Example Exam

ES 3053 Thermo **EXAM III** **November 20, 2019**

Open Books and Notes

Name: Solution

A vapor compression refrigeration cycle is used with R-134a working fluid. Use the R-134a table in the appendix of your book for all calculations. Use reasonable assumptions for a typical vapor compression cycle to complete the calculations. However, in this case, there will be a pressure drop in the condenser (usually we assume the condenser is constant P) so that P_4 = 1400kPa. The thermal efficiency, η, of the compressor is 75% and the heat load on the evaporator ($\dot{\mathbf{Q}}_{evap}$) is one ton of refrigeration (1 ton = 3.5 kW).

A. 51 points

Fill in the missing numbers in the following table using the numbering sequence given in the figure (each empty box is worth 3 points):

	Point 1	Point 2	Point 3	Point 4' (base case)	Point 4
T (°C)	48	-10	-10	59.7	71.4
P (kPa)	1253.6	200.74	200.74	1400	1400
H (kJ/kg)	120.41	120.41	244.55	285.11	298.63
S (kJ/kg-°K)	0.43251	0.46610	0.93782	0.93782	0.9777
x (vapor fraction)		0.3974			

B. 17 points 0.0282 kg/s

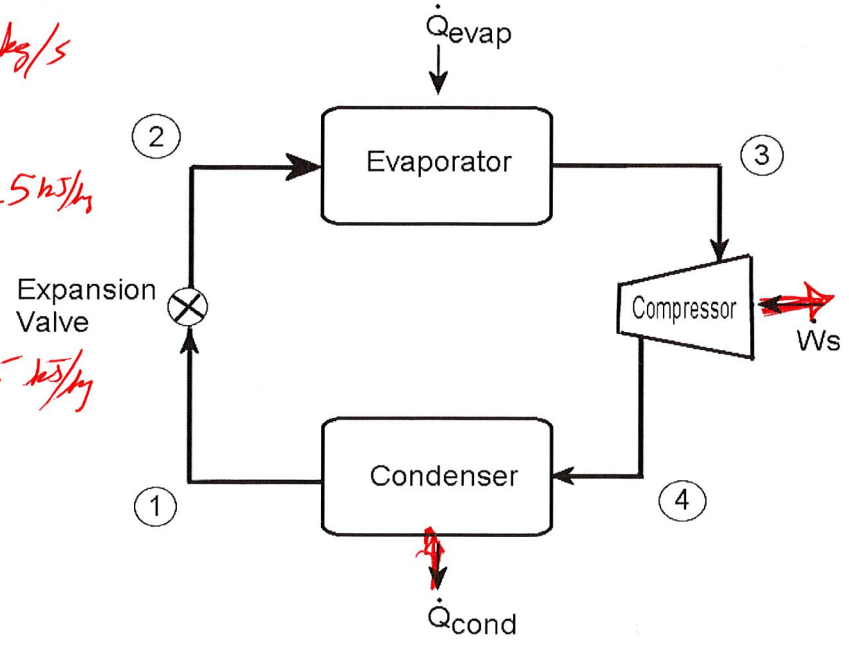
Find the flowrate, $\dot{\mathbf{m}}$ of the R-134a

C. 16 points $-\dot{W}_s = 1.525$ kJ/kg

Find the work requirement for the compressor in kW.

D. 16 points $\dot{Q} = -5.025$ kJ/kg

Find $\dot{\mathbf{Q}}_{cond}$ in kW.



ES353 Thermo Exam III Nov. 20, 2019

Solution

A. Point 1 — sat liquid at 48°C

Point 2 — $H_2 = H_1$, $T = -10°C$

$120.41 = (1-x_2)38.53 + x_2(244.55)$ saturated @ −10°C

$x_2 = 0.3974$

$s_2 = 0.3974(0.93782) + (1-0.3974)(0.15496)$

$s_2 = 0.46610$ kJ/kg·K

Point 3, assume sat v @ −10°C

Point 4, $s_4 = s_3 = 0.93782$, $P_4 = 1400$ kPa

interpolate between saturated T = 52.40°C @ P = 1.4 MPa = 1400 kPa

s	h	T °C
0.9107	276.17	52.4
0.93782	285.11	59.7
0.9389	285.47	60.0

Point 4: $-w_s' = 285.11 - 244.55 = 40.56$

$-w_s = 40.56 / 0.75 = 54.08$

$H_4 = 244.55 + 54.08 = 298.63$

H_4	s_4	T_4
297.10	0.9733	70
298.63	0.9777	71.4
308.34	1.0056	80

B. $\dot{m}\Delta h = \dot{Q} - \dot{W}_s$ across the evaporator

$\dot{m}(h_2 - h_1) = 3.5$ kJ/s

$\dot{m}(244.55 - 120.41) = 3.5$ kJ/s

$\dot{m} = 0.0282$ kg/s

C. $\dot{m}\Delta h = \cancel{\dot{Q}}^{\,0} - \dot{W}_s$

$(0.0282\ kg/s)(298.63 - 244.55) = -\dot{W}_s$

$\boxed{-\dot{W}_s = 1.52473\ kW}$

D. $\dot{m}\Delta h = \dot{Q} - \cancel{\dot{W}_s}^{\,0}$

$(0.0282)(120.41 - 298.63) = \dot{Q}$

$\boxed{\dot{Q} = -5.025\ kW}$

overall the cycle $\dot{m}\Delta h = 0 = \dot{Q} + \dot{Q} - \dot{W}_s$

$= 3.5 - 5.025 + 1.525 = 0$ ✓