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University of Jordan
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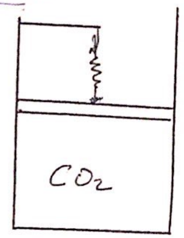
Prof. M. A. Hamdan — **Date: 1-1-2017**
First Examination — **Time: One hours**
Thermodynamics I (94341)

Name: [redacted] **Section:** 11-12

The shown sketch contains two kg of Carbon dioxide, which is heated from 100 kPa and 25 C to 1000 kPa and 300 C. Sketch the PV diagram and find the heat added.



$m = 2$ kg
$P_1 = 100$ kPa
$T_1 = 25 + 273$

$P_2 = 1000$ kPa
$T_2 = 300 + 273$

$C_v = 0.657$ kJ/kg.K
$\cancel{C_p = 0.846 \text{ kJ/kg.K}}$
$C_p = 0.846$ kJ/kg.K

$Q - W = \Delta E$

$\boxed{Q = W + \Delta E}$

$W = \frac{(P_1 + P_2)}{2}(V_2 - V_1)$ (area under curve)

$W = (550)(0.455)(2)$ (2)

$\cancel{W = 250.28}$

$\boxed{W = 500.5 \text{ kJ}}$

$\Delta u = C_v(T_2 - T_1)$
$= 0.657(275)$

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sol: $R = 0.1889$

$PV = mRT$

$V_1 = \frac{mRT_1}{P_1}$

$V_1 \Rightarrow \frac{(2)(0.1889)(298)}{100}$

$\boxed{V_1 = 1.126 \text{ m}^3}$

$v_1 = \frac{V_1}{m} \Rightarrow \boxed{0.563 \text{ m}^3/\text{kg} = v_1}$

$V_2 = \frac{mRT_2}{P_2}$

$V_2 = \frac{(2)(0.1889)(573)}{1000}$

$\boxed{V_2 = 0.2166 \text{ m}^3}$ $v_2 = \frac{V_2}{m} \Rightarrow \boxed{0.108 \text{ m}^3/\text{kg} = v_2}$

(4)

$h = C_p \Delta T$

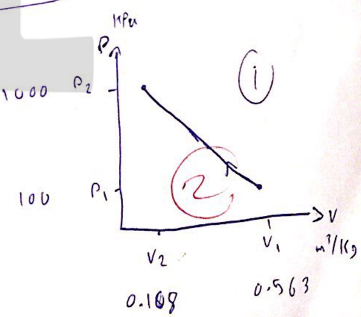
$\cancel{h = (0.840)(573 - 298)}$

$\cancel{h = 232.65 \text{ kJ/kg}}$

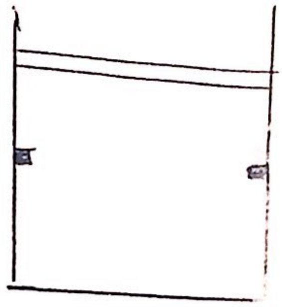
$h = (0.846)(573 - 298)$

$\boxed{h = 232.65 \text{ kJ/kg}}$ → heat added (2)

(1)



2. The shown arrangement contains 1 kg of water at 150 C and 100 kPa. How much heat must be removed to condense 50% of the steam. Given the piston diameter to be 1 m and it is initially 1.5 m above the stops. Also sketch the PV diagram



H_2O

$m = 1$ kg

$T_1 = 150$ C

$P_1 = 100$ kPa

$d = 1$ m

Sol^n: at state 1

the phase is superheated

$v_1 = 1.9367$ m^3/kg

$u_1 = 2582.9$ kJ/kg

$h_1 = 2776.6$

$v_2 = \frac{1}{2} v_1$

~~$v_2 = 0.96835$ m^3/kg~~

State 2

~~before stop~~

assume the phase ~~wet mixture~~

$\boxed{V = x A}$

$= (1.5)(\frac{\pi}{4} 1^2)$

$\frac{V}{m} = 1.1781$ m^3/kg

at P = 100 kPa because it's free to move

$T_2 = 99.61$ / $v_f = 0.001043$ / $v_g = 1.6941$

$v_{av} = v_f + x v_{fg}$

$$x = \frac{1.1781 - 0.001043}{1.69357}$$

$\boxed{\cancel{x = 0.6957}}$ so it's wet mixture

$\boxed{x = 0.695}$

X = 0.5 ↑ given

State 3:

The volume will be constant

so $W_b = 0$

$v_2 = v_3 = 1.1781$

~~$v_3 = v_2 = 0.96835$ m^3/kg~~

P = 200 kPa

$-W_b = P(v_2 - v_1)(m)$

$= 100(1.1781 - 1.9367)(1)$

$\boxed{W = -75.86 \text{ kJ}}$

$u_2 = u_f + x u_{fg}$

~~$= 417.4 + (0.695)(2088.2)$~~

~~$= 1868.7$ kJ/kg~~

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$Q = W + m(u_2 - u_1)$

$= -75.86 + (1)(1868.7 - 2582.9)$

$\boxed{Q = -790.061}$ → heat must be removed