NAME:

STUDENT NUMBER:

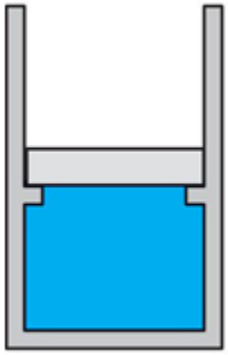
MCG2130: Thermodynamics I

Quiz 3

Instructions: 50 minutes. Closed book. Non-programmable calculators allowed.

Question:

Initially, a piston/cylinder filled with water at **60°C** that is **99% vapour by volume**. The piston sits on the stops as seen in the figure with a **volume of 100 litres** and the piston requires a **pressure of 400kpa** to float. The cylinder then is then heated to a **final temperature of 300°C**.



(a) What are your assumptions?
   a. Closed System
   b. Quasistatic

(b) Solve for the initial quality.

$$x = \frac{m_{vap}}{m_{tot}}$$

$$m_{vap} = \frac{V_{vap}}{v_g}$$

$$m_{tot} = m_{vap} + m_{liq}$$

$$m_{liq} = \frac{V_{liq}}{v_f}$$

$$x = 0.01296$$

(c) Find the initial specific volume.

$$v = \frac{V}{m_{tot}}$$

$$v = 0.1003814$$

(d) At what temperature would the piston begin to rise? What is the phase of the water at this point?

$$T = T_{sat@400kPa} = 143.63°C$$

Phase is Liquid gas Mixture

(e) Draw the P-v diagram showing the process.

Up at constant volume, then over at constant pressure to superheated vapour.

(f) Draw the T-v diagram showing the process.

Up at constant volume, then following a constant pressure line to superheated vapour.

(g) What is the phase of the water at the final temperature?

Superheated Vapour

(h) Solve for the final volume (V).

$$V = (v)(m_{tot})$$

$$v = v_{@400kpa,300C} = 0.65484$$

$$V = 0.65235m^3$$

Bonus: What is the WORK produced by the system?

$$W = \int PdV = P(V_2 - V_1) = 220.94\ kJ$$

HINTS:

- Notice that the mixture is described as a percentage of volume, but $x=m_{vap}/m_{tot}$
- There are 1000L in $1m^3$
- This process happens in two steps.

Saturation Table for Water – Temperature Entry

T [°C]	P [kPa]	v_f [m^3/kg]	v_g [m^3/kg]
60	19.941	0.001017	7.67071
70	31.19	0.001023	5.04217
80	47.39	0.001029	3.40715
90	70.14	0.001036	2.36056
100	101.3	0.001044	1.67290

110	143.3	0.001052	1.21014
120	198.5	0.001060	0.89186
130	270.1	0.001070	0.66850
140	361.3	0.001080	0.50885
150	475.9	0.001090	0.39278
160	617.8	0.001102	0.30706

Saturation Table for Water – Pressure Entry

P [kPa]	T [°C]	v_f [m^3/kg]	v_g [m^3/kg]
100	99.62	0.001043	1.69400
200	120.3	0.001061	0.88573
300	133.55	0.001073	0.60582
400	143.63	0.001084	0.46246
500	151.86	0.001093	0.37489
600	158.85	0.001101	0.31567

Superheated Vapour Table for Water

T [°C]	P = 100 kPa	P = 200 kPa	P = 400 kPa	P = 1000 kPa
	v [m^3/kg]	v [m^3/kg]	v [m^3/kg]	v [m^3/kg]
150	1.93636	0.95964	0.47084	-
200	2.17226	1.08034	0.53422	0.20596
250	2.40604	1.19880	0.59512	0.23268
300	2.63876	1.31616	0.65484	0.25794
400	3.10263	1.54930	0.77262	0.30659
500	3.56547	1.78139	0.88934	0.35411
600	4.02781	2.01297	1.00555	0.40109