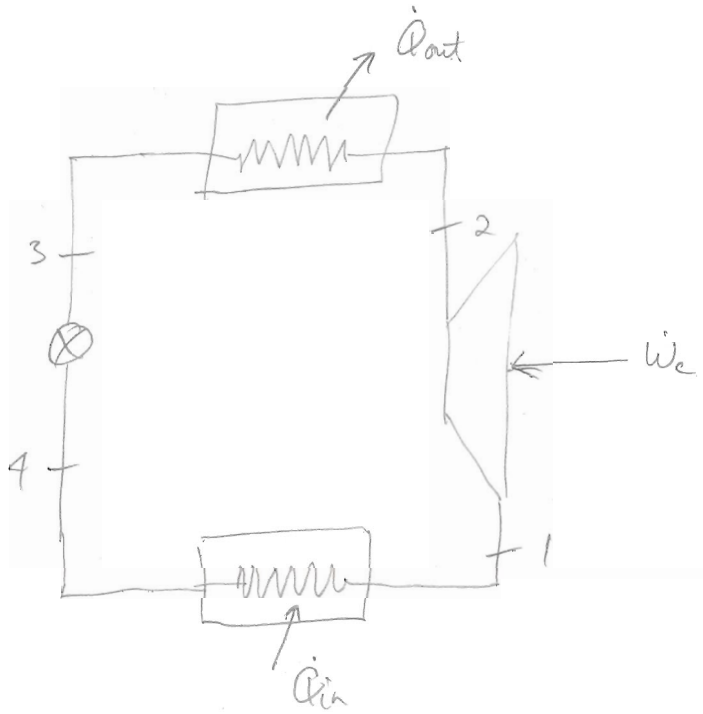
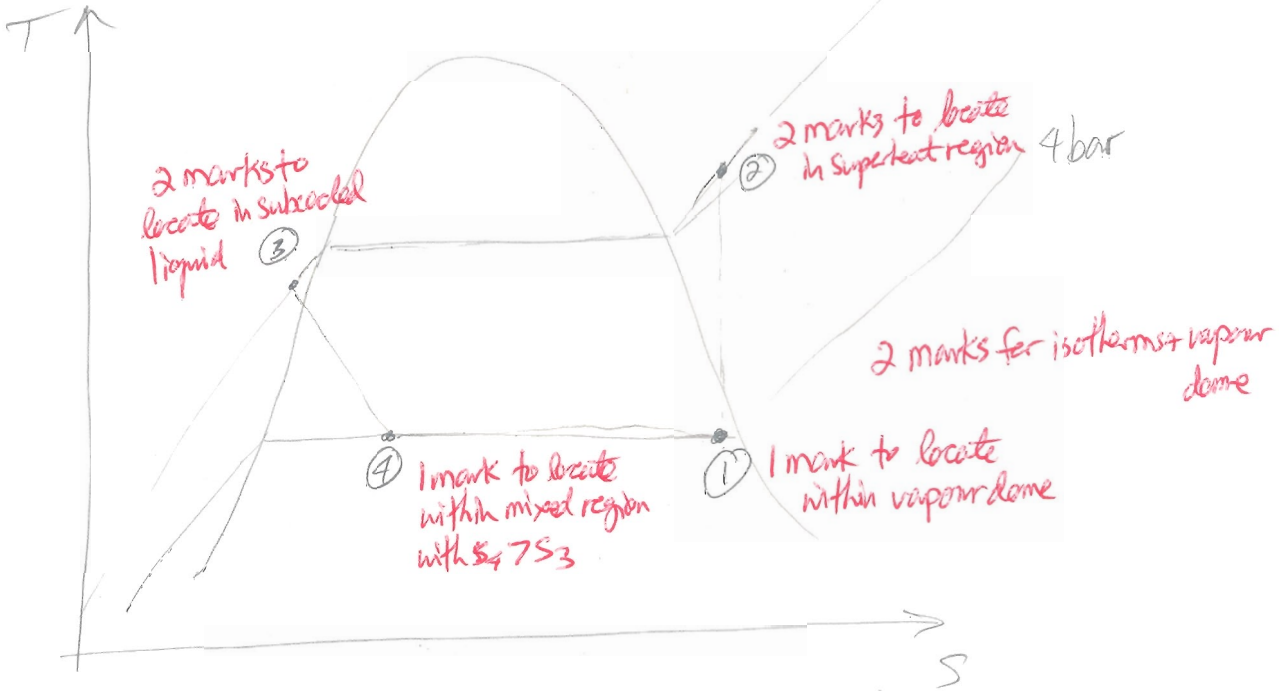
Vapour Compression Refrigeration Question





a)

