# Formule za prvi kolokvij

Toplinsko širenje čvrstih tijela i tekućina

$l = l_0(1 + \alpha\Delta T) \qquad \Delta T = T_2 - T_1$

$V = V_0(1 + \gamma\Delta T) \qquad \gamma = 3\alpha$

Prijenos topline

vođenje:

$$Q = -\lambda\frac{\Delta T}{\Delta x}S\tau \qquad \Phi = \frac{Q}{\tau}$$

$$q = \frac{\Phi}{S} = \frac{Q}{S\tau} = -\lambda\frac{\Delta T}{\Delta x}$$

$$R = -\frac{\Delta T}{\Phi} = -\frac{\Delta T}{qS} = \frac{\Delta x}{\lambda S}$$

cilindar

$$\Phi = \frac{2\pi\lambda l(T_1 - T_2)}{\ln\frac{r_2}{r_1}}$$

strujanje:

$$q = h_c\left(T_p - T_f\right)$$

$$R = -\frac{\Delta T}{qS} = \frac{1}{h_c S}$$

zračenje:

$$M = \frac{\Phi_e}{S} = \frac{e\sigma S T^4}{S} = e\sigma T^4$$

$$M = \int_0^\infty M_\lambda \mathrm{d}\lambda$$

$$\lambda_m T = 2{,}898 \cdot 10^{-3}\ \mathrm{K\,m}$$

$$M_\lambda^{ct} = \frac{2\pi hc^2}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$$

Toplinski kapacitet i specifična toplina

$Q = mc\Delta T$

$C_t = mc$

$Q = mL$

Plinski zakoni

$$\frac{pV}{T} = \frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2} = \text{konst.}$$

Jednadžba stanja idealnog plina

$pV = nRT$

$$n = \frac{m}{M} = \frac{N}{N_A} = \frac{V}{V_m}$$

$pV = NkT$

Molekulsko - kinetička teorija topline

$$l = \frac{1}{\sqrt{2}n_0\sigma} = \frac{1}{\sqrt{2}n_0 d^2\pi}$$

$$n_0 = \frac{N}{V}$$

$$p = \frac{1}{3}m_0 n_0\overline{v^2}$$

$$v_{sk} = \sqrt{\overline{v^2}} = \sqrt{\frac{3kT}{m_0}}$$

$$U = \frac{f}{2}NkT$$

$$\overline{E_k} = \frac{3}{2}kT$$

$$U = N\overline{E_k} = \frac{3}{2}NkT$$

Van der Waalsova jednadžba

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

$$V_k = 3b \quad p_k = \frac{a}{27b^2} \quad T_k = \frac{8a}{27bR}$$

Molni toplinski kapaciteti

$$C_{\mathrm{m},p} = \frac{1}{n}\left(\frac{\delta Q}{\mathrm{d}T}\right)_p$$

$$C_{\mathrm{m},V} = \frac{1}{n}\left(\frac{\delta Q}{\mathrm{d}T}\right)_V \qquad C_{\mathrm{m},V} = \frac{1}{n}\frac{\mathrm{d}U}{\mathrm{d}T}$$

$$C_{\mathrm{m},p} = Mc_p \qquad C_{\mathrm{m},V} = Mc_V$$

$$C_{\mathrm{m},p} - C_{\mathrm{m},V} = R$$

$$\frac{C_{\mathrm{m},p}}{C_{\mathrm{m},V}} = \frac{C_p}{C_V} = \frac{c_p}{c_V} = \kappa$$

jednoatomni plin $\kappa = 1{,}67$
dvoatomni plin $\kappa = 1{,}4$

Prvi zakon termodinamike

$$Q = \Delta U + W \qquad \delta Q = \mathrm{d}U + \delta W$$

$$\Delta U = U_2 - U_1 \qquad W = \int_{V_1}^{V_2} p\mathrm{d}V$$

Rad pri promjenama stanja plina

izobaran proces: $W = p(V_2 - V_1)$

izoterman proces: $W = nRT\ln\frac{V_2}{V_1} = nRT\ln\frac{p_1}{p_2}$

adijabatski proces: $W = \frac{nR}{\kappa - 1}(T_1 - T_2)$

Poissonove jednadžbe

$$\frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{\kappa}$$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\kappa-1}$$

