

3. Σεipά. $V_0 \rightarrow 2V_0$, $pV = Nk_B T = nRT$ \rightarrow # mol

Ασκ. 1. A) $dW = p dV$, $T = \text{const}$ \rightarrow # mol

$$P = nRT \Rightarrow W_{A \rightarrow B} = \int_{V_0}^{2V_0} p dV = \int_{V_0}^{2V_0} nRT \frac{dV}{V} = nRT \left[\ln \frac{V}{V_0} \right]_{V_0}^{2V_0}$$

$$W_{A \rightarrow B} = nRT \left[\ln V \right]_{V_0}^{2V_0} = nRT (\ln 2V_0 - \ln V_0) \Rightarrow$$

$$W_{A \rightarrow B} = nRT \ln \left(\frac{2V_0}{V_0} \right) = nRT \ln 2 = \frac{p_0 V_0}{T} \ln 2$$

B) $p = \text{const}$, $dW = p dV \Rightarrow W_{A \rightarrow B} = \int_{V_0}^{2V_0} p dV = p_0 (2V_0 - V_0)$

$$W_{A \rightarrow B} = p_0 V_0 = nRT$$

$$\Gamma) \delta Q = 0 \Rightarrow d \left[Nk_B \ln (T^{3/2} V) \right] = 0$$

$$\Rightarrow T^{3/2} V = \text{const} \quad \left(T = \frac{pV}{Nk_B} \right) \Rightarrow p^{3/2} V^{5/2} = \text{const}$$

$$\Rightarrow p^{3/2} V^{5/2} = \text{const} \Rightarrow p V^{5/3} = \text{const}$$

$$pV^\gamma = \text{const}, \quad \gamma = 5/3$$

$$pV^\gamma = p_0 V_0^\gamma \Rightarrow p = \frac{p_0 V_0^\gamma}{V^\gamma}$$

$$W_{A \rightarrow B} = \int_{V_0}^{2V_0} p dV = \int_{V_0}^{2V_0} p_0 V_0^\gamma \frac{dV}{V^\gamma} = p_0 V_0^\gamma \int_{V_0}^{2V_0} \frac{dV}{V^\gamma}$$

$$W_{A \rightarrow B} = p_0 V_0^\gamma \int_{V_0}^{2V_0} V^{-\gamma} dV = p_0 V_0^\gamma \left[\frac{V^{1-\gamma}}{1-\gamma} \right]_{V_0}^{2V_0} \Rightarrow$$

$$W_{A \rightarrow B} = p_0 V_0^\gamma \left[\frac{2^{1-\gamma} V_0^{1-\gamma}}{1-\gamma} - \frac{V_0^{1-\gamma}}{1-\gamma} \right] = p_0 V_0^\gamma \frac{V_0^{1-\gamma}}{1-\gamma} \times$$

$$\times (2^{1-\gamma} - 1) \Rightarrow W_{A \rightarrow B} = p_0 V_0 \frac{(2^{1-\gamma} - 1)}{(\gamma - 1)}$$

$$\Delta Q = \Delta U + W = \frac{3}{2} nRT + W \quad U = \frac{3}{2} Nk_B T = \frac{3}{2} nRT$$

$$\rightarrow W = Q - \frac{3}{2} nRT$$

2) Ansatz $dS = \frac{\delta Q}{T} = d [Nk_B \log(T^{3/2} V)]$

$\Rightarrow dS = d [Nk_B \log(T^{3/2} V)] ; \delta Q = 0 \Rightarrow dS = 0$

$\Rightarrow Nk_B \log(T^{3/2} V) = \text{const} = c, \Rightarrow T^{3/2} V = e^{c/Nk_B}$
 $T V^{2/3} = e^{\frac{2c}{3Nk_B}}$ (A) $T = \frac{pV}{Nk_B} \Rightarrow$ (B) $PV^{5/3} = c'$

$pV = Nk_B T = nRT, n = \# \text{mol}$
 $\hookrightarrow \# \text{molekulen in einem He, Ne, H}_2$

$k_B = \frac{R}{N_A}, N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

3) DELTA Q

$\frac{\delta Q}{T} = \frac{3}{2} Nk_B \frac{dT}{T} + Nk_B \frac{dV}{V} = \frac{3}{2} Nk_B d(\log T) + Nk_B d(\log V)$

$\frac{d(\log x)}{dx} = \frac{1}{x} \Rightarrow d(\log x) = \frac{dx}{x}$
 $\frac{\delta Q}{T} = Nk_B (d \log T^{3/2} + d \log V)$

$\Rightarrow \frac{\delta Q}{T} = Nk_B d(\log T^{3/2} + \log V) = Nk_B d \log(T^{3/2} V) = d [Nk_B \log(T^{3/2} V)]$

$(\ln x)' = \frac{1}{x} \Rightarrow \frac{d}{dx} (\ln x) = \frac{1}{x} \Rightarrow d \ln x = \frac{dx}{x}$

$()' = \frac{d}{dx}$

4) $P_1 = P_0, V_1 = 0.5V_0, P_2 = 2P_0, V_2 = V_0$

$\frac{\delta Q}{T} = dS = d [Nk_B \log(T^{3/2} V)] \Rightarrow \Delta S_{1,2} = [Nk_B \log(T^{3/2} V)]$

$\Rightarrow \Delta S_{1,2} = Nk_B \log \left(\left(\frac{T_2}{T_1} \right)^{3/2} \left(\frac{V_2}{V_1} \right) \right) \quad \frac{V_2}{V_1} = 2$

