PROBLEM 1

3.1 FROM BOOK R-22

$T_H = 30°C$ $T_L = 10°C$

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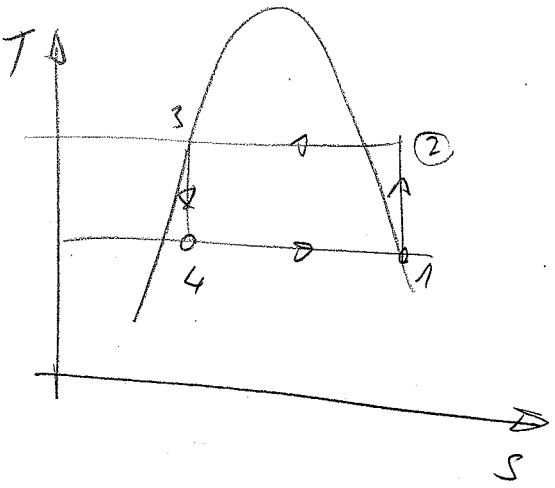


STATE	T °C	P (MPa)	L [kJ/kg]	v [m³/kg]	s [kJ/kgK]
1	10	0.68	253,4	0,0347	0.9129
2	30	1,19	~268	0.025	0.9129
3	30	1,19	81,3	0,0008	0,3004
4	10	0,68	79.7	0,0048	0,3004

$$X = \frac{s_4 - s_f}{s_g - s_f} = \frac{0,3018 - 0,2193}{0,9129 - 0,2193} = 0,119$$

$$h_4 = h_f + x(h_g - h_f) = 79.7$$

$$v_4 = v_f - x(v_g - v_f) = 0,0048$$

$$COP_L = \frac{h_1 - h_4}{h_2 - h_1} = \frac{253.4 - 79.7}{268 - 253.4} \approx 12$$

(173.7 / 14.6)

$$COP_{CARNOT} = \frac{T_L}{T_H - T_L} = \frac{283}{20} = 14,15$$

PROBLEM 2

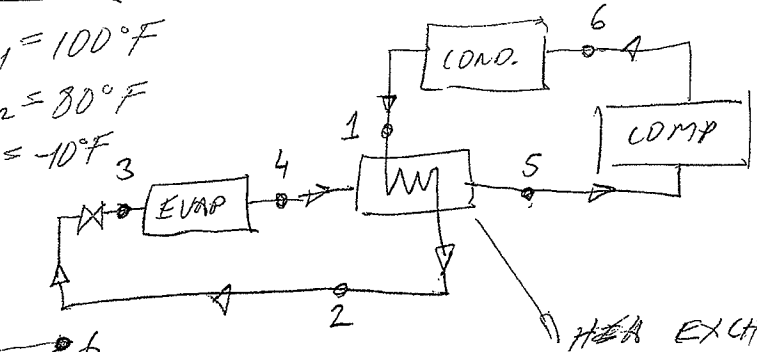
3.5 FROM BOOK

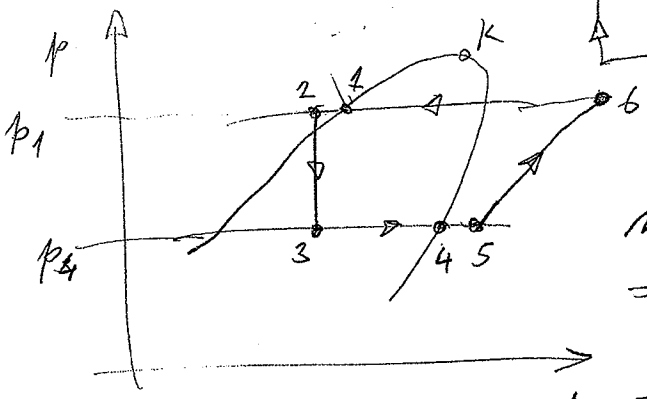
R22

$t_1 = 100°F$

$t_2 = 80°F$

$t_4 = -10°F$





FOR REFRIGERANT $Q_{45} = Q_{21}$

$\dot{m}_4 = m_1 \Rightarrow$

$\Rightarrow t_1 - t_2 = t_5 - t_4 \Rightarrow$

$\Rightarrow \boxed{t_5 = t_4 + (t_1 - t_2) = -10 + 20 = 10°F}$

FROM TABLE A.3E IN BOOK $t_4 = -10°F \Rightarrow \begin{cases} h_4 \approx 103.5 \text{ Btu/lb} \\ p_4 = 31.15 \text{ psia} \end{cases}$

