① $\Delta U_1 = 0$

$\Delta U = q + w$

$\therefore \; q = -w$

$w_1 = -nRT_H \ln \frac{V_B}{V_A}$

$q_1 = nRT_H \ln \frac{V_B}{V_A}$

$\Delta S_1 = nR \ln \frac{V_B}{V_A}$

$\Delta H_1 = 0$

③

$$\Delta U_3 = 0$$

$$w_3 = -nRT_c \ln \frac{V_D}{V_C}$$

$$q_3 = nRT_c \ln \frac{V_D}{V_C}$$

$$\Delta S_3 = nR \ln \frac{V_D}{V_C}$$

$$\Delta H_3 = 0$$

② $q_2 = 0$

$\Delta U_2 = nC_V(T_C - T_H)$

$W_2 = nC_V(T_C - T_H)$

$\Delta S_2 = 0$

$\Delta H_2 = nC_P(T_C - T_H)$

$\Delta U = q + w$

$\Delta U = w$

$\Delta U = q_V$

$\Delta U = nC_V\Delta T$

$\Delta H = q_P$

$dS = \frac{\delta q_{rev}}{T}$ $\Big\}$ 0

④ $q_v = 0$

$\Delta U_4 = n C_v (T_H - T_c)$

$w_4 = n C_v (T_H - T_c)$

$\Delta S_4 = 0$

$\Delta H_4 = n C_p (T_H - T_c)$

Next

$$0 = \Delta U_{cycle} = \underbrace{\Delta U_1}_{0} + \underbrace{\Delta U_2}_{nC_V(T_C - T_H)} + \underbrace{\Delta U_3}_{0} + \underbrace{\Delta U_4}_{nC_V(T_H - T_C)}$$

q_{cycle}

$$w_{cycle} = -nRT_H \ln\frac{V_B}{V_A} + nC_V(T_C - T_H) - nRT_C \ln\frac{V_D}{V_C} + nC_V(T_H - T_C)$$

$$\Delta S_{cycle} = nR\ln\frac{V_B}{V_A} + nR\ln\frac{V_D}{V_C} = 0$$

$0 = \Delta H_{cycle}$ same as ΔU except C_p instead of C_V

$$W_{cycle} = W_1 + W_3$$

$$= -nRT_H \ln \frac{V_B}{V_A} - nRT_C \ln \frac{V_D}{V_C}$$

$$= -nRT_H \ln \frac{V_B}{V_A} + nRT_C \ln \frac{V_B}{V_A}$$

$$= nR(T_C - T_H) \ln \frac{V_B}{V_A}$$

$$\frac{V_B}{V_A} = \frac{V_C}{V_D}$$

W_{cycle} is negative