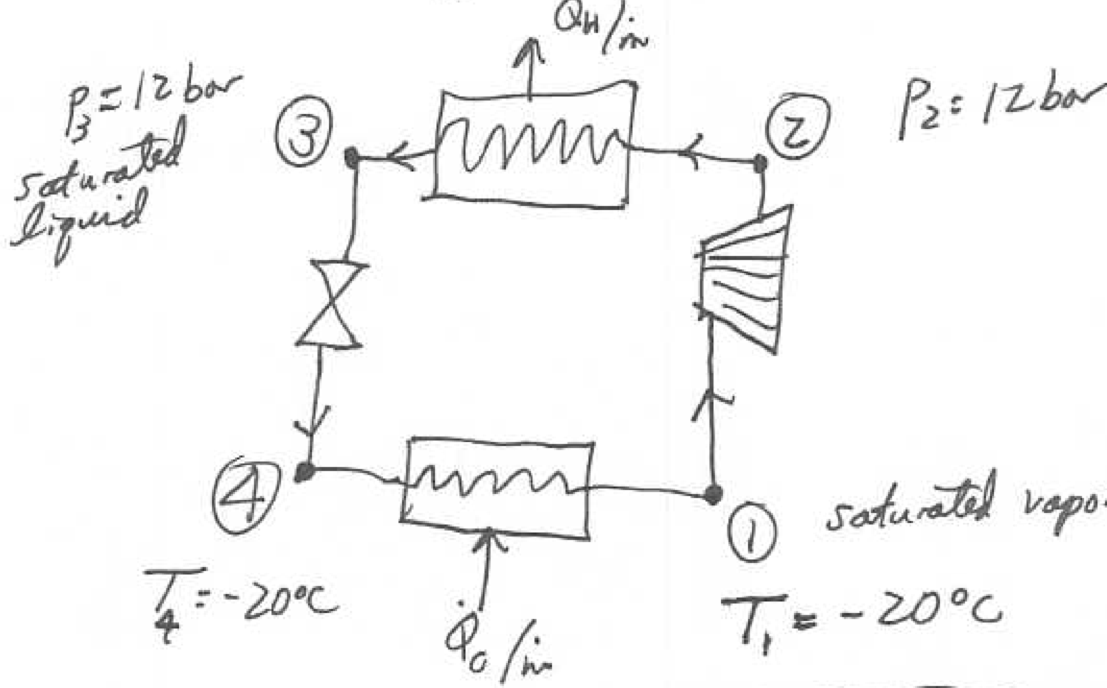
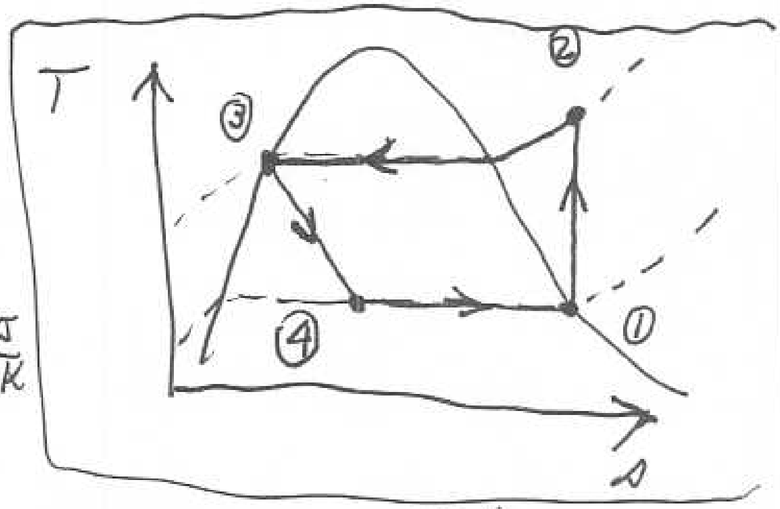
10.11 — Ideal vapor-compression refrigeration cycle
— Ammonia is working fluid



$\dot{m} = 3\ kg/min = \mathbf{0.05}\ kg/s$

First, get h at each state



① sat vapor at $T = -20°C$

$h_1 = h_g = 1417.8\ kJ/kg$ $\quad s_1 = 5.6144\ \frac{kJ}{kg \cdot K}$

② $p_2 = 12$ bar $\quad s_2 = s_1 = 5.6144\ \frac{kJ}{kg \cdot K}$
superheated. Interpolating, we get $h_2 = 1689.5\ kJ/kg$

③ $p_3 = 12$ bar, saturated liquid $\quad h_3 = h_f = 327.01\ kJ/kg \quad s_3 = 1.2152\ \frac{kJ}{kg \cdot K}$

④ $T_4 = -20°C$ and saturated state. $\quad h_4 = h_3 = 327.01\ \frac{kJ}{kg}$

(a) What is the coefficient of performance?

$$\beta = \frac{\dot{Q}_C/\dot{m}}{\dot{Q}_H/\dot{m} - \dot{Q}_C/\dot{m}} = \frac{h_1 - h_4}{(h_2 - h_3) - (h_1 - h_4)} = \underline{4.01}$$

10.11 (continued)

(b) The refrigerating capacity, in tons.

$$\dot{Q}_c = \dot{m}(h_1 - h_4) = \left(3\,\frac{kg}{min}\right)\left(1417.8\,\frac{kJ}{kg} - 327.01\,\frac{kJ}{kg}\right)$$

$$\dot{Q}_c = 3272.4\ kJ/min$$

1 ton of refrigeration = 211 kJ/min

$$\dot{Q}_c = 3272.4\,\frac{kJ}{min}\cdot\left(\frac{1\ ton}{211\ kJ/min}\right)$$

$$\boxed{\dot{Q}_c = 15.5\ tons}$$