Homework #2

MEMS 0051 - Introduction to Thermodynamics

Assigned January 19th, 2018
Due January 26th, 2018

Problem #1

Consider a 2,000 [kg] car driving up a 10 [m] tall hill. The car is driving at a velocity of 10 [m/s] and has a total internal energy (U) of 600 [kJ] [1 kJ = 10^3 J]. Determine:

(a) Determine the kinetic energy (KE) of the car [kJ].
(b) Determine the potential energy (PE) of the car based on the hill height [kJ].
(c) Determine the total energy (E) of the car [kJ].
(d) Determine the total specific energy (e) of the car [kJ/kg].
(e) Determine the specific internal energy (u) of the car [kJ/kg].

Problem #2

Answer the following questions based on the P-T diagram for CO2 given below. (Short answers are fine, no need to re-draw the diagram on your solution)

1. What phase is CO_2 in at the following temperature and pressure combinations?
   (a) 250 K, 10^4 [kPa]
   (b) 170 K, 10^2 [kPa]
   (c) 270 K, 10^1 [kPa]
   (d) 330 K, 10^2 [kPa]
2. Consider a piece of dry ice that is dropped into a room at 20 °C and 1 atm (101.3 [kPa]). What phase change(s) will the dry ice undergo?
3. Consider CO_2 gas enclosed in an isothermal chamber fixed at 250 K. More CO_2 is injected into the chamber, causing the internal pressure to rise from 100 [kPa] to 10^4 [kPa]. What phase change(s) will the CO_2 undergo?

Problem #3

Answer the following questions based on the T-v diagram for H_2O given below. (Short answers are fine, no need to re-draw the diagram on your solution)

1. What phase(s) of H_2O are present at the following conditions?
   (a) 200 °C, 2 [m^3/kg]
   (b) 200 °C, 10^{-4} [m^3/kg]
   (c) 0.1 [MPa], 0.1 [m^3/kg]
   (d) 400 °C, 10^{-2} [m^3/kg]
2. What phase change is occurring for a mass of H_2O going from B→C on the diagram?
3. Let's say that we know the temperature and pressure of a mass of H_2O are 1 [MPa] and 179.9 °C. Can we determine the specific volume of this sample? Why or why not?
4. Consider liquid water enclosed in a piston-cylinder. The water is heated, causing an isobaric expansion at 0.1 [MPa] until all of the water boils, making saturated vapor. What is the final specific volume of the sample?

Problem #4

You will need the steam tables (Tables B.1.1-B.1.5) in order to complete these exercises.

1. Determine the phase(s) for each of the following water states:
   (a) 70 °C, 50 [kPa]
   (b) 100 °C, 0.1 [m^3/kg]
   (c) 75 [kPa], 3.0 [m^3/kg]
   (d) 10 [kPa], 50 °C
   (e) 125 °C, 250 [kPa]
2. Look up the requested properties for H2O at the following states:
   (a) Specific volume at 100 [kPa], 250 °C
   (b) Specific internal energy at 5,000 [kPa], 120 °C
   (c) Specific volume for saturated liquid at 40 °C
3. Use linear interpolation (show your work) to calculate the following properties for H_2O at the given states:
   (a) Specific internal energy at 10,000 [kPa], 75 °C
   (b) Specific volume of superheated steam existing at 250 °C and 1,700 [kPa]
   (c) Specific volume of water existing at 375 °C and 5,500 [kPa]
   (d) Specific volume of water at 75 °C and 500 [kPa]
   (e) Specific volume of water at 100 °C and 1,500 [kPa]
   (f) Specific volume of water at 22.5 °C and 17,500 [kPa]
4. Your friend asks you for the specific volume (ν) of liquid water at room conditions (25 °C, 100 [kPa]), but you can't find that low of a pressure in the compressed liquid water table. Is it okay to use the saturated liquid value (ν_f) at 25 °C as an approximation? Why or why not?
5. Now your (pesky) friend asks you for the specific volume (ν) of water vapor at 200 °C, 50 [kPa]. Is it okay to use the saturated vapor value (ν_g) at 200 °C as an approximation? Why or why not?

