Merné teplo 1 mol ideálneho plynu:

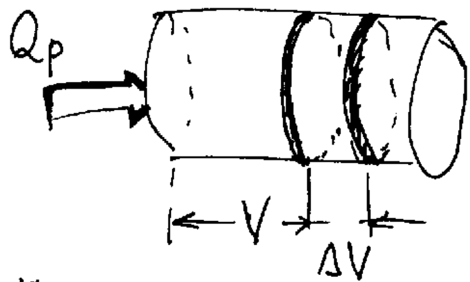
1/ jednoatómový plyn

$$U = N_A \bar{\varepsilon} = N_A \frac{3}{2} kT = \frac{3}{2} RT$$

$$C_V = \frac{dU}{dT} = \frac{3}{2} R \quad ; \quad C_p - C_V = R$$

$$C_p - \frac{3}{2} R = R$$

$$C_p = R + \frac{3}{2} R = \frac{5}{2} R$$




$$C_p = M c_p$$

$C_p$ – mólová tepelná kapacita

$c_p$ – špecifická tepelná kapacita

$$\boxed{C_p > C_V}$$

V = konšt

$$Q_V = C_V \Delta T$$

p = konšt

$$Q_p = C_p \Delta T = \underbrace{C_V \Delta T}_{Q_V} + p\Delta V \Rightarrow \frac{Q_p}{\Delta T} = C_V + p\frac{\Delta V}{\Delta T} = C_p$$

$$p\Delta V = \frac{m}{M} R \Delta T$$

$$C_V + \frac{m}{M} R = C_p$$

$$\boxed{C_p - C_V = \frac{m}{M} R}$$

$$n = \frac{m}{M} = 1 \text{ mol}$$

$$C_p - C_V = R$$

Univerzálna plyn. konšt. sa rovná rozdielu molárny tep. kapacít jedného mólu id. plynu.

6.10

$\Delta U = N\bar{\varepsilon} = N \cdot \frac{i}{2} kT$ ; $N = N_A \cdot n$

$pV = nRT$

a) $\Rightarrow i = 3$

b) $\Rightarrow i = 5$

$$\Delta U_1 = \frac{3}{2} NkT = \frac{3}{2} n N_A kT = \frac{3}{2} nRT = \underline{\underline{\frac{3}{2} pV}}$$

$$\Delta U_2 = \quad \ldots \quad = \frac{5}{2} pV$$

6.3

$N_0 = N_A$ $N = 2N_A$ $\varepsilon_i = \frac{i}{2} kT$

$\varepsilon_{N_0} = \varepsilon_N$ $V = V_0$

b)

$$\frac{i}{2} kT_0 \cdot N_A = ikN_AT$$

$$\frac{T_0}{2} = T$$

$$\underline{\underline{\frac{T}{T_0} = \frac{1}{2}}}$$

a)

$$p_0V = \frac{m}{M} RT_0$$

$$pV = 2\frac{m}{M} RT$$

$$\frac{p_0}{p} = \frac{T_0}{2T}$$

$$2\frac{p_0}{T_0} = \frac{p}{T}$$

$$2\frac{p_0}{p} = \frac{T_0}{T} = 2$$

$$\boxed{\frac{p_0}{p} = 1}$$

6.23 $Q = W + \Delta U = 0$ $\boxed{p_0 V_0^{\kappa} = pV^{\kappa}}$

$$W = p_0 V_0^{\kappa} \int_{V_0}^{V} \frac{dV}{V^{\kappa}} = \dots = \frac{p_0 V_0}{\kappa - 1}\left[1 - \left(\frac{V_0}{V}\right)^{\kappa-1}\right]$$

$$p_0 V_0 = \frac{m}{M} R T_0 = m\left[c_v(\kappa-1)\right] T_0$$

$$W = m c_v T_0 \left[1 - \left(\frac{V_0}{V}\right)^{\kappa-1}\right] = 8 \cdot 10^{-3} \cdot 741 \cdot 293{,}15\left[1 - 5^{0{,}41}\right] =$$

$$= -1624\,\mathrm{J}$$

$T_1 = 293{,}15\,\mathrm{K}$

$$\left.\begin{array}{l} \dfrac{p_1 V_1}{T_1} = \dfrac{p_2 V_2}{T_2} \\ p_1 V_1^{\kappa} = p_2 V_2^{\kappa} \end{array}\right\} \Rightarrow \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\kappa-1} \Rightarrow T_2 = \dots$$