$Nk_B T_1 = P_1 V_1 \rightarrow T_2 = \frac{P_2 V_2}{P_1 V_1} = \frac{2P_0 V_0}{0.5P_0 V_0} = 4, \Delta S_{1,2} = Nk_B \log(4 \cdot 2)$

5) $H = U + pV = U(V, T) + pV \Rightarrow H = \frac{5}{2} Nk_B T, U = \frac{3}{2} Nk_B T, pV = Nk_B T$

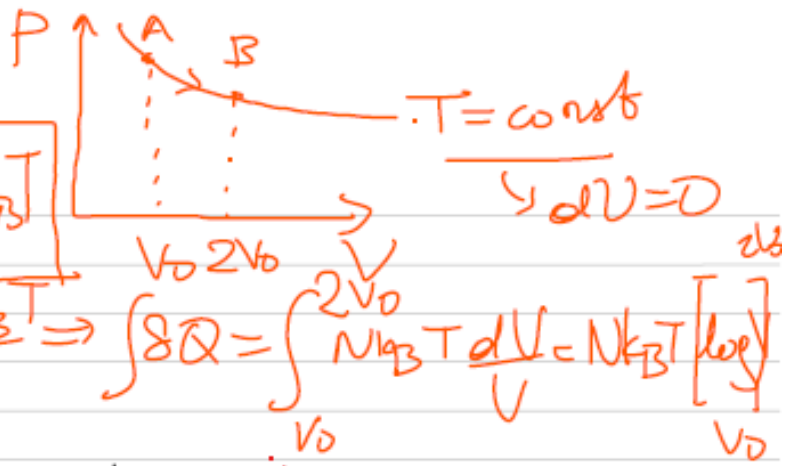
6) $\sigma \lambda$. 13/14 $\sigma \lambda$.

7) A) $\delta Q = ?$

$\delta Q = dU + PdV$, $U = \frac{3}{2} Nk_B T$

$\delta Q = PdV$, $P = \frac{Nk_B T}{V} \Rightarrow \int \delta Q = \int_{V_0}^{2V_0} \frac{Nk_B T}{V} dV = Nk_B T \ln 2$

$\Rightarrow Q = Nk_B T \ln 2$



B) δQ , $p = p_0 = \text{const}$.

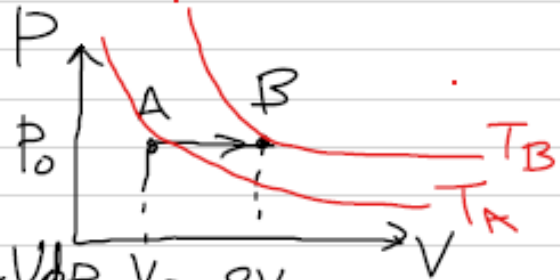
$\delta Q = dU + PdV$, $H = U + pV$

$dH = dU + PdV + Vdp$, $\delta Q = dH + Vdp$

$p = p_0 = \text{const}$, $dp = 0 \Rightarrow \delta Q = dH$

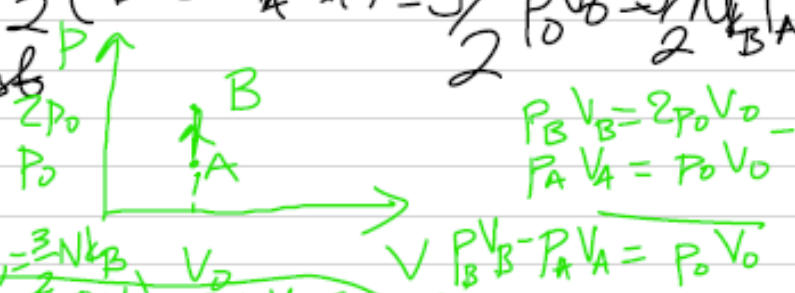
$C_p = \left(\frac{\partial H}{\partial T}\right) = \frac{5}{2} Nk_B$, $Q = C_p \Delta T$

$PV = Nk_B T \Rightarrow Q = \frac{5}{2} (P_B V_B - P_A V_A) = \frac{5}{2} p_0 V_0 = \frac{5}{2} Nk_B T$



Г) $p_0 \rightarrow 2p_0$, $V = V_0 = \text{const}$

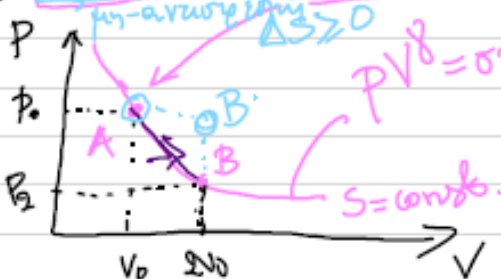
$Q = C_v \Delta T$, $C_v = \left(\frac{\partial U}{\partial T}\right)_V = \frac{3}{2} Nk_B$



$P_B V_B = 2p_0 V_0$
 $P_A V_A = p_0 V_0$
 $P_B V_B - P_A V_A = p_0 V_0$

$Q_{A \rightarrow B} = \frac{3}{2} Nk_B (T_B - T_A) = \frac{3}{2} (P_B V_B - P_A V_A) = \frac{3}{2} p_0 V_0 = \frac{3}{2} Nk_B T_A$

Δ) $Q = 0$, E) $Q = 0 + \text{averoprema}$



8) $\sigma \lambda$. 22 $\sigma \lambda$.