SEMINAR

$H_2O_{(l)}$, 20°C, 1 atm
↓ segrevamo
$H_2O_{(g)}$, 250°C, 1 atm

ΔH, ΔU, ΔS = ?

$C_{pM(l)} = 75{,}3\ J\,mol^{-1}K^{-1}$

ΔH_M izparilna = 40,668 kJ/mol

$C_{pM(g)} = 36{,}0\ J\,mol^{-1}K^{-1}$

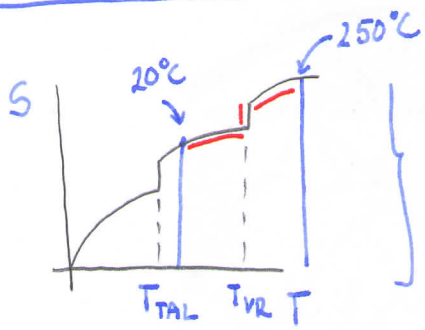
$n = 1\ mol$

$$\Delta H = q_p = n\cdot\int_{293}^{373} C_{pM(l)}\cdot dT + n\,\Delta_{izp}H_M + n\int_{373}^{523} C_{pM(g)}\cdot dT =$$

$$= n\cdot C_{pM(l)}\cdot(373K - 293K) + n\cdot\Delta_{izp}H_M + n\,C_{pM(g)}(523K - 373K) =$$

$$= \underline{52{,}092\ kJ}$$

$\Delta U = 47{,}745\ kJ$ - izračunaj sam!



ΔS = ?

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3 =$$

$$= n\cdot\int_{293}^{373}\frac{c_{pM}\cdot dt}{T} + n\cdot\Delta_{izp}S_M + \int_{373}^{523}\frac{C_{pM(g)}\cdot dT}{T} =$$

Pri 100°C in 1 atm imamo RAVNOTEŽJE med tekočo vodo in paro. $\Delta S = \frac{q}{T}$

$$= n\cdot C_{pM_{(l)}}\ln\frac{373K}{293K} + n\cdot\frac{\Delta_{izp}H_M}{T_{VR}} + n\cdot C_{pM(g)}\ln\frac{523K}{373K} =$$

$$\Delta S = \underline{139{,}3\ J/K}$$

$T_1 = 300\,K$, $p_1 = 1{,}00\,bar$ $\longrightarrow$ $T_2 = 1000\,K$, $p_2 = 0{,}01\,bar$

Izračunaj spremembo entropije 1 mol SO_2, ki se obnaša idealno!

$C_{pM} = \left(a + \frac{b}{T} + \frac{c}{T^2}\right) R$

$a = 7{,}871$

$b = 1454{,}6\,K$

$c = 160\,351\,K^2$

$dU = TdS - pdV$ 2. primer

$dS = \frac{dU}{T} + \frac{p}{T}dV$

$dS = n\int \frac{C_{VM}\cdot dT}{T} + nR\int \frac{dV}{V}$

$$\Delta S = n\int_{T_1}^{T_2} \frac{C_{pM}\cdot dT}{T} - nR\ln\frac{p_2}{p_1} = nR\int_{T_1}^{T_2} \frac{\left(a + \frac{b}{T} + \frac{c}{T^2}\right)dT}{T} - nR\ln\frac{p_2}{p_1} =$$

$$= nR\int_{T_1}^{T_2}\left(\frac{a}{T} + \frac{b}{T^2} + \frac{c}{T^3}\right)dT - nR\ln\frac{p_2}{p_1} = nR\left(a\ln\frac{T_2}{T_1} - b\left(\frac{1}{T_2} - \frac{1}{T_1}\right) - \frac{1}{2}c\left(\frac{1}{T_2^2} - \frac{1}{T_1^2}\right)\right) - nR\ln\frac{p_2}{p_1} =$$

$\Delta S = \underline{95{,}6\,J\,K^{-1}}$ - povečanje entropije. : segrevanje T
: zmanjšanje tlaka oz. povečanje volumna
p V

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2 mol He

$p_1 = 2\,atm$, $V_1 = 30\,cm^3$ $\longrightarrow$ $p_2 = 1\,atm$, $V_2 = 100\,cm^3$

$C_{VM} = \frac{3}{2}R$ (enoatomarni plin)

Izračunaj spremembo 2 mol He, ki se obnaša idealno!

$$\Delta S = n\cdot\int_{T_1}^{T_2}\frac{C_{VM}\cdot dT}{T} + nR\ln\frac{V_2}{V_1} = n\cdot C_{VM}\ln\frac{T_2}{T_1} + nR\ln\frac{V_2}{V_1} =$$

$$= n\cdot C_{VM}\ln\frac{p_2V_2}{p_1V_1} + nR\ln\frac{V_2}{V_1} =$$

$p_1V_1 = nRT_1$, $p_2V_2 = nRT_2$ $\Rightarrow$ $\frac{p_2V_2}{p_1V_1} = \frac{T_2}{T_1}$ $\Delta S = \underline{32{,}8\,J\,K^{-1}}$