(8)

Given: $P_1 = P_4 = 4\,bar$

$P_2 = P_3 = 10\,bar$

$v_1 = 0.0504 \frac{m^3}{kg}$

$T_3 = 38°C$

R134a

① $P_1 = 4\,bar$, $v_1 = 0.0504 \frac{m^3}{kg}$ } within mixed region by Table A-11.

$x_1 = 0.990$

$s_1 = 0.9078 \frac{KJ}{kgK}$ by Table A-11

$h_1 = 250.42 \frac{KJ}{kg}$

② $P_2 = 10\,bar$

$s_2 \geq s_1 = 0.9078 \frac{KJ}{kgK}$

$s_g = 0.9043 \frac{KJ}{kgK}$ (Table A-11)

$\therefore s_2 \geq s_g \Rightarrow$ superheated

③ $P_3 = 10\,bar$

$T_3 = 38°C$

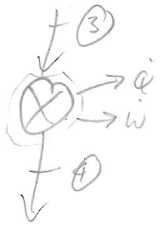
$T_{sat} = 39.39°C$

$\therefore T_3 < T_{sat} \Rightarrow$ subcooled liquid

$h_3 \approx h_f(T_3) = 103.21 \frac{KJ}{kg}$ (Table A-10)

④ $P_4 = 4$ bar

$$\left.\begin{aligned} h_f &= 62.0 \ \tfrac{kJ}{kg} \\ h_g &= 252.32 \ \tfrac{kJ}{kg} \end{aligned}\right\} \text{Table A-11}$$



$$1^{st}\ \text{law:}\quad \frac{dE_{cv}}{dt}^{SS} = -\dot{Q}^{\text{assume adiabatic}} - \dot{W}^{\text{no work}} + \dot{m}\left(h + \frac{V^2}{2} + gz\right)_3 - \dot{m}\left(h + \frac{V^2}{2} + gz\right)_4^{\text{neglect } \Delta KE \text{ \& } \Delta PE \text{ effects}}$$

$$\therefore\ h_4 = h_3 = 103.21 \ \tfrac{kJ}{kg}$$

$$x_4 = \frac{103.21 - 62.0}{252.32 - 62.0} = 0.216$$

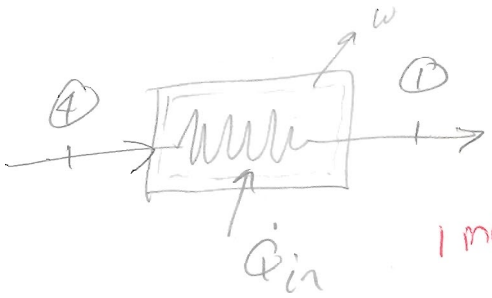
(3) b) $T_1 = T_4 = T_{sat}(4\text{bar}) = 8.93°C$ 2 marks

To effect a heat transfer from the wine cabinet (the cold reservoir) to the working fluid at the evaporator, there must be a finite temperature difference. Therefore, the wine cabinet must be warmer that 8.93°C.

1 mark to state that wine cabinet must be warmer than T_{sat}

④

c)



④

1 mark for 1st law + assumptions

1st law: $\frac{dE_{cv}^{\cancel{SS}}}{dt} = \dot{Q}_{in} - \cancel{\dot{W}}^{\text{no work}} + \dot{m}\left(h + \cancel{\frac{V^2}{2}}^{\text{neglect } \Delta KE \text{ \& } \Delta PE \text{ effects}} + g\cancel{z}\right)_4 - \dot{m}\left(h + \cancel{\frac{V^2}{2}} + g\cancel{z}\right)_1$

$$\frac{\dot{Q}_{in}}{\dot{m}} = h_1 - h_4$$

1 mark for h_1 1 mark for h_4

$$= 250.42 - 103.21 \quad \left(\frac{kJ}{kg}\right)$$

$$\boxed{\frac{\dot{Q}_{in}}{\dot{m}} = 147.21 \ \frac{kJ}{kg}}$$

1 mark for $\frac{\dot{Q}_{in}}{\dot{m}}$