Midterm ENGR251 / 2015

Problem I 12 pts

1) we have $W = \frac{P_2V_2 - P_1V_1}{1-n}$ $n \neq 1$

V_1 ✓ P_1 ✓ T_1 ✓ P_2 ✗ V_2 ✗

computation of V_2.

$PV^n = ct \Rightarrow P_1V_1^n = P_2V_2^n$

1 $V_2 = V_1\left(\frac{P_1}{P_2}\right)^{1/n}$

$= 0.1\left(\frac{120}{1200}\right)^{1/1.2}$

1 $\boxed{V_2 = 0.0147\ m^3}$

Then $\boxed{W = -28.2\ kJ}$ 2

2) The change in internal energy for an ideal gas: $\Delta U = m\,c_v(T_2 - T_1)$

we have to determine T_2 and m

$m = \frac{P_1V_1}{RT_1} = \frac{120 \times 0.1}{0.285 \times 298} = 0.141\ kg$

1 1

and : $m_1 = m_2 \Rightarrow \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$.

1

So $\boxed{T_2 = T_1 \left(\frac{P_2 V_2}{P_1 V_1} \right) = 438\,K}$ 1

Then $\Delta U = m\, c_v \,(T_2 - T_1)$ 1

$\boxed{\Delta U = 14.2\ kJ}$ 1

3) Heat transferred

Hyp: ΔE_p and ΔE_k are neglected

1st law for a closed system

$\Delta U = Q - W \Leftrightarrow Q = \Delta U + W$ 1

$= 14.2 - 28.2$

$\boxed{Q = -14\ kJ}$ 1

Problem II 12 pts

Hyp : ΔE_K and ΔE_p are neglected

$$\Delta U = Q_{net} - W_{net}$$

$$Q_{net} = Q_{13}$$

$$W_{net} = \underbrace{W_{12}}_{\text{isothermal}} + \underbrace{W_{23}}_{\text{isobaric}}$$

Then $m\, c_v (T_3 - T_1) = Q_{net} - W_{net}$ 2

1

$$m = \frac{P_1 V_1}{R T_1} = \frac{100 \times 0.4}{0.2081 \times 300} = 0.6407 \text{ kg}$$

$$\boxed{m = 0.6407 \text{ kg}}$$ 1

computation of W_{12}

$$W_{12} = P_1 V_1 \ln \frac{V_2}{V_1} = 100 (0.4) \ln \left(\frac{0.2}{0.4} \right)$$

1

$$\boxed{W_{12} = -27.7 \text{ kJ}}$$ 1

computation of W_{23}

$$W_{23} = \cancel{P_2(V_3 - T_2)} \quad P_2(V_3 - V_2)$$ 1

with $P_2 = P_1 \frac{V_1}{V_2} = 200\ kPa$ (isotherm process) 1

Then $\boxed{W_{23} = 80\ kJ}$ 1

finally :

$$Q_{inet} = \Delta U + W_{net}$$

$$= m\, c_v (T_3 - T_1) + W_{net}$$

with $T_3 = T_2 \frac{V_3}{V_2} = 900\ K$ (isobaric process)
1 1

$$Q_{net} = 0.6407\,(0.3122)(900 - 300) + (-27.7 + 80)$$

$$\boxed{Q = +172.3\ kJ}$$ 1

Problem III 6 pts.

(0.5) 1) yes C_p is higher than C_v.

because $C = \frac{Q}{\Delta T}$ and for the

Same Q, ΔT is smaller when the

process is at $P = ct$ than at ~~$T = ct$~~ $v = ct$.

(2) 2) $C_p - C_v = R$?

$h = U + Pv$

$h = U + RT$ (for ideal gas)

(2.5) $dh = dU + R\,dT$

$\frac{dh}{dT} = \frac{dU}{dT} + R$ $\Rightarrow$ $C_p = C_v + R$

C_p C_v

OR

$C_p - C_v = R$

3) 1^{st} law of Thermodynamics

(1) introduces Energy (or internal energy)