CHE 260
QUIZ 1 - 2016

① $m = 0.1\ kg$

$PV^n = const$, $n = 1.25$

Assuming ideal gas

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Combining, $\frac{P_1^{n-1}}{T_1^n} = \frac{P_2^{n-1}}{T_2^n}$

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

$T_1 = 27^\circ C = 300.15 K$

$P_1 = 100\ kPa \quad P_2 = 250\ kPa$

$$\Rightarrow T_2 = 300.15\ K \left(\frac{250\ kPa}{100\ kPa}\right)^{\frac{0.25}{1.25}}$$

$$T_2 = 360.5\ K.$$

$$W_{12} = -\int_{V_1}^{V_2} P\,dV = -C\int_{V_1}^{V_2} \frac{dV}{V^n} = -C\left[\frac{V^{1-n}}{1-n}\right]_{V_1}^{V_2}$$

$$= C\left[\frac{V_2^{1-n} - V_1^{1-n}}{n-1}\right] = \frac{P_2 V_2 - P_1 V_1}{n-1}$$

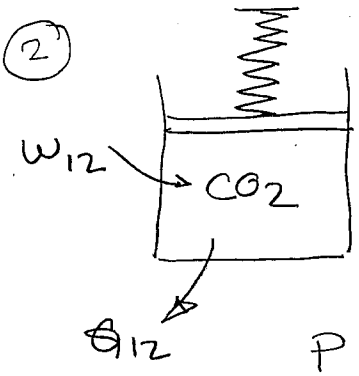
Ideal gas $\Rightarrow PV = mRT$

$$W_{12} = \frac{mR(T_2 - T_1)}{n-1}$$

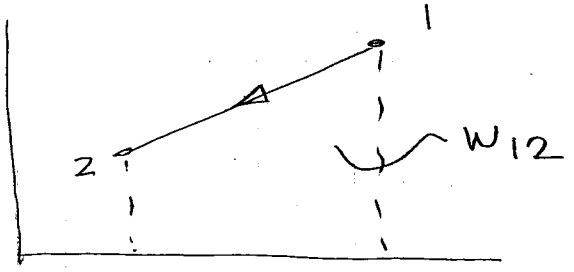
$$= \frac{0.1\ kg \times 0.2968\ \frac{kJ}{kg\,K}\,(360.5 - 300.15)K}{1.25 - 1}$$

$$= 7.165\ kJ$$

(2)



$P_1 = 500\,kPa$ $\quad T_1 = 400^\circ C$ $\quad P_2 = 300\,kPa$ $\quad T_2 = 40^\circ C$



$$W_{12} = -\int_{V_1}^{V_2} P\,dV = \frac{1}{2}(P_1 + P_2)(V_1 - V_2)$$

$$V_1 = \frac{mRT_1}{P_1} = \frac{2\,kg \times 0.1889 \frac{kJ}{kg\,K} \times 673.15\,K}{500\,kPa}$$

$$= 0.5086\ m^3$$

$$V_2 = \frac{mRT_2}{P_2} = \frac{2\,kg \times 0.1889 \frac{kJ}{kg\,K} \times 313.15\,K}{300\,kPa}$$

$$= 0.3944\ m^3$$

$$W_{12} = \frac{1}{2}(500 + 300)\,kPa \times (0.5086 - 0.3944)\,m^3$$

$$= 45.68\ kJ$$

$$\Delta U_{12} = m c_v (T_2 - T_1)$$

$$c_v = c_p - R = 0.842 - 0.1889 = 0.653 \frac{kJ}{kg\,K}$$

$$\Delta U_{12} = 2\,kg \times 0.653 \frac{kJ}{kg\,K} (40^\circ C - 400^\circ C) = -470.16$$

$$Q_{12} = \Delta U_{12} - W_{12} = -470.16\,kJ - 45.68\,kJ$$

$$= -515.84\ kJ$$

(3)

$$\dot{W} + \cancel{\dot{Q}} = \dot{m}(h_2 - h_1)$$

$$0 =$$

$$\dot{W} = \dot{m}\, c_p\, (T_2 - T_1)$$

$$-100\ W = \dot{m} \times 1004 \frac{J}{kg\,K} (-30^\circ C - 50^\circ C)$$

$$\Rightarrow \dot{m} = 1.25 \times 10^{-3}\ kg/s$$