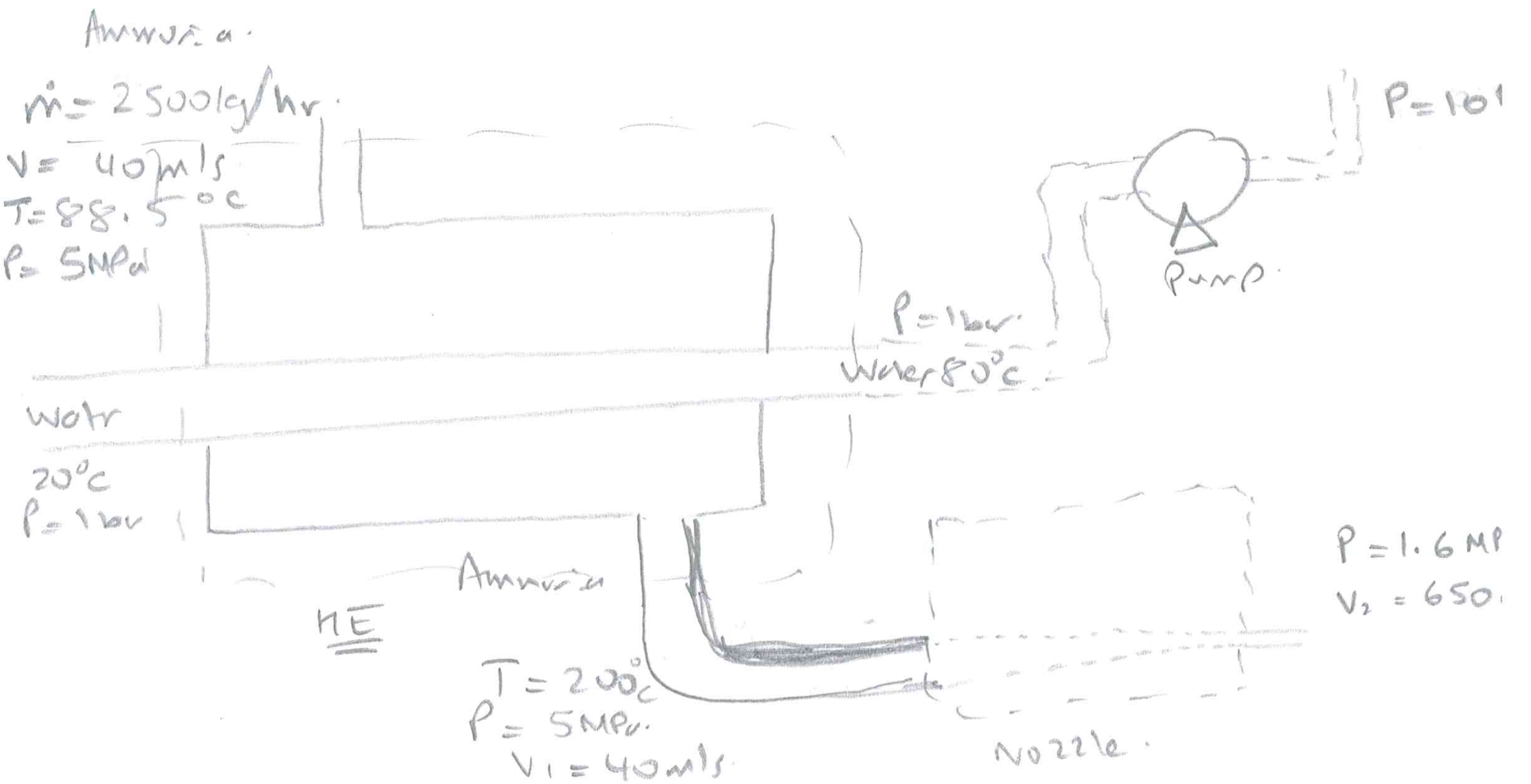
(i) $W = -42.46$ kW

(ii) $m = \frac{A_1 vel_1}{v_1} = \frac{A_2 vel_2}{v_2} \Rightarrow \frac{A_1}{A_2} = \frac{v_1 \times vel_2}{v_2 \times vel_1}$

$\frac{A_1}{A_2} = \frac{90 \times 0.5}{12 \times 0.14} = 26.786$

but $A_1 = \pi d_1^2$, $A_2 = \pi d_2^2 \Rightarrow \left[\frac{d_1^2}{d_2^2}\right] = 26.786 \Rightarrow \left[\frac{d_1}{d_2}\right] = 5.176$

Problem 3



① Heat Exchanger.

Impossible → 2 streams are being heated!

∴ either one of the streams is heated.

Not enough information is provided to determine Q for water:- $\dot{Q} = \dot{m}\, c_p\, \Delta T$ ∴ (d), (f) and (g) are not possible

For Ammonia, Q can be calculated as follows:-

(b) From Table B.2.1 + B.2.1. T_{sat} at 5MPa is 88.90.

∴ Ammonia is a compressed liquid, but very close to being saturated liquid.

