Treating the plane problem as a closed system.

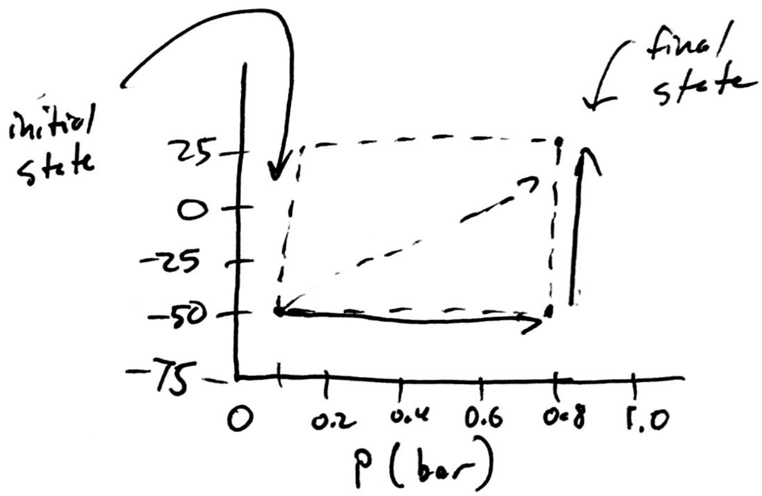
plane final volume = $100\ m^3$

initial state $-50°C$ 0.1 bar

final state $25°C$ 0.8 bar

$C_p^* = 30\ J/(mol\ K)$

\$0.2 per kWhr



many paths to solve this problem.

Path A: isothermal compression → isobaric heating.

Closed system energy balance -

no kinetic, potential energy

no shaft work

no streams, flows.

Energy Balance: $\boxed{\Delta U = Q - \int P\,dV}$

Path A. $\rightarrow$ isothermal compression

$$W_i = -\int_{\underline{V}_1}^{\underline{V}_2} p\, d\underline{V} = -\int_{\underline{V}_1}^{\underline{V}_2} \frac{RT}{\underline{V}}\, d\underline{V} = -RT\int_{\underline{V}_1}^{\underline{V}_2} \frac{d\underline{V}}{\underline{V}} = -RT\ln\frac{\underline{V}_2}{\underline{V}_1}$$

for isothermal

$$W_i = \boxed{-RT\ln\left(\frac{P_2}{P_1}\right)}$$

$$\Delta U = ? = \int_{T_1}^{T_2} C_v^{*}\, dT = 0$$ since isothermal $T_1 = T_2$

so $\Delta U_i = Q_i + W_i \rightarrow \boxed{Q_i = -W_i} = \cancel{5707.}$

$= -8.314\ J/(mol\,K) \cdot 223.15\ K \cdot \ln(8)$

$= \boxed{-3,857.92\ J/mol}$

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isobaric heating

$$\Delta U_{ii} = Q_{ii} \underbrace{- \int p\, dV_{ii}}_{W_{ii}}$$

$$W_{ii} = -\int_{\underline{V}_2}^{\underline{V}_3} P_2\, d\underline{V} = -P_2\int_{\underline{V}_2}^{\underline{V}_3} d\underline{V} = -P_2(\underline{V}_3 - \underline{V}_2) = -R(T_3 - T_2)$$

and $$\Delta \underline{U} = \int_{T_2}^{T_3} C_v^{*}\, dT = C_v^{*}(T_3 - T_2)$$

$\downarrow$ combine

so $$Q_{ii} = \Delta U_{ii} - W_{ii} = C_p^{*}(T_3 - T_2)$$

$Q_{ii} = 30\,J/(mol\cdot K) \cdot (75\,K) = 2250\,J/mol$

$W_{ii} = -8.314\,J/(mol\cdot K)\,(75\,K) = -623.55\,J/mol$

$\Delta U = Q + W$ total

$Q = Q_i + Q_{ii} = -3{,}857.92 + 2250 = -1{,}607$

$W = W_i + W_{ii} = 3{,}857.92 - 623.55 = 3{,}234.37$

$\Delta U = -1{,}607 + 3234.37$

$= \boxed{1{,}627.4\ J/mol}$

$PV = nRT$

$\dfrac{0.8\,bar \cdot 100\,m^3}{8.314\cdot 10^{-5} \cdot 298.15} = 3{,}227.34$ mol air

$= 5{,}252{,}178$ Joules total per minute

$1\,kW\text{-}h = 3{,}600{,}000\,J$

315,130,180 Joules/hour.

87.53 kWhr

$= \$43.~~76~~$ / hour

or $1.37 per minute.