Quiz #1

MEMS 0051 - Introduction to Thermodynamics

Assigned: February 8th, 2021
Due: February 12th, 2021, 9:00 pm

Intermediate Problem #1

(1 pt) Determine the quality of the water existing at 180 °C with a specific volume of 0.140 0 [m^3/kg].

At 180 °C, the saturated liquid and saturated vapor specific volumes can be found from the saturated water temperature tables: v_f=0.001 127[m^3/kg] v_g=0.194 05 [m^3/kg] Therefore, the quality can be found as:

$$x = \frac{v - v_f}{v_g - v_f} = \frac{0.140\,0 - 0.001\,127}{0.194\,05 - 0.001\,127} = \boxed{71.98\%}$$

Intermediate Problem #2

(1 pt) Determine the mass of saturated vapor at 155 °C in a 40 [m^3] rigid tank.

Saturated water vapor has a saturated vapor specific volume of 0.346 76 [m^3/kg] at 155 °C per the saturated water temperature tables. Therefore:

$$m = \frac{\forall}{v_g} = \frac{40\ [\text{m}^3]}{0.346\,76\ [\text{m}^3/\text{kg}]} = \boxed{115.35\ [\text{kg}]}$$

Intermediate Problem #3

(1 pt) Determine the specific volume for water existing at 1,823 [kPa] and 462 °C.

Water is existing as a superheated vapor. Referencing table B.1.3 on page 789, we will interpolate to find the specific volume of water existing at 462 °C and pressures of 1,800 and 2,000 [kPa]:

$$\frac{(462 - 400)\,^\circ\text{C}}{(500 - 400)\,^\circ\text{C}} = \frac{(\nu(1,800\,[\text{kPa}]) - 0.168\,47)\ [\text{m}^3/\text{kg}]}{(0.195\,50 - 0.168\,47)\ [\text{m}^3/\text{kg}]} \implies \nu(1,800\,[\text{kPa}]) = 0.185\,23\ [\text{m}^3/\text{kg}]$$

$$\frac{(462 - 450)\,^\circ\text{C}}{(500 - 450)\,^\circ\text{C}} = \frac{(\nu(2,000\,[\text{kPa}]) - 0.163\,53)\ [\text{m}^3/\text{kg}]}{(0.175\,68 - 0.163\,53)\ [\text{m}^3/\text{kg}]} \implies \nu(2,000\,[\text{kPa}]) = 0.166\,44\ [\text{m}^3/\text{kg}]$$

Now we can interpolate between pressure at our given temperature:

$$\frac{(1,823 - 1,800)\ [\text{kPa}]}{(2,000 - 1,800)\ [\text{kPa}]} = \frac{(\nu(1,823\,[\text{kPa}]) - 0.185\,23)\ [\text{m}^3/\text{kg}]}{(0.166\,44 - 0.185\,23)\ [\text{m}^3/\text{kg}]} \implies \nu(1,823\,[\text{kPa}]) = \boxed{0.183\,07\ [\text{m}^3/\text{kg}]}$$

Challenge Problem #1

(2 pt) Water vapor at 3,000 [kPa] and 300 °C is contained within a piston-cylinder. The water is cooled in a constant volume process until the temperature reaches 200 °C. The water is then compressed in a constant temperature process until the pressure is 2,500 [kPa]. **Determine the following**:

1. The specific volumes at States 1, 2 and 3.
2. The quality at State 2.

1. At State 1, $T>T_{\text{sat}}$ at 3,000 [kPa], which means this is a superheated vapor. Using Table B.1.3 on page 787,

$$\boxed{\nu_1 = 0.081\,14\,[\text{m}^3/\text{kg}]}$$

At State 2, the specific volume is the same as State 1 because it is cooled in a *constant volume* process:

$$\boxed{\nu_2 = 0.081\,14\,[\text{m}^3/\text{kg}]}$$

At State 3, $P>P_{\text{sat}}$ at 200°C, thus is exists as a compressed/subcooled liquid. Using either Table B.1.4 and interpolating, or recognizing $\nu=\nu(T)$ and $\nu \neq \nu(P)$, we can use Table B.1.1 on page 778,

$$\boxed{\nu_3 = 0.001\,156\,[\text{m}^3/\text{kg}]}$$

2. To determine the quality at State 2, we recognize $\nu_f<\nu_2<\nu_g$. Therefore,

$$x_2 = \frac{\nu - \nu_f}{\nu_g - \nu_f} - \frac{0.081\,14 - 0.001\,156\,[\text{m}^3/\text{kg}]}{0.127\,36 - 0.001\,156\,[\text{m}^3/\text{kg}]} \implies \boxed{x_2 = 0.634}$$

Academic Integrity Statement:

I hereby attest that I have received no assistance (from a friend, from another student, from an on-line resource, such as Chegg, etc.), and that I have provided no assistance to another student, during this examination. All the work presented within is solely my own work.

Signature: _____

Date: _____