HE Balance

Assumpt: $\Delta KE = 0$, $\Delta PE = 0$, well insulated, $\dot{W} = 0$

c) Ammonia is evaporated and then superheated:

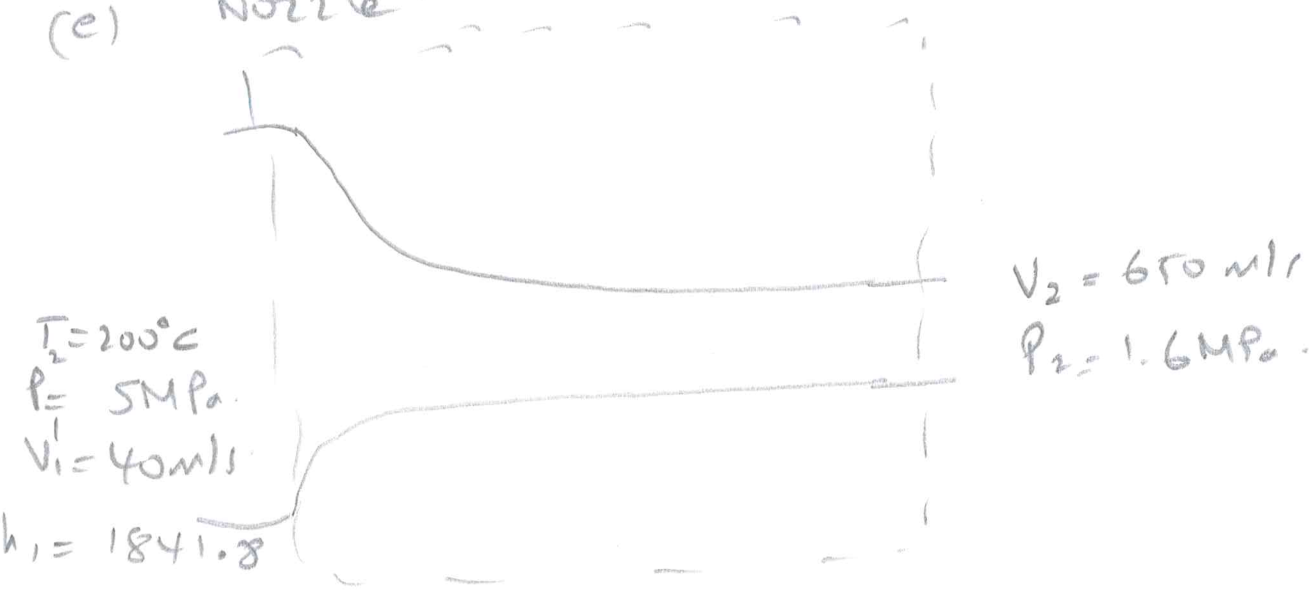
$\dot{m}\,\Delta h = (h_{fg} + (h_{200} - h_{88.90})) \times \dot{m}_{Ammonia} = \dot{Q}$

$= [800.8 + (1841.8 - 1441.4)] \frac{2500}{3600}$

$\dot{Q} = 834.17\ kW$

Probl. 3 continued

(e) Nozzle



Energy Balance + Assump.

$\Delta PE = 0$, $W = 0$, $Q = 0$ (well insulated)

$$\therefore \quad h_2 = h_1 + \left[\frac{V_1^2}{2} - \frac{V_2^2}{2}\right] \cdot \frac{1}{1000}$$

$$= 1841.8 - 210.45$$

$$= 1,631.35 \text{ kJ/kg}.$$

We have 2 properties $P_2 + h_2$

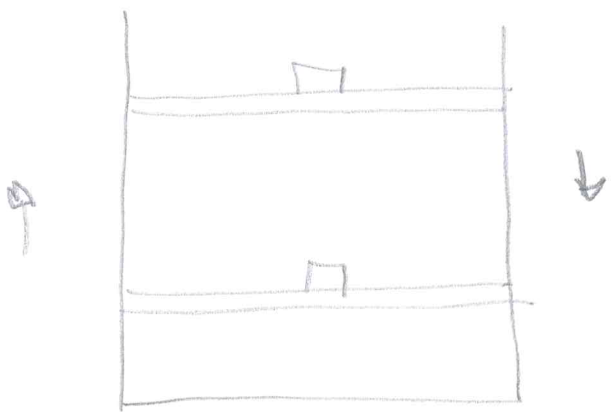
From Table B.7.2 at $P = 1,600 kPa$ + $h_2 = 1,631.3$

we have a superheated vapour

$h_2 > h_{sat}$

By interpolation $T_2 = 95°C$

Problem 4



$$\eta = 1 - \frac{T_L}{T_H} = 1 - \frac{1}{1.5}$$

$$= 0.3333 \qquad \underline{33.33\%}$$

but $$\eta_{carnot} = \frac{W}{Q_H} = \frac{Q_H - Q_L}{Q_H}$$

$$\Rightarrow 0.333 = \frac{30}{Q_H} \Rightarrow Q_H = 90$$

but $Q_H - Q_L = W \Rightarrow Q_L = 90 - 30$
$= 60 kW$

$$\therefore q_L = \frac{60}{0.02457} = 2,442 \text{ kJ/kg} = h_{fg}$$

From Tables. $\boxed{T = 25°C}$

Problem 5

Refrigeration cycle: $COP = \frac{\dot{Q}_L}{W} = \frac{\dot{Q}_L}{\dot{Q}_H - \dot{Q}_L}$

$$\text{Carnot } \eta_{RC} = \frac{T_L}{T_H - T_L} = \frac{5+273.15}{(40+273.15) - (5+273.1}$$

$$= 7.95$$

$\therefore$ refrig. $\eta_{RC} = 0.6 \times 7.95 = 4.77$

$$\Rightarrow \dot{W} = \frac{\dot{Q}_L}{\text{ref. } \eta_{RC}} = \frac{8}{4.77} = \boxed{1.68\,kW}$$