6.6 $i = 3$, $\kappa = \frac{5}{3}$, $\boxed{\Delta \varepsilon = \frac{i}{2} k \Delta T}$ $C_v = \frac{3}{2} R$

$$Q = \Delta U + W \Rightarrow W = 0$$

$$Q = \Delta U = \frac{m}{M} C_v \Delta T = \frac{m}{M} \underbrace{\frac{R}{\kappa - 1}}_{\frac{3}{2}R} \Delta T \Rightarrow \Delta T = \frac{QM(\kappa-1)}{mR}$$

$$\Delta \varepsilon = \frac{i}{2} k \frac{QM(\kappa-1)}{mR} = \frac{i}{2} \cancel{N_A k} \frac{QM(\kappa-1)}{m N_A \cancel{R}} = \frac{iQM(\kappa-1)}{2 m N_A} =$$

$$= \frac{3 \cdot 3516 \cdot 40 \cdot 10^{-3}\left(\frac{5}{3} - 1\right)}{2 \cdot 0{,}2 \cdot 6{,}026 \cdot 10^{23}} = 1{,}165 \cdot 10^{-21}\,\mathrm{J}$$

## 6.22

$$p_0V_0 = pV \quad ; \quad p = 10p_0$$

$$\frac{R}{M} = c_p - c_v = c_v(k-1) \quad ; \quad \frac{c_p}{c_v} = k$$

a)

$$W = \int p\,dV = p_0V_0\int_{V_0}^{V}\frac{dV}{V} = p_0V_0 \ln\left(\frac{V}{V_0}\right) =$$

$$= p_0V_0 \ln\left(\frac{p_0}{p}\right) = \frac{m}{M}RT_0 \ln\left(\frac{p_0}{p}\right) =$$

$$= mc_v(k-1)T_0 \ln\left(\frac{p_0}{p}\right) = 1\cdot 728\cdot(1{,}41-1)\cdot 273{,}15 \ln\left(\frac{1}{10}\right) =$$

$$= \underline{\underline{-183{,}15\,\mathrm{kJ}}}$$

## 6.1

$$p_1V = \frac{m_1}{M}RT \qquad \Delta m = m_1 - m_2$$

$$p_2V = \frac{m_2}{M}RT$$

$$\Delta m = p_1V\frac{M}{RT} - p_2V\frac{M}{RT} = (p_1 - p_2)\frac{MV}{RT} =$$

alebo $= (2-1)\cdot 10^6 \dfrac{29\cdot 5\cdot 10^{-3}}{8314\cdot 300} = \underline{\underline{0{,}0581\,\mathrm{kg}}}$

$$c_p - c_v = \frac{R}{M} \quad ; \quad \frac{c_p}{c_v} = k \Rightarrow c_p = kc_v$$

$$\boxed{c_v(k-1) = \frac{R}{M}}$$

6.18

$$C_p = M c_p$$
$$C_p - C_v = \frac{m}{M} R$$

$$c_p - c_v = \frac{R}{M} \quad ; \quad \frac{c_p}{c_v} = k$$

$$c_v(k-1) = \frac{R}{M} \Rightarrow c_v = \frac{R}{M(k-1)}$$

$$\Delta T = T - T_0 \qquad p = \text{konst}$$

$$dQ = dW + \Delta U$$

$$Q = \int p\,dV + m c_v \int dT = p\,\Delta V + m c_v \Delta T =$$

$$= \frac{m}{M} R \Delta T + m c_v \Delta T = \frac{m}{M} R \Delta T + \frac{mR}{M(k-1)} \Delta T =$$

