Problem 4

Given: Air as an ideal gas in an insulated diffuser at steady state

- $P_1 = 1$ bar, $T_1 = -3°C$, $V_1 = 260$ m/s
- $V_2 = 130$ m/s

Determine: (a) T_2

(b) Max air pressure on exit

$$0 = \cancel{\dot{Q}_{cv}}^{\,0} - \cancel{\dot{W}_{cv}}^{\,0} + \dot{m}\left(h_1 - h_2 + \frac{V_1^2 - V_2^2}{2} + \cancel{g(z_1 - z_2)}^{\,0}\right)$$

$$0 = h_1 - h_2 + \frac{V_1^2 - V_2^2}{2}$$

Table A-22 @ $P = 1$ bar & $T = -3°C$ $\quad h_1 = 270.11$ kJ/kg

$$0 = 270.11 \text{ kJ/kg} - h_2 + \frac{(260 \text{ m/s})^2 - (130 \text{ m/s})^2}{2(1000)}$$

$$\boxed{h_2 = 295.46 \text{ kJ/kg}}$$

Interpolating in A-22 with $h_2 = 295.46$ kJ/kg

$$\boxed{T_2 = 295\ K}$$

$$s_2 - s_1 = s^\circ(T_2) - s^\circ(T_1) - R\ln\left(\frac{P_2}{P_1}\right)$$

For mat air pressure

$\dot{\sigma}_{cv} = 0$ (reversible)

$$0 = \cancel{\sum \frac{\dot{Q}}{T}}^{0} + \dot{m}(s_1 - s_2) + \cancel{\dot{\sigma}_{cv}}^{0}$$

$$\underline{s_1 = s_2}$$

$$0 = s^\circ(T_2) - s^\circ(T_1) - R\ln\left(\frac{P_2}{P_1}\right)$$

Table A-22 @ $p = 1$ bar & $T = -3°C$, $\Rightarrow s^\circ(T_1) = 1.59634$ kJ/kg·K

Interpolating in A-22 with $h_2 = 295.46$ kJ/kg

$s^\circ(T_2) = 1.68515$ kJ/kg·K

$$0 = 1.68515 - 1.59634 - \left(\frac{8.314}{28.97}\right)\ln\left(\frac{P_2}{1\ bar}\right)$$

$$\boxed{P_2 = 1.363\ bar}$$