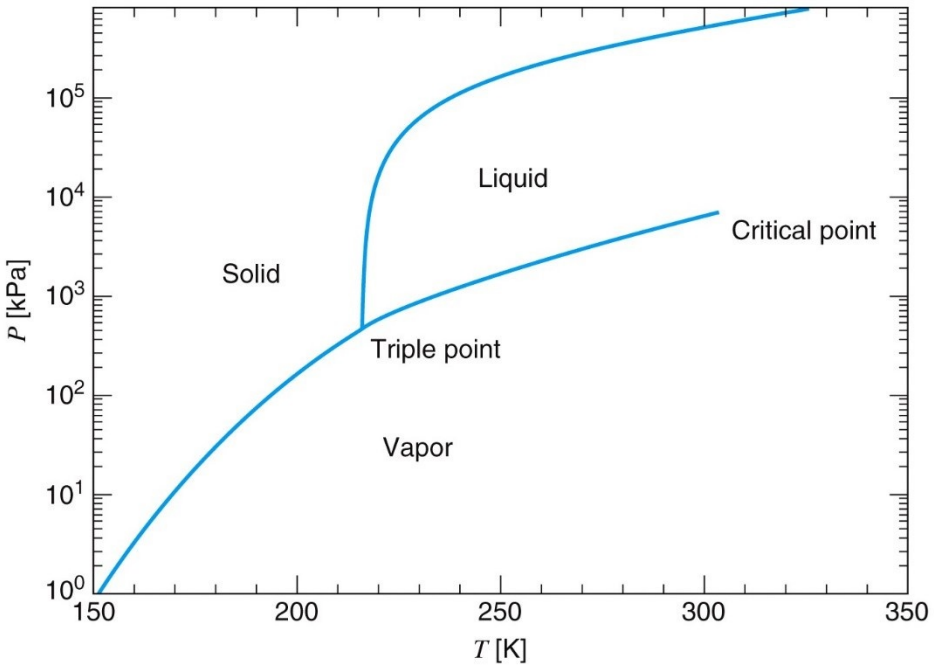

Figure 1: Phase diagram of CO_2

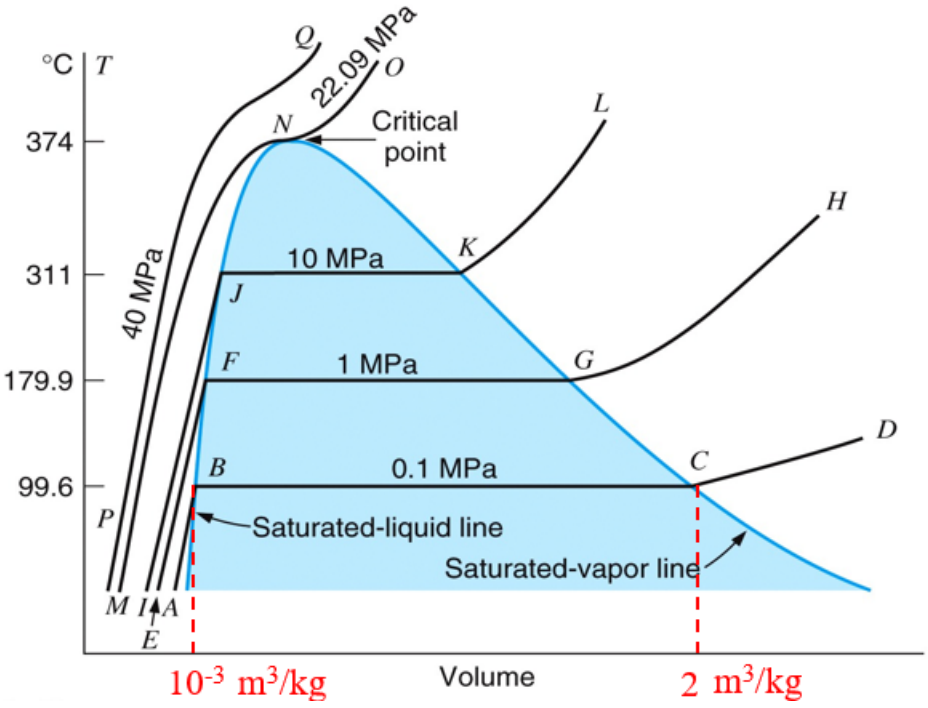

Figure 2: T-V diagram of water