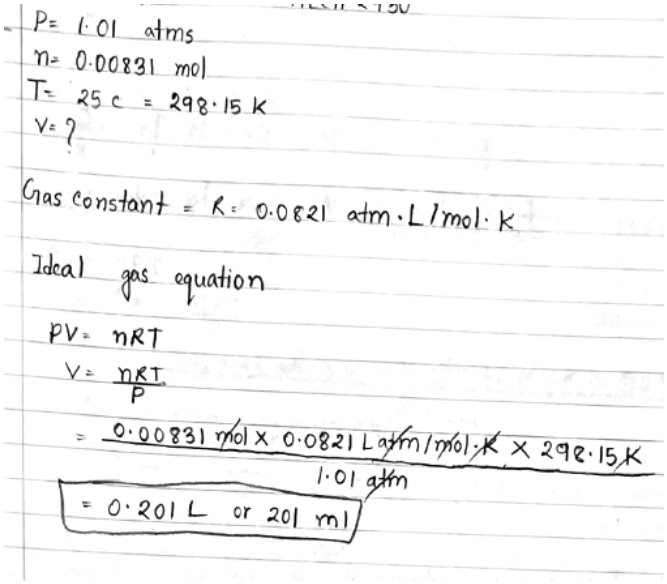
MECH 2430: Thermodynamics: Mid Term

Spring, 2021: Point: 80

(Write the answers to all the questions in your own words. Hand-write math answers and upload in the answer script)

1. Given the following sets of values, Calculate the unknown quantity- (10)
   P=1.01 atm
   n=0.00831 mol
   T=25 c
   V=?



2. Explain first law of thermodynamics by showing the relationship between Q, U and W. (10)

   When heat is added to a system, it transforms into other form of energy. Total heat input equals the internal energy generated and work done by the system.
   Therefore, Q=U+W

3. Calculate the pressure in a 200 Liter Tank containing 23.3 kg Nitrogen gas at 30 C. (10)

PV=nRT, Where n=m/A=23.3*1000 gm/28 gm/mol=832.14 mol R=8.314= Jule/mol*K

So, P=n*R*T/V=832.14 mol*8.314(Jule/mol*K)*(273+30)K/(200Liter/1000)m^3

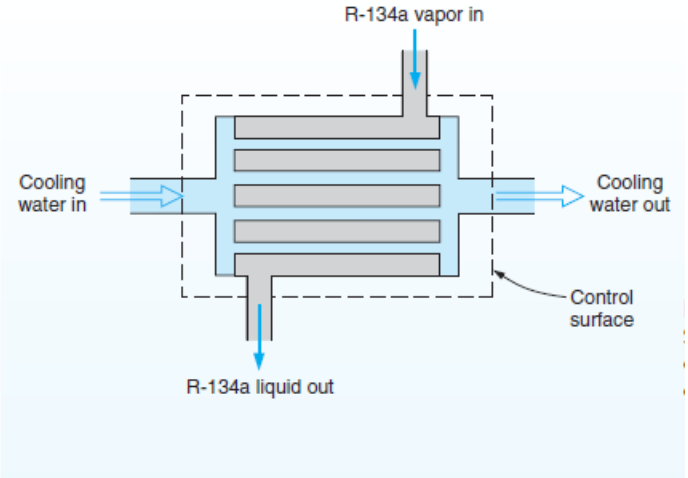
=832.14*8.314*300/0.2=10377617 Jule/m^3=10377617 N/m^2=10377617 Pa=10.37 MPa

4. What is specific volume and density of a liquid? What's their units? How are they related to each other?

(5)

Specific volume= 1/density

5. Consider a water-cooled condenser in a large refrigeration system in which R-134a is the refrigerant fluid. Cooling water enters the condenser at 10 C and exits at 20 C at the rate of 1 kg/s. The refrigerant enters the condenser at 800 kPa MPa and 60 C, and exits as a liquid at 45 C. Determine the rate at which refrigerant flows through the condenser. (20)



$$\dot{m}_r(h_i)_r + \dot{m}_w(h_i)_w = \dot{m}_r(h_e)_r + \dot{m}_w(h_e)_w$$

$$\Rightarrow \quad \dot{m}_r(h_i - h_e)_r = \dot{m}_w(h_e - h_i)_w$$

$$\Rightarrow \quad \dot{m}_r = \dot{m}_w \frac{(h_e - h_i)_w}{(h_i - h_e)_r}$$

water side → 10°C saturated water, $h_i = 42.6$ kJ/kg

20°C saturated water, $h_e = 84.2$ kJ/kg

R-134a side → superheated 800kPa at 60C

$h_i = 294$ kJ/kg

Saturated liquid at 45C, $h_e = 114$ kJ/kg

$$\therefore \dot{m}_r = 1 * \frac{(84.2 - 42.6)}{(294 - 114)} = 0.23 \text{ kg/s}$$

6. Multiple choice questions (15)

I. In a standard Pressure and Temperature which substance stays in a gaseous phase?
   a. Water
   b. Mercury
   c. Nitrogen
   d. Calcium

II. Which of the following is the Macroscopic property of a substance?
   a. Heat
   b. Phase
   c. Pressure
   d. Elevation

III. Which of the following is an absolute zero temperature?
   a. 0 °C
   b. 0 F
   c. -273 °C
   d. None of the above

IV. If heat 20 J heat is added on a water bottle (assume no heat loss), then how much internal energy will be raised in the water?
   a. 10 J
   b. -10 J
   c. 20 J

d. -20 J

V. The Specific volume and Enthalpy of saturated water vapor at 100 C are

a. 1.67 m^3/kg and 2257 kJ/kg

b. 1.67 m^3/kg and 2676 kJ/kg

c. 0.001 m^3/kg and 419.02 kJ/kg

d. 17.19 m^3/kg and 2515 kJ/kg

7. True/False questions- (10)

e. Control surface is an imaginary surface representing a confined space where thermodynamic process occurs. T

f. In SI system the unit of weight is kg but the unit of force is Newton. F

g. Heat flows from hot to cold. T