

$$1 \rightarrow 2$$

$$V = \frac{V_1}{T_1} * T; V_2 = V_1 \frac{T_2}{T_1};$$

$$T(V) = T_1 * \frac{V}{V_1}$$

$$p = \frac{\nu R T}{V} = \frac{\nu R T}{\frac{V_1}{T_1} * T} = \frac{\nu R T_1}{V_1}; p_1 = p_2 = \frac{\nu R T_1}{V_1}; p(V) = \text{const} = \frac{\nu R T_1}{V_1};$$

$$A_{1 \rightarrow 2} = p * (V_2 - V_1) = \frac{\nu R T_1}{V_1} * \left(V_1 \frac{T_2}{T_1} - V_1 \right) = \nu R * (T_2 - T_1)$$

$$\Delta U_{1 \rightarrow 2} = \frac{3}{2} \nu R * (T_2 - T_1)$$

$$Q_{1 \rightarrow 2} = A_{1 \rightarrow 2} + \Delta U_{1 \rightarrow 2} = \frac{5}{2} \nu R * (T_2 - T_1) > 0$$

$$2 \rightarrow 3$$

$$V = \frac{V_1}{T_1} * T_2 = V_1 * \frac{T_2}{T_1} = \text{const}; V_3 = V_1 \frac{T_2}{T_1};$$

$$p = \frac{\nu R T}{V} = \frac{\nu R T}{V_1 * \frac{T_2}{T_1}} = \frac{T_1}{T_2} * \frac{\nu R T}{V_1}; p_3 = \frac{T_1}{T_2} * \frac{\nu R T_3}{V_1}$$

$$A_{2 \rightarrow 3} = 0$$

$$\Delta U_{2 \rightarrow 3} = \frac{3}{2} \nu R * (T_3 - T_2)$$

$$Q_{2 \rightarrow 3} = A_{2 \rightarrow 3} + \Delta U_{2 \rightarrow 3} = \frac{3}{2} \nu R * (T_3 - T_2) > 0$$

$$3 \rightarrow 1$$

$$V = V_1 \sqrt{\frac{T}{T_1}}; V_3 = V_1 \sqrt{\frac{T_3}{T_1}}$$

$$T(V) = T_1 * \frac{V^2}{V_1^2}$$

$$p = \frac{\nu R T}{V} = \frac{\nu R T}{V_1 \sqrt{\frac{T}{T_1}}} = \frac{\nu R \sqrt{T * T_1}}{V_1}; p_3 = \frac{\nu R \sqrt{T_3 * T_1}}{V_1};$$

$$p(V) = \frac{\nu R T}{V} = \frac{\nu R}{V} T_1 * \frac{V^2}{V_1^2} = \frac{\nu R T_1}{V_1^2} * V$$

$$A_{3 \rightarrow 1} = \frac{\nu R T_1}{V_1^2} * \frac{V_1^2}{2} - \frac{\nu R T_1}{V_1^2} * \frac{V_3^2}{2} = \frac{\nu R T_1}{2} * \left(1 - \frac{V_3^2}{V_1^2} \right) = \frac{\nu R T_1}{2} * \left(1 - \frac{T_3}{T_1} \right) = \frac{\nu R}{2} (T_1 - T_3)$$

$$\Delta U_{3 \rightarrow 1} = \frac{3}{2} \nu R * (T_1 - T_3)$$

$$Q_{3 \rightarrow 1} = A_{3 \rightarrow 1} + \Delta U_{3 \rightarrow 1} = \frac{\nu R}{2} (T_1 - T_3) + \frac{3}{2} \nu R * (T_1 - T_3) = 2 \nu R * (T_1 - T_3) < 0$$

$$Q = Q_{1 \rightarrow 2} + Q_{2 \rightarrow 3} = \frac{5}{2} \nu R * (T_2 - T_1) + \frac{3}{2} \nu R * (T_3 - T_2)$$

$$A = A_{1 \rightarrow 2} + A_{2 \rightarrow 3} + A_{3 \rightarrow 1} = \nu R * (T_2 - T_1) + 0 + \frac{\nu R}{2} (T_1 - T_3)$$

$$\left\{ \begin{array}{l} p_3 = \frac{T_1}{T_2} * \frac{\nu R T_3}{V_1} \\ p_3 = \frac{\nu R \sqrt{T_3 * T_1}}{V_1} \\ T_3 = \tau * T_1 \end{array} \right\} \Rightarrow \left\{ \begin{array}{l} \frac{T_1}{T_2} * \frac{\nu R T_3}{V_1} = \frac{\nu R \sqrt{T_3 * T_1}}{V_1} \\ T_3 = \tau * T_1 \end{array} \right\} \Rightarrow \left\{ \begin{array}{l} \frac{T_1}{T_2} * \tau = \sqrt{\tau} \\ T_3 = \tau * T_1 \end{array} \right\} \Rightarrow \left\{ \begin{array}{l} T_2 = \sqrt{\tau} * T_1 \\ T_3 = \tau * T_1 \end{array} \right.$$

$$Q = Q_{1 \rightarrow 2} + Q_{2 \rightarrow 3} = \frac{5}{2} \nu R * (T_2 - T_1) + \frac{3}{2} \nu R * (T_3 - T_2) = \frac{\nu R T_1}{2} (5 * (\sqrt{\tau} - 1) + 3 * (\tau - \sqrt{\tau}))$$

$$A = A_{1 \rightarrow 2} + A_{2 \rightarrow 3} + A_{3 \rightarrow 1} = \nu R * (T_2 - T_1) + 0 + \frac{\nu R}{2} (T_1 - T_3) = \frac{\nu R T_1}{2} (2 * (\sqrt{\tau} - 1) + (1 - \tau))$$

$$\eta = \frac{|A|}{Q} = \frac{|2 * (\sqrt{\tau} - 1) + (1 - \tau)|}{5 * (\sqrt{\tau} - 1) + 3 * (\tau - \sqrt{\tau})} = \frac{|2 * (\sqrt{9} - 1) + (1 - 9)|}{5 * (\sqrt{9} - 1) + 3 * (9 - \sqrt{9})} = \frac{4}{28} = \frac{1}{7}$$