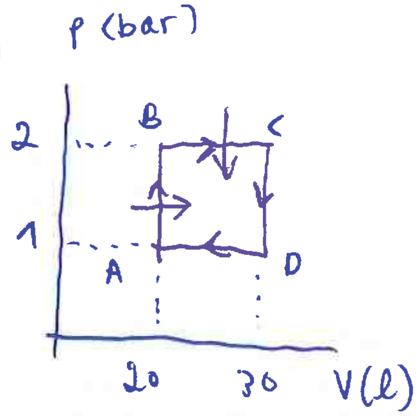
4) $\gamma = \frac{7}{5}$

$$\boxed{C_v = \frac{R}{(\gamma-1)}}$$

$$C_v = \frac{R}{\left(\frac{7}{5}-1\right)} = \frac{5}{2}R$$



a) $\boxed{pV = nRT} \rightarrow T = \frac{pV}{nR} = \frac{pV}{R}$

$$T_A = \frac{1\times10^5 (Pa) \cdot 20\,(\times10^{-3})\,(m^3)}{8{,}31\left(\frac{J}{mol\,K}\right)} = \frac{2000}{8{,}31} = \boxed{241\ K}$$

$$T_B = 2T_A = \boxed{482\ K}$$

$$T_D = \frac{pV}{R} = \frac{1\times10^5 \cdot 30\times10^{-3}}{8{,}31} = \frac{3000}{8{,}31} = \boxed{361\ K}$$

$$T_C = 2T_D = \boxed{722\ K}$$

b) $\boxed{\eta = \frac{W}{Q}} = \frac{W}{Q_{AB}+Q_{BC}}$

$W = p\Delta V = 1\times10^5 (Pa) \times 10\times10^{-3} (m^3)$

$\boxed{W = 1000\ J}$

$$\boxed{Q_{AB} = \Delta U + \cancel{W}^{\,0}} = \boxed{C_v \Delta T} = C_v(T_B - T_A) = \frac{5}{2}R(T_B - T_A)$$

$$= \frac{5}{2} \cdot 8{,}31 \times 240$$

$$\boxed{Q_{AB} = 5006\ J}$$

$$\boxed{Q_{BC} = \Delta U + W} = C_v(T_C - T_B) + p\Delta V$$

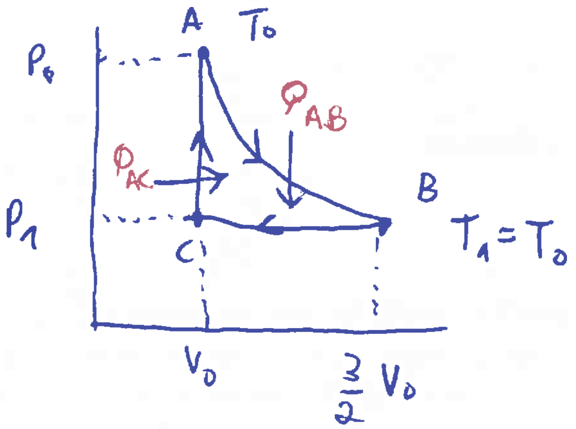
$$= \frac{5}{2}R(T_C - T_B) + 2\times10^5 \times 10\times(10^{-3})$$

$$= \frac{5}{2} \cdot 8{,}31 \cdot 240 + 2000 = 4986 + 2000$$

$\boxed{Q_{BC} = 6986}$ (J) $\rightarrow \boxed{Q = 5006 + 6986 = 11992\ J}$

$$\eta = \frac{1000}{11992} = 0{,}08 = \boxed{8\%}$$

5)