$$\frac{T_1}{T_2} = \left(\frac{p_1}{p_2}\right)^{\frac{\kappa-1}{\kappa}}$$

Toplinski stroj

$$\eta = \frac{W}{Q_1} \qquad W = |Q_1| - |Q_2| = Q_1 + Q_2$$

$$\eta_C = 1 - \frac{T_2}{T_1}$$

Entropija

$$\Delta S = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T}$$

idealni plin:

$$\Delta S = nR\ln\frac{p_1}{p_2} + nC_{\mathrm{m},p}\ln\frac{T_2}{T_1}$$

$$\Delta S = nR\ln\frac{V_2}{V_1} + nC_{\mathrm{m},V}\ln\frac{T_2}{T_1}$$

čvrsta tijela i tekućine:

$$\Delta S = mc\ln\frac{T_2}{T_1}$$

Osnovna termodinamička jednadžba

$$T\mathrm{d}S \geq \mathrm{d}U + p\mathrm{d}V$$

Termodinamički potencijali

1. $U = U(S,V)$

   $$T = \left(\frac{\partial U}{\partial S}\right)_V \qquad p = -\left(\frac{\partial U}{\partial V}\right)_S$$

2. $H = H(S,p) = U + pV$

   $$T = \left(\frac{\partial H}{\partial S}\right)_p \qquad V = \left(\frac{\partial H}{\partial p}\right)_S$$

3. $F = F(T,V) = U - TS$

   $$p = -\left(\frac{\partial F}{\partial V}\right)_T \quad S = -\left(\frac{\partial F}{\partial T}\right)_V$$

4. $G = G(T,p) = H - TS$

   $$V = \left(\frac{\partial G}{\partial p}\right)_T \qquad S = -\left(\frac{\partial G}{\partial T}\right)_p$$

Maxwellove termodinamičke jednadžbe

$$\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial p}{\partial S}\right)_V$$

$$\left(\frac{\partial T}{\partial p}\right)_S = \left(\frac{\partial V}{\partial S}\right)_p$$

$$\left(\frac{\partial p}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$$

$$\left(\frac{\partial V}{\partial T}\right)_p = -\left(\frac{\partial S}{\partial p}\right)_T$$

$T\mathrm{d}S$ jednadžbe

1. $$T\mathrm{d}S = C_V \mathrm{d}T + T\left(\frac{\partial p}{\partial T}\right)_V \mathrm{d}V$$

2. $$T\mathrm{d}S = C_p \mathrm{d}T - T\left(\frac{\partial V}{\partial T}\right)_p \mathrm{d}p$$

3. $$T\mathrm{d}S = C_V\left(\frac{\partial T}{\partial p}\right)_V \mathrm{d}p + C_p\left(\frac{\partial T}{\partial V}\right)_p \mathrm{d}V$$

Jednadžbe za unutarnju energiju

$$\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_V - p$$

$$\left(\frac{\partial U}{\partial p}\right)_T = -T\left(\frac{\partial V}{\partial T}\right)_p - p\left(\frac{\partial V}{\partial p}\right)_T$$

Opća termodinamička jednadžba

$$\mathrm{d}U = C_V \mathrm{d}T + \left[T\left(\frac{\partial p}{\partial T}\right)_V - p\right]\mathrm{d}V$$

Jednadžbe za toplinske kapacitete

$$C_p - C_V = T\left(\frac{\partial p}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_p$$

$$C_p - C_V = -T\left(\frac{\partial V}{\partial T}\right)_p^2 \left(\frac{\partial p}{\partial V}\right)_T$$

Konstante

$k = 1{,}38 \cdot 10^{-23}\ \mathrm{J\,K^{-1}}$

$R = 8{,}314\ \mathrm{J\,mol^{-1}K^{-1}}$

$\sigma = 5{,}67 \cdot 10^{-8}\ \mathrm{W\,m^{-2}K^{-4}}$

$N_A = 6{,}022 \cdot 10^{23}\ \mathrm{mol^{-1}}$

$V_m = 22{,}4 \cdot 10^{-3}\ \mathrm{m^3\,mol^{-1}}$

$h = 6{,}626 \cdot 10^{-34}\ \mathrm{J\,s}$