Air flows steadily through a supersonic nozzle. The entering air has negligible velocity. If the process is reversible and adiabatic, (Everybody sing! That means it's also __________________!) 

(a) find the exit air temperature, and 
(b) the exit velocity. 
(c) What do you think the isentropic efficiency of this nozzle is? 

\[ \frac{dE}{dt} = \dot{m} \Delta h + \dot{W} + \sum m_i (\Delta h + \frac{V_i^2}{2} + ...) - \sum m_i (\Delta h + \frac{V_i^2}{2} + ...) \]

\[ 0 = m (h_1 + \frac{V_1^2}{2}) - m (h_2 + \frac{V_2^2}{2}) \]

\[ h_2 = h_1 - \frac{V_2^2}{2} \] (1)

\[ \frac{d}{dt} (S_{sv_0}) = \sum \frac{\dot{Q}_j}{T_j} + \sum m_\omega \Delta T - \sum m_\Delta + S_{j=1} \]

\[ 0 = \dot{m}(\Delta h_1) - \dot{m}(\Delta h_2) \]

\[ \Delta h_2 - \Delta h_1 = 0 \]

\[ 0 = \Delta^o(T_2) - \Delta^o(T_1) - R \Delta h (\frac{p_2}{p_1}) \]

FROM IDEAL GAS TABLES FOR AIR
\[ \Delta^o(T_2 = 600\, K) = 2.4092\, \text{kJ/kg.K} \]

\[ \Delta^o(T_2) = \Delta^o(T_1) + R \ln\left(\frac{P_1}{P_2}\right) \]

\[ = 2.4092\, \frac{\text{kJ}}{\text{kg.K}} + 0.287\, \frac{\text{kJ}}{\text{kg.K}} \ln\left(\frac{100\, \text{kPa}}{200\, \text{kPa}}\right) \]

\[ = 2.21\, \frac{\text{kJ}}{\text{kg.K}} \]

\[ T_2 = 495.5\, \text{K} \quad \rightarrow \quad h_2 = 498.2\, \frac{\text{kJ}}{\text{kg}} \]

(b) From (1)

\[ V_2 = \sqrt{2\left(h_2 - h_1\right)} \]

\[ = \sqrt{2\left(607.02 - 498.2\right)\, \frac{\text{kJ}}{\text{kg}}} \left(\frac{1000\, \text{J}}{\text{kJ}}\right) \left(\frac{\text{m}^2/\text{s}^2}{\text{J/kg}}\right) \]

\[ = 467\, \text{m/s} \]

(c) The isentropic efficiency is 100%.