A e B $\left\{ \dfrac{P_A V_A}{\cancel{T_A}} = \dfrac{P_B V_B}{\cancel{T_B}} \right.$

$$P_0 \cancel{V_0} = P_B \frac{3}{2}\cancel{V_0}$$

$$\boxed{P_B = \frac{2}{3} P_0}$$

$$\gamma = \frac{5}{3} \qquad \boxed{C_V} = \frac{R}{(\gamma-1)} = \frac{R}{(\frac{5}{3}-1)} = \boxed{\frac{3}{2}R}$$

$$\eta = \frac{W}{Q_{AC} + Q_{AB}}$$

$$W = W_{AB} - W_{BC} = \int_{V_0}^{\frac{3}{2}V_0} p\,dV + \int_{\frac{3}{2}V_0}^{V_0} p\,dV$$

$$= nRT_0 \ln\left(\frac{\frac{3}{2}\cancel{V_0}}{\cancel{V_0}}\right) + \frac{2}{3}P_0\left(V_0 - \frac{3}{2}V_0\right) = \underbrace{nRT_0}_{P_0V_0} \ln 3/2 - \frac{1}{3}P_0V_0$$

$$\boxed{W = P_0V_0\left(\ln\frac{3}{2} - \frac{1}{3}\right)}$$

AB $\left\{ Q_{AB} = \cancel{\Delta U}^{\,0} + W_{AB} \right.$ $\qquad Q_{AB} = P_0V_0 \ln\frac{3}{2}$

CA $\left\{ Q_{CA} = \Delta U + \cancel{W_{CA}}^{\,0} = nC_V(T_A - T_C) = \frac{3}{2}(nRT_A - nRT_C) \right.$

$$Q_{CA} = \frac{3}{2}\left(P_0V_0 - \frac{2}{3}P_0V_0\right) = \frac{P_0V_0}{2}$$

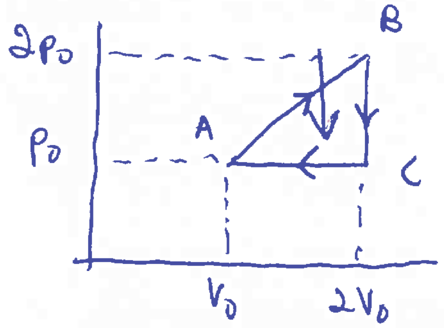
$$Q = Q_{AB} + Q_{CA} = P_0V_0\left(\ln\frac{3}{2} + \frac{1}{2}\right)$$

$$\boxed{\eta = \frac{W}{Q}} = \frac{\cancel{P_0V_0}(\ln 3/2 - 1/3)}{\cancel{P_0V_0}(\ln 3/2 + 1/2)} = \frac{0.40 - 0.33}{0.40 + 0.50} \cong 0{,}08 = \boxed{8\%}$$

$$\eta_{carnot} = 1 - \frac{T_{min}}{T_{max}} \text{“}\frac{T_C}{T_A}\text{”} \qquad \frac{P_AV_A}{T_A} = \frac{P_CV_C}{T_C} = \frac{\cancel{P_0}\cancel{V_0}}{T_A} = \frac{2}{3}\frac{\cancel{P_0}\cancel{V_0}}{T_C}$$

$$= \frac{1}{1} - \frac{2}{3} = \frac{1}{3} = 30\% \qquad \frac{T_C}{T_A} = \frac{2}{3}$$

6)



γ $\quad C_V = \dfrac{R}{(\gamma-1)}$

a)

AB $\left\{ W_{AB} = \dfrac{3}{2} p_0 V_0 \right.$

$$q_{AB} = W_{AB} + \Delta U = W_{AB} + nC_V(T_B - T_A)$$

$$= \frac{3}{2} p_0 V_0 + \frac{nR}{(\gamma-1)} (T_B - T_A)$$

$$= \frac{3}{2} p_0 V_0 + \frac{1}{(\gamma-1)} (\underbrace{nRT_B}_{2p_0 2V_0} - \underbrace{nRT_A}_{p_0 V_0})$$

$$\boxed{q_{AB} = \frac{3}{2} p_0 V_0 + \frac{3}{(\gamma-1)} p_0 V_0 = p_0 V_0 \left(\frac{3}{2} + \frac{3}{\gamma - 1}\right)}$$

