24

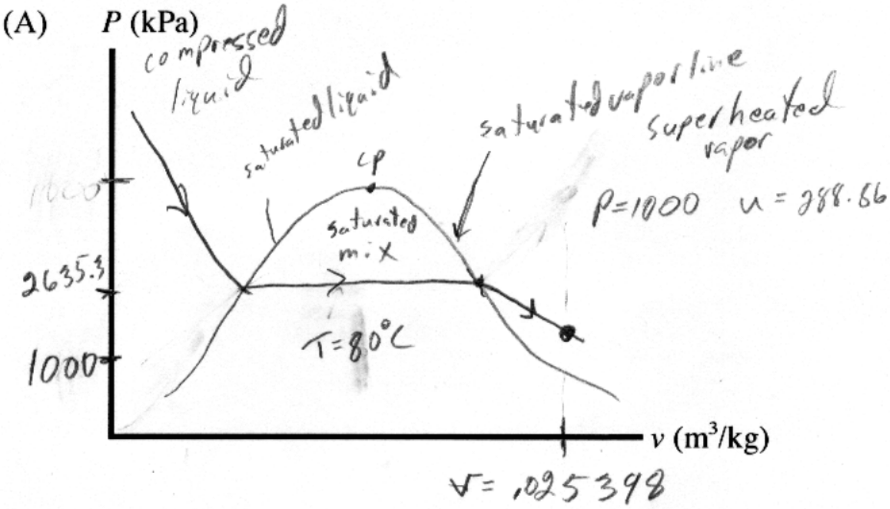
1. (25 points) On the *T*-*v* and *P*-*v* diagrams provided below sketch (not to scale) with respect to the saturated liquid and saturated vapor lines and label the following processes and states for R-134a. Use arrows to indicate the direction of the process and label the initial and final states:

(A) On the *P*-*v* diagram below locate the state $P = 1000$ kPa, $u = 288.86$ kJ/kg by sketching and labeling the constant temperature curve through the state and placing the value of the specific volume for the state on the volume axis. Make sure your temperature curve extends from the compressed liquid region into the superheated vapor region. Place the value of the saturation pressure for this temperature on the *P*-axis.

(B) On the *T*-*v* diagram below locate the state $T = 10$ °C, $h = 260.65$ kJ/kg. Sketch the constant pressure curve through the state so that it extends from the compressed liquid region into the superheated vapor region. Place the value of the saturation temperature for this pressure on the *T*-axis.

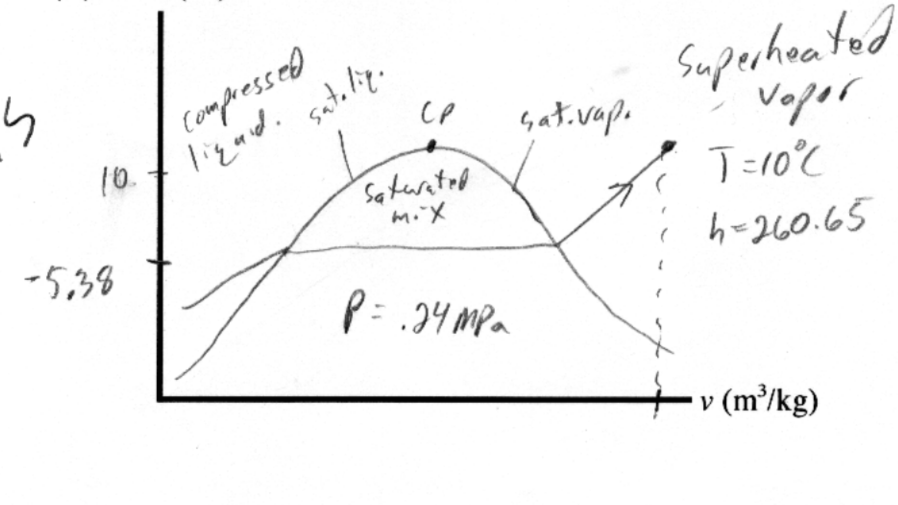
12.5

(A)



11.5

(B)



22

2. (25 points) If sufficient data are provided, complete the blank (non-gray) cells in the following table of properties of water. In the last column describe the condition of water as compressed liquid, saturated mixture, superheated vapor, or insufficient information; and, if applicable, give the quality. Only those answers recorded in the table will be graded.

$h \approx u_f @T°C + P v_f @T°C$

		P (kPa)	T (°C)	v (m^3/kg)	h (kJ/kg)	Condition description and quality, if applicable
2	A	200	70		No enough info.	compressed liquid.
5	B	270.28	130		cant solve for	saturated mixture Not enough to solve for quality
5	C	198.67	120	0.2000	995.89	saturated mixture quality → $x = .2234$
5	D	1600		0.2350	3582.2	Superheated.
5	E	800	732.2599		4000	Superheated.

$V = V_f + x V_{fg}$

(C) $.200 = .001060 + x \cdot (.89133 - .001060) =$

$x = .22346$

$h = h_f + x h_{fg}$

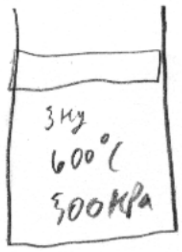
$= 503.81 + .22346 (2202.1)$

(D) Interpolate

(E)

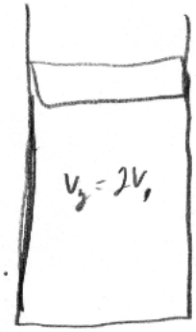
13

3. (25 points) A piston cylinder device contains 3 kg of Helium at 600 °C, 300 kPa. An isothermal process takes place such that the volume of the helium increases by 50%. Determine the boundary work done during the process in kJ.



$W = P_1 V_1 \ln \frac{V_2}{V_1}$ ✓

Ideal gas
Isothermal
constant mass



3 kg

$V_1 =$

$T_1 = 600 + 273 = 873.15$

$V_2 = 2 \cdot 18.13 = 36.2689$ X

$T_2 = 873.15$

$PV = mRT$

$V_1 = \frac{mRT}{P} = \frac{3(2.0769)\,873.15\,K}{300\ kPa} = 18.13\,m^3$ ✓

$W = P_1 V_1 \ln\left(\frac{2V_1}{V_1}\right)$

$\boxed{W = 3770.95\ kJ}$ done by the system X

24

4. (25 points) Refrigerant 134-a is contained in a constant volume tank as a saturated vapor. When it is heated, the refrigerant pressure and temperature become 500 kPa and 70°C, respectively. Determine the initial pressure of the refrigerant in the tank in kPa.

1

134 a

$V_1 = C$

T_1 ?

$P_1 = ?$

Q

Saturated Vapor

mass constant

constant volume

$V_2 = V_1$

$v_2 = v_1$

2

500 Kpa

T = 70°C

V = C

superheated.

$v_2 = .052427$

$v_2 = v_1 = v_g$ ✓

$v_g = v_1 = .052427$

Interpolate $\frac{v_g - v_1}{P_g - P_1} = \frac{v_g - v}{P_g - P}$

$P = \frac{.052762 - .049403}{387.86 - 414.89} = \frac{.052762 - .052427}{387 - P}$

$\boxed{P = 390.57 \text{ Kpa}}$ ✓