$$= \underbrace{\Delta T \left( \frac{mR}{M} + \frac{mR}{M(k-1)} \right)}$$

$$\Downarrow$$

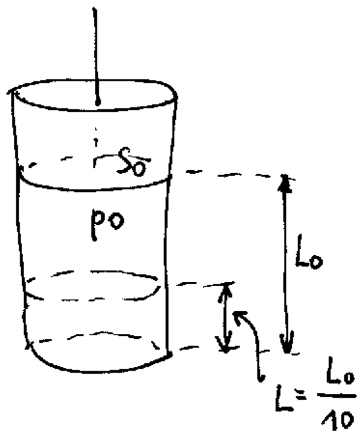
$$\Delta T = \frac{Q}{\frac{mR}{M}\left(1 + \frac{1}{k+1}\right)} = \frac{Q}{\underbrace{\frac{mR}{M} \cdot \frac{k}{k+1}}_{c_v}} = \frac{Q}{m c_v k} =$$

$$= \frac{98 \cdot 10^3}{0{,}5 \cdot 728 \cdot 1{,}40} = 192{,}31\,\text{K}$$

$$T = T_0 + \Delta T = 308{,}15 + 192{,}31 = 500{,}49\,\text{K}$$

$$t = \underline{\underline{227{,}34\,^\circ\text{C}}}$$

6.19




$$dW = p\,dV$$

$$W = \int dW = \int_{V_0}^{V} p\,dV =$$

$$\frac{p_0 V_0}{T_0} = \frac{pV}{T} \quad ; \quad T = T_0$$

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

$$= p_0 V_0 \int_{V_0}^{V} \frac{dV}{V} = p_0 V_0 \left[ \ln V \right]_{V_0}^{V} = p_0 V_0 \ln \left| \frac{V}{V_0} \right| =$$

$$= p_0 V_0 \ln \left| \frac{\frac{V_0}{10}}{V_0} \right| = p_0 V_0 \ln \left| \frac{1}{10} \right| = p_0 S_0 L_0 \ln \left| \frac{1}{10} \right|$$

$$dS = \frac{dQ}{T} = \frac{n C_v dT + p dV}{T} \qquad \boxed{6.24}$$

$$S - S_0 = \int \frac{n C_v dT}{T} + \int \frac{p dV}{T} \quad ; \; n = \frac{m}{M}$$

$\boxed{dV = 0}$

$$S - S_0 = \frac{m}{M} C_v \int_{T_0}^{T_1} \frac{dT}{T} = \frac{m}{M} C_v \, Ln\left|\frac{T_1}{T_0}\right| = m c_v \, Ln\left|\frac{T_1}{T_0}\right|$$

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$\boxed{dp = 0}$

$$pV = \frac{m}{M} RT$$

$$pdV + Vdp = \frac{m}{M} R dT$$

$$pdV = \frac{m}{M} RT$$

$$S - S_0 = \frac{m}{M} C_v \int_{T_0}^{T_1} \frac{dT}{T} + \frac{m}{M} R \int_{T_0}^{T_1} \frac{dT}{T} =$$

$$= \boxed{\begin{matrix} c_p = c_v + \frac{R}{M} \\ C_p = M c_p \end{matrix}} = \frac{m}{M} (C_v + R) \, Ln\left|\frac{T_1}{T_0}\right| =$$

$$= \left(c_v + \frac{R}{M}\right) m \, Ln\left|\frac{T_1}{T_0}\right| = m c_p \, Ln\left|\frac{T_1}{T_0}\right|$$

usik $\kappa = \frac{5}{3}$

$$= \kappa c_v m \, Ln\left|\frac{T_1}{T_0}\right|$$

6.25 $T_0 = 300K \quad V_0 = 6L \quad V = 4L$

$$\frac{p_0 V_0}{T_0} = nR = \frac{m}{M} R$$

$$dQ = dW + \underbrace{dU}_{\to \emptyset}$$

$$dQ = dW = p\,dV = p_0 V_0 \frac{dV}{V}$$

$$dS = \frac{dQ}{T} \Rightarrow S = \int \frac{dQ}{T} = \frac{p_0 V_0}{T_0} \int_{V_0}^{V} \frac{dV}{V} =$$

$$= \frac{p_0 V_0}{T_0} \cdot Ln\left(\frac{V}{V_0}\right) = \frac{mR}{M} Ln\left(\frac{V}{V_0}\right) =$$

$$= \frac{2 \times 10^{-3} \times 8314}{28} Ln\left(\frac{4}{6}\right) = -0{,}2408\, JK^{-1}$$

$$\approx -0{,}24\, JK^{-1}$$