$NH_3(g)$ ~ $n = 1\,mol$

$T_1 = 25°C$

$S_M(100°C) = ?$

$S_M^\circ(500°C) = ?$

$\int_{S^\circ(T_1)}^{S^\circ(T_2)} dS^\circ = \int_{T_1}^{T_2}\frac{n\cdot C_{p,M}\,dT}{T}$

$S_M^\circ(100°C) = 200{,}6\,J/molK$

$S_M^\circ(500°C) = 231{,}9\,J/molK$

$S_M = 192{,}4\,J/molK$

$C_{pM} = a + bT + \frac{c}{T^2}$

$a = 29{,}75\,J/molK$

$b = 2{,}51\cdot10^{-2}\,J/molK^2$

$c = -1{,}55\cdot10^5\,J/molK^{-1}$ (JK/mol)

$S^\circ(T) = S^\circ(298) + \int_{298}^{T}\frac{n\cdot C_{p,M}\cdot dT}{T}$

Imamo toplotno izoliran sistem.

1 mola $H_2O_{(l)}$ pri 0°C dodamo 10 mol H_2O pri 25°C.

$c_{p,m(l)} = 75{,}3\ J/molK$

$\Delta_{tal}H_m = 6{,}008\ kJ/mol$

$\Delta S = ?$

$$Q_l = n_{(l)} \cdot \int_0^{T_l - 25°C} c_{p,m(l)}\, dT =$$

$$= n_{(l)} \cdot c_{p,m(l)} \cdot 25K =$$

$$= 10\ mol \cdot 75{,}3\ J/molK \cdot 25K =$$

$$Q_l = \underline{18\,825\ J}$$

$$\sum q_n = \sum \Delta H = 0$$

$$\Delta H_{(s)} + \Delta H_{(l)} = 0$$

$$n_{(s)} \cdot \Delta_{tal}H_m + n_{(s)} \int_{273}^{T_{zmesna}} c_{p,m(l)}\, dT + n_{(l)} \int_{273}^{T_{zmesna}} c_{p,m} \cdot dT = 0$$

$$n_{(s)} \cdot \Delta_{tal}H_m + n_{(s)} c_{p,m(l)} (T_{zmes} - 273K) + n_{(l)} c_{p,m(l)} (T_{zmes} - 273K) = 0$$

$$T_{zmes} = \frac{n_{(s)} c_{p,m(l)} 273K + n_{(l)} \cdot c_{p,m(l)} 273K - n_{(s)} \cdot \Delta_{tal}H_m}{n_{(s)} c_{p,m(l)} + n_{(l)} c_{p,m(l)}}$$

$$= 288{,}62\ K = \underline{15{,}47\ °C}$$

$$\Delta S = \Delta S_l + \Delta S_s = n_{(l)} \int_{298}^{T_{zmes}} \frac{c_{p,m(l)} \cdot dT}{T} + n_{(s)} \Delta_{tal}S_m + n_{(s)} \cdot \int_{273}^{T_{zmes}} \frac{c_{p,m(l)} \cdot dT}{T} =$$

$$= n_{(l)} c_{p,m(l)} \ln \frac{T_z\ (288{,}62K)}{298K} + n_{(s)} \frac{\Delta_{tal}H_m}{T_{tal}} + n_{(0)} \cdot c_{p,m(l)} \ln \frac{T_{zmes}}{273K} =$$

$$\Delta S = \underline{1{,}68\ J/K}$$

$S^\circ_m(l) = 70{,}0\ J/molK$ pri $T = 25°C$ Zanima nas molska entropija vodne pare pri 25°C!

$S^\circ_m(g)$ pri $25°C = ?$

$T = 25°C \quad l \xrightarrow{\Delta_{izp}S^\circ} g$ $\quad \Delta_{izp} S^\circ_m = S^\circ_m(g) - S^\circ_m(l)$; $T = 25°C$

$$S^\circ_m(g) = S^\circ_m(l) + \Delta_{izp} S^\circ_m$$

$\Delta_{izp} H_m = q_{izp}$

$\Delta S_{25°C} > \frac{q}{T_{298K}}$

$\Delta_{izp} S^\circ_m(25°C) = \Delta_{izp} S^\circ_m(100°C) + \int_{373,15}^{298,15} \frac{\Delta C_p dT}{T}$

$\Delta_{izp} S^\circ_m(100°C) = \frac{\Delta_{izp} H_m}{T_{VR}}$, $373,15K$

$\Delta C_p = C_{p,m}(g) - C_{p,m}(l)$

$C_{p,m}(g) = \checkmark$
$C_{p,m}(l) = \checkmark$
$\Delta_{izp} H_m = \checkmark$
} imamo podatke

PAZI: enačba $\Delta S = \frac{q_p}{T}$ velja le, ko sta 2 AG. STANJI v RAVNOTEŽJU (npr. led in voda pri 0°C, voda in para pri 100°C)

$\Delta S_{263K} = \Delta S_{273K} + \int_{273}^{263} \frac{\Delta C_p dT}{T}$ pri čemer je $\Delta S_{273K} = + \frac{-\Delta_{kal} H_m}{273K}$