CHE 260 QUIZ 1 - 2014

(1) Ideal gas $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

Polytropic process $P_1 V_1^{\,n} = P_2 V_2^{\,n}$

$$\Rightarrow \quad P_2 = P_1 \left(\frac{T_2}{T_1}\right)^{\frac{n}{n-1}}$$

$$= 100 \text{ kPa} \left(\frac{340 \text{ K}}{300 \text{ K}}\right)^{\frac{1.1}{0.1}}$$

$$= 396 \text{ kPa}$$

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

$$= 0.2 \text{ m}^3 \left(\frac{100 \text{ kPa}}{396 \text{ kPa}}\right)^{\frac{1}{1.1}}$$

$$= 0.0572 \text{ m}^3$$

$$W = -\int_{V_1}^{V_2} p\,dV = \frac{P_2 V_2 - P_1 V_1}{n-1}$$

$$= \frac{396 \times 0.0572 - 100 \times 0.2}{1.1 - 1}$$

$$= 26.5 \text{ kJ}$$

(2)

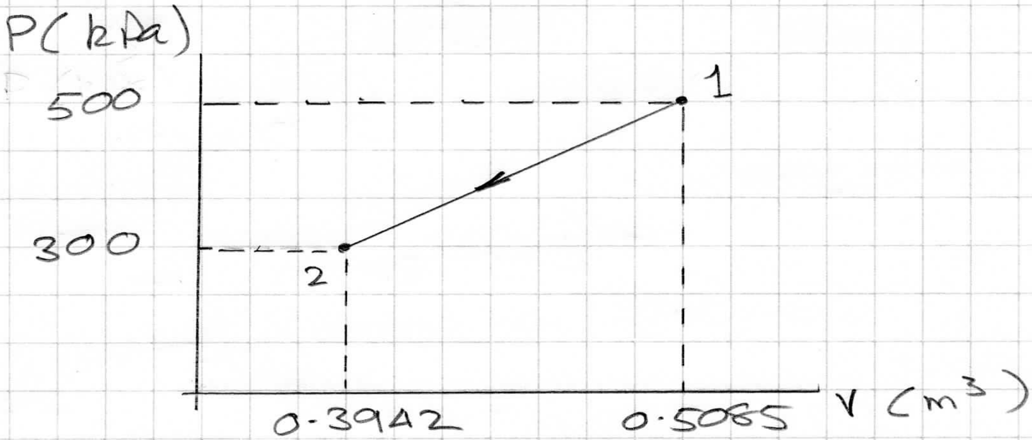
For CO_2 $\quad R = 0.1889 \ kJ/kg\,K$

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

$$= \frac{2 \times 0.1889 \times 673\ K}{500\ kPa} = 0.5085\ m^3$$

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

$$= \frac{2 \times 0.1889 \times 313\ K}{300\ kPa} = 0.3942\ m^3$$



$$W = -\int_{V_1}^{V_2} P\,dV = \frac{1}{2}(P_1 + P_2)(V_1 - V_2)$$

$$= \frac{1}{2}(500 + 300)(0.5085 - 0.3942)$$

$$= 45.72\ kJ$$

$$Q + W = \Delta U = m c_v (T_2 - T_1)$$

$c_{v,avg}$ at $500\ K = 0.825\ kJ/kg\,K$

$$Q = m c_v (T_2 - T_1) - W$$

$$= 2 \times 0.825 (313 - 673) - 45.72$$

$$= -640\ kJ$$

(3) $$\dot{Q} + \dot{W} = \dot{m}(h_e - h_i)$$

$$\Rightarrow \dot{Q} = \dot{m} c_p (T_e - T_i) - \dot{W}$$

For helium $c_p = 5.193$ kJ/kg K.

$$\Rightarrow \dot{Q} = 0.05 \times 5.193 (300 - 550) + 55$$

$$= -9.9 \text{ kW}$$