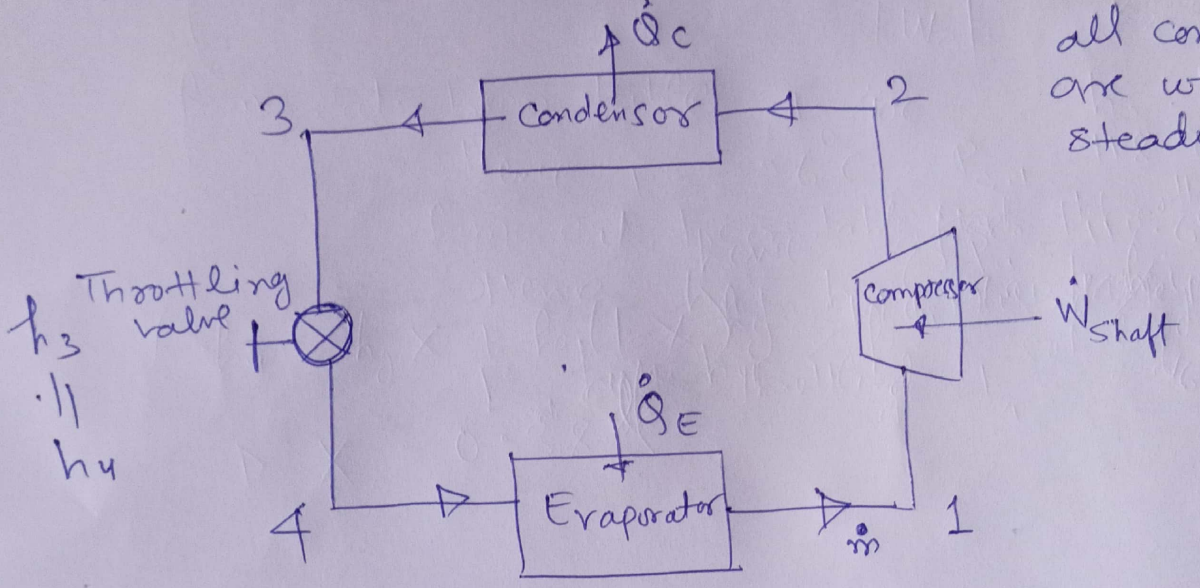
Class illustration on Refrigeration cycle

→ In a vapor compression refrigerator, Freon-12 leaves the compressor as sat. vap at 40°C ($x=1$) enters the condensor & leave it as sat. liq at 40°C ($x=0$) The liquid Freon-12 is then throttled to a low pressure & low temp = −26°C. Determine the pressure up to which refrigerant has been throttled & also determine the state of refrigerant.



Evaporator & condensor both are working as heat exchanger's

hence $\dot{m} h_4 + |\dot{Q}_E| = \dot{m} h_1$

$\Rightarrow h_4 + \frac{|\dot{Q}_E|}{\dot{m}} = h_1 \Rightarrow \boxed{h_1 - h_4 = \frac{|\dot{Q}_E|}{\dot{m}}}$

&

$\dot{m} h_2 - |\dot{Q}_C| = \dot{m} h_3 \Rightarrow \boxed{h_2 - h_3 = \frac{|\dot{Q}_C|}{\dot{m}}}$

hence $h_3 = h_4$ (throttling process)

$\Rightarrow h_2 - h_4 = \frac{|\dot{Q}_C|}{\dot{m}}$

Compressor (no heat interaction across compressor)

$$\dot{m}h_1 - \dot{m}h_2 + \cancel{\dot{Q}} - \dot{W}_s = 0$$

$$\Rightarrow \boxed{h_2 = h_1 + \left(-\frac{\dot{W}_s}{\dot{m}}\right)} \quad \text{or} \quad \left(-\dot{W}_s\right) = \dot{m}\left(h_2 - h_1\right)$$

$= +\dot{W}_{compressor}$

$$\boxed{\text{COP is defined as} = \frac{|\dot{Q}_E|}{|\dot{W}_s|} = \frac{h_1 - h_4}{h_2 - h_1}}$$

from sat. Freon table @ $T = 40^\circ C$, $h_3 = 75.1134$ kJ/kg

Hence $h_4 = h_3 = 75.1234$ kJ/kg

T_{out} after Throttling $= T_4 = -26^\circ C$

from sat Freon table at $T = -26^\circ C$

$h_g = 176.1723$ kJ/kg $\quad h_e = 12.53$ kJ/kg

$h_e < h_4 < h_g$

Hence after throttling at stage 4, we have mix of sat liq & sat vap

Hence $T = -26^\circ C$, $P_{sat} = 118.643$ kPa

$\Rightarrow P_4 = 118.643$ kPa Ans

$h_4 = h_g X + h_e (1 - X)$

$\Rightarrow X = 0.3825$