$$\frac{3\gamma - 3 + 3\times 2}{2(\gamma-1)} = \frac{3\gamma+3}{2(\gamma-1)}$$

$$\boxed{W_{total} = \frac{1}{2} p_0 V_0}$$

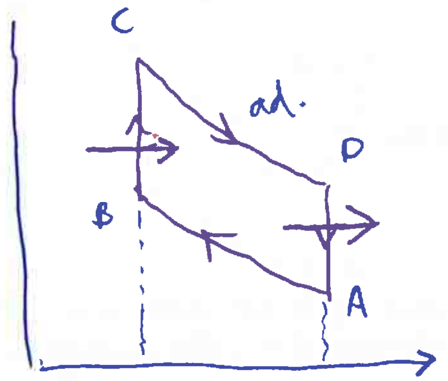
$$\eta = \frac{\frac{1}{\cancel{2}} \cancel{p_0 V_0}}{\frac{3}{\cancel{2}} \frac{(\gamma+1)}{(\gamma-1)} \cancel{p_0 V_0}}$$

$$\boxed{\eta = \frac{1}{3} \frac{(\gamma-1)}{(\gamma+1)}}$$

b) $\eta_c = 1 - \dfrac{T_A}{T_B} = 1 - \dfrac{\frac{p_A V_A}{\cancel{nR}}}{\frac{p_B V_B}{\cancel{nR}}} = 1 - \dfrac{p_0 V_0}{2p_0 2V_0} = 1 - \dfrac{1}{4} = \dfrac{3}{4}$

$$\eta = \frac{1}{3} \frac{(\gamma-1)}{(\gamma+1)} < \frac{1}{3} < \frac{3}{4}$$

8)



$\gamma \qquad C_V = \frac{R}{(\gamma-1)}$

$P_D V_D^{\gamma} = P_A V_A^{\gamma}$

$P_C V_C^{\gamma} = P_D V_D^{\gamma} = P V^{\gamma}$

$P = \frac{P_C V_C^{\gamma}}{V^{\gamma}}$

$\eta = ? \qquad \eta = \left(\frac{Q_{BC}}{W}\right)^{-1} = \frac{W}{Q_{BC}}$

$$BC \left\{ \boxed{Q_{BC} =} \cancelto{0}{W_{BC}} + \Delta U_{BC} = n C_V \Delta T = n C_V (T_C - T_B) \boxed{= \frac{nR}{(\gamma-1)} (T_C - T_B)} \right.$$

$$W_{CD} = \int_C^D p\,dV = P_C V_C^{\gamma} \int_{V_C}^{V_D} \frac{1}{V^{\gamma}}\,dV = P_C V_C^{\gamma} \left. \frac{V^{1-\gamma}}{1-\gamma} \right|_{V_C}^{V_D}$$

$$= P_C V_C^{\gamma} \left[\frac{V_D^{1-\gamma}}{(1-\gamma)} - \frac{V_C^{1-\gamma}}{(1-\gamma)} \right]$$

$$W_{CD} = \frac{P_D V_D^{\gamma}}{(1-\gamma)} V_D^{1-\gamma} - \frac{P_C V_C^{\gamma}}{(1-\gamma)} V_C^{1-\gamma}$$

$$= \frac{P_D V_D}{(1-\gamma)} - \frac{P_C V_C}{(1-\gamma)} = \frac{1}{(1-\gamma)} nR (T_D - T_C)$$

$$W_{AB} = + \frac{nR}{(1-\gamma)} (T_B - T_A)$$

$$W_{total} = W_{CD} + W_{AB} = \frac{nR}{(1-\gamma)} [T_D - T_C + T_B - T_A] \qquad T_C - T_B - (T_D - T_A)$$

$$\eta = \frac{W_{total}}{Q} = \frac{\left[nR \Big/ \cancel{(1-\gamma)}^{(-1)}\right] [T_D - T_C + T_B - T_A]}{T_C - T_B \quad \frac{n\cancel{R}}{\cancel{(\gamma-1)}}} = \frac{\overbrace{T_C - T_D - T_B + T_A}}{T_C - T_B}$$

$$\eta = 1 - \frac{T_D - T_A}{T_C - T_B}$$