4.6 The compressor discussed in Illustrations 3.4-4 and 4.5-1 is being used to compress air from 1 bar and 290 K to 10 bar. The compression can be assumed to be adiabatic, and the compressed air is found to have an outlet temperature of 575 K.

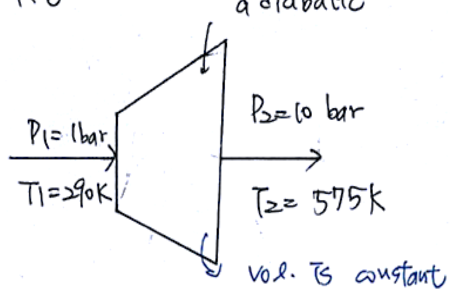
a. What is the value of ΔS for this process?

b. How much work, W_s, is needed per mole of air for the compression?

c. The temperature of the air leaving the compressor here is higher than in Illustration 4.5-1. How do you account for this? -

In your calculations you may assume air is an ideal gas with $C_p^* = 29.3$ J/ (mol K).

4.6



ideal gas.

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example 3.4-4

(a) Find ΔS

$$d\underline{H} = T d\underline{S} + \underline{V} dP \quad \left(\underline{V} \rightarrow \frac{RT}{P}\right)$$

$$\Rightarrow d\underline{S} = \frac{d\underline{H}}{T} - \frac{\underline{V} dP}{T}$$

$$\Rightarrow \int d\underline{S} = \int C_p^* \frac{dT}{T} - \int R \frac{dP}{P}$$

$$\Rightarrow \Delta \underline{S} = C_p^* \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}$$

$$= 29.3 \text{ J/mol.K} \ln \frac{575}{290} - 8.314 \text{ J/mol.K} \ln \frac{10}{1}$$

$$\fallingdotseq 20.1 - 19.1 \text{ J/mol.K}$$

$$= 1 \text{ J/mol.K}$$

(b)

From energy balance

$\frac{dU}{dt}$ (0 ∵ S.S ∈ operates continuously) $= \dot{N}_1 \underline{H}_1 + \dot{N}_2 \underline{H}_2 + \dot{Q}$ (0, adiabatic) $+ \dot{W}_s - P\frac{dV}{dt}$ (0)

$\Rightarrow \dot{W}_s = -\dot{N}_1 \underline{H}_1 - \dot{N}_2 \underline{H}_2 \qquad \because \dot{N}_2 = -\dot{N}_1$

$\Rightarrow \frac{\dot{W}_s}{\dot{N}_1} = -\underline{H}_1 + \underline{H}_2$

$\Rightarrow \underline{W}_s = C_p^*(T_2 - T_1) = 29.3\ \text{J/mol.K}\ (575 - 290\text{K})$

$= 8350.5\ \text{J/mole}$ #

(c) $\underline{W}_s = 8350.5\ \text{J/mole} > 7834.8\ \text{J/mole}$ (P.128)

⇒ the process is irreversible

⇒ part of work is converted into heat

⇒ increase of internal energy

⇒ Temp. of outlet flow is higher