$t_1 = 100°F \Rightarrow \begin{cases} p_1 = 210.55 \text{ psia} \\ h_1 = 39.3 \text{ Btu/lb} \end{cases}$

$t_2 = 80°F \quad h_2 = h_f(t=80°F) = 33.1 \frac{\text{Btu}}{\text{lb}}$

$h_3 = h_2 = 33.1 \frac{\text{Btu}}{\text{lb}}$

FOR HEAT EXCHANGER:

$h_5 - h_4 = h_1 - h_2$

$\boxed{h_5 = h_4 + (h_1 - h_2) = 103.5 + (39.3 - 33.1) = 109.7 \text{ Btu/lb}}$ ✓

FROM p–h DIAGRAM FOR R22 & h_5 & $p_4 = p_5 \Rightarrow$

$\Rightarrow s_5 = 0.245 \frac{\text{Btu}}{\text{lb R}}$

$s_6 = s_5 = 0.245 \text{ Btu/lb R}$

FROM s_6 & p_1 $\{ \boxed{h_6 \approx 135 \text{ Btu/lb}}$

$\boxed{COP = \frac{h_4 - h_3}{h_6 - h_5} = \frac{103.5 - 33.1}{135 - 109.7} = \frac{70.4}{25.3} = 2.78}$

$COP = 2.78 \frac{\text{ton cool}}{\text{kW EE}} = 2.78 \frac{\text{ton cool}}{12000 \text{ Btu/1 EE}} = 2.78 \frac{\text{ton cool}}{4.68 \text{ HP}} = 0.594 \frac{\text{ton cool}}{\text{HP}}$

FOR 1 ton OF COOL WE NED 1.68 HP_{EE}

PROBLEM 3 — AMMONIA

SAME LIKE PROBLEM 2 WITH AMONIA TABLES AND CHART

$t_4 = -10°F$ { $h_4 = 607.6$ Btu/lb ; $p_4 = 23.75$ psia

$t_1 = 100°F$ { $p_1 = 211.95$ psia ; $h_1 = 155.0$ Btu/lb

$t_2 = 80°F$ { $h_2 = h_3 = 131.7$ Btu/lb

$s_5 = s_6 = 1.4$ Btu/lbR

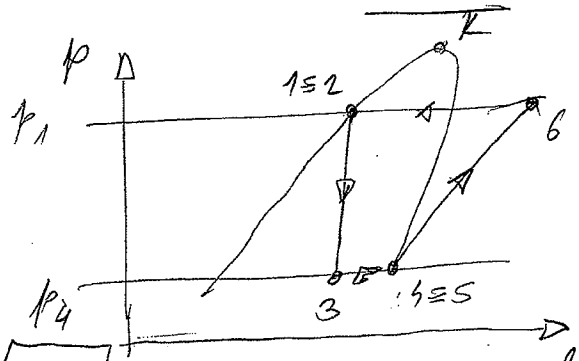
$h_5 = h_4 + (h_1 - h_2) = 607.6 + (155 - 131.7) = 630.9$ Btu/lb

$h_6 \approx 781$ Btu/lb

$COP = \frac{607.6 - 131.7}{781 - 630.9} = \frac{476}{150} = 3.17$

$COP = 3.17 \frac{\text{ton cool}}{4.68 \text{ HP}} = 0.678 \frac{\text{ton cool}}{\text{HP}}$ ⇒ FOR 1 ton cool WE NEED 1.47 HP

PROBLEM 4 — SAME LIKE 1 WIT NO INTERCOOLER R22



FROM PROB 1:

$h_5 = h_4 = 103.5$

$h_3 = h_1 = h_2 = 39.3$

FROM DIA GRAM $h_6 = 127$ Btu/lb

$COP = \frac{h_4 - h_5}{h_6 - h_5} = \frac{103.5 - 39.3}{127 - 103.5} = \frac{64.2}{23} = 2.79$ ⇒ 1,68 HP$_{EE}$ FOR TON OF COOLING

NOTICE THAT INTER-COOLER DO NOT INCREASE COP! IN THIS PROBLEM

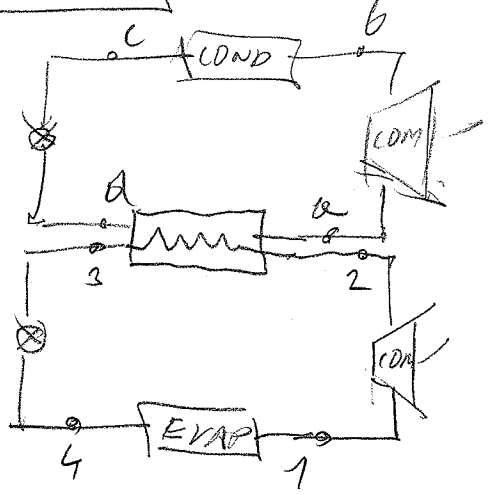
PROBLEM 5

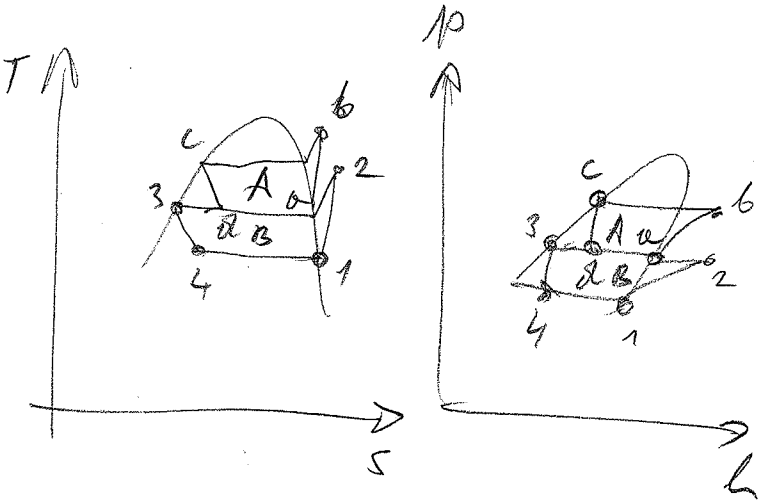
$COP = 2.78$ ⇒ $P_{EE} = COP \cdot Q_{COOL.COIL}$

$P_{EE} = 2.78 \cdot 195600$ Btu/h $= 543768$ Btu/h OF EL. EN.

$P_{EE} = 159$ kW$_{EE}$ SAME IS FOR 1 lb

PROBLEM 5





STATE	T[°C]	h[kJ/kg]	s[kJ/kgK]	P[MPa]	X
1	0	249.9	0,927	0,4974	1
2	—	272	0,927	1,1916	—
3	30	81.3	0,3004	1,1916	0
4	0	81.3	—	0,4974	—
a	30	259.1	0,8872	1,1916	1
b	—	271	0,8872	2,4260	—
c	60	122.2	0,4255	2,4260	0
d	30	122.2	0,4255	1,1916	—

$$Q_{cond\,B} = Q_{EVAP\,A} \Rightarrow \dot{m}_A (h_a - h_d) = \dot{m}_B (h_2 - h_3)$$

$$\frac{\dot{m}_A}{\dot{m}_3} = \frac{h_2 - h_3}{h_a - h_d}$$

$$COP_{REAL} = \frac{\dot{m}_6 (h_1 - h_4)}{\dot{m}_6 (h_2 - h_1) + \dot{m}_A (h_6 - h_a)} = \frac{h_1 - h_4}{(h_2 - h_1) + \frac{\dot{m}_a}{\dot{m}_6} (h_a - h_a)}$$

$$COP_{REAL} = \frac{273}{60} = 4,31$$

$$COP_{CARNOT} = 4,55$$

$$\eta = \frac{4,31}{4,55} = 96\%$$