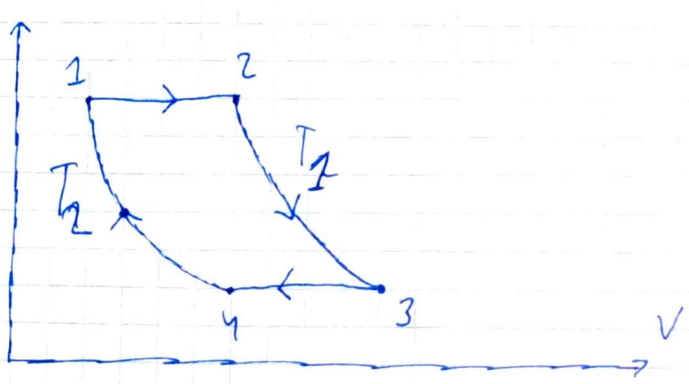
~~№32~~ №1.32

T_1, T_2

$V_4 = 2V_1$

C_p



Применим первое начало термодинамики ко всем процессам цикла:

$$Q_{12} = C_p(T_1 - T_2)\nu + p_1(V_2 - V_1) > 0$$

$$Q_{23} = \int_{V_2}^{V_3} \frac{RT_1}{V} dV = RT_1 \ln(2) > 0$$

$$Q_{34} = C_p(T_2 - T_1) + p_3(V_4 - V_3) < 0$$

$$Q_{41} = \int_{V_4}^{V_1} \frac{RT_2}{V} dV = -RT_2 \ln(2) < 0$$

$p = \frac{RT}{V}$

$p_1 V_1 = RT_2 \quad p_1 V_2 = RT_1 \quad p_3 V_3 = 2p_3 V_2 \Rightarrow \underline{V_3 = 2V_2}$

$p_3 V_4 = RT_2 \quad p_3 V_3 = RT_1$

$p_1 V_1 = p_3 V_4 \Rightarrow \underline{p_1 = 2p_3}$

$$\int_{V_2}^{V_3} \frac{RT_1}{V} dV = RT_1 \int_{V_2}^{2V_1} \frac{1}{V} dV = RT_1 (\ln(2V_1) - \ln(V_1)) = RT_1 \ln(2)$$

$$\int_{V_4}^{V_1} \frac{RT_2}{V} dV = RT_2 \int_{2V_1}^{V_1} \frac{1}{V} dV = RT_2 (\ln(V_1) - \ln(2V_1)) = -RT_2 \ln(2)$$

Найдём работу газа: $A = p_1(V_2 - V_1) + p_3(V_4 - V_3) + R\ln(2)(T_1 - T_2)$

$$A = p_1(V_2 - V_1) + p_3(V_4 - V_3) + R\ln(2)(T_1 - T_2)$$

$$A = 2p_3(V_2 - V_1) + p_3(V_4 - V_3) + R\ln(2)(T_1 - T_2)$$

$$A = p_3(2V_2 - 2V_1 + V_4 - V_3) + R\ln(2)(T_1 - T_2)$$

$$A = R\ln(2)(T_1 - T_2)$$

Найдём полученную теплоту:

$$Q_+ = RT_1\ln(2) + \underbrace{p_1(V_2 - V_1) + p_3(V_4 - V_3)}_{=0} + C_p(T_1 - T_2)$$

$$Q_+ = RT_2\ln(2) + C_p(T_1 - T_2)$$

$$\eta = \frac{A}{Q_+} = \frac{R\ln(2)(T_1 - T_2)}{C_p(T_1 - T_2) + RT_1\ln(2)}$$

$$Q_+ = RT_1\ln(2) + C_p(T_1 - T_2) + p_1(V_2 - V_1)$$

Для изобары $V_1 = \frac{T_2}{T_1} \cdot V_2$ $p_1(V_2 - V_1) = p_1\left(V_2 - \frac{T_2}{T_1}V_2\right)$

$$p_1V_2\left(1 - \frac{T_2}{T_1}\right) = RT_1\left(1 - \frac{T_2}{T_1}\right) = R(T_1 - T_2)$$

$$Q_+ = RT_1\ln(2) + C_p(T_1 - T_2) + R(T_1 - T_2)$$

$$\eta = \frac{A}{Q_+} = \frac{R\ln(2)(T_1 - T_2)}{RT_1\ln(2) + (C_p + R)(T_1 - T_2)}$$