3 ingeleverde Bladen

8

Thermodynamica

1 a $C_V = \left(\frac{\partial U}{\partial T}\right)_V$

1

$C_p = \left(\frac{\partial H}{\partial T}\right)_p$

b $C_p - C_V = \left(\frac{\partial H}{\partial T}\right)_p - \left(\frac{\partial U}{\partial T}\right)_V = \left(\frac{\partial(U+pV)}{\partial T}\right)_p - \left(\frac{\partial U}{\partial T}\right)_V$

$= \left(\frac{\partial U}{\partial T}\right)_p + \left(\frac{\partial pV}{\partial T}\right)_p - \left(\frac{\partial U}{\partial T}\right)_V$

$1\frac{1}{2}$

$\left(\frac{\partial U}{\partial T}\right)_p = \left(\frac{\partial U}{\partial T}\right)_V$ voor een ideaal gas waarom?

dus $C_p - C_V = \left(\frac{\partial(pV)}{\partial T}\right)_p = \frac{\partial(nR\cdot T)}{\partial T} = nR$

nu delen we de hele vergelijking door n.
men houdt dan over: $C_{p,m} - C_{V,m} = R$

$H = U + pV$ $\quad p>0$ (geen drukverschil)
$V>0$ (niet gedefinieerd, alleen bij ~~druk~~ volumeverschil.)

dus $H \underset{m}{>} U$
en zodoende $C_{p,m} > C_{V,m}$ (volgt ook uit de vergelijking.)

c Reversibele ~~Adiabatische~~ Adiabatische Expansie

d

~~$pV = n \cdot R \cdot T$~~

$\rho = \frac{m}{V}$
$m = \rho \cdot V$

$m_{OB} = m_{VL} - m_{GB}$

$m_{OB} = V_{ballon} \cdot \rho_{lucht} - V_{ballon} \cdot \rho_{ballon}$

Eerst V_{ballon} uitrekenen ~~$pV = n \cdot R \cdot T$~~ ~~$V = \frac{nRT}{p}$~~ $d = 10{,}0\,m$ $r = 5{,}0\,m$

$V_{ballon} = \frac{4}{3}\pi r^3$ ~~$V =$~~ ~~$0{,}0\,m$~~ 202

$V_{ballon} = \frac{4}{3}\pi \cdot \frac{10}{5}^3 = \cancel{4188,79\ m^3}$

523,598

$\boxed{523,6\ m^3}$

$\rho_{lucht} = \frac{m}{V}$

$V = \frac{n \cdot RT}{p}$ $\quad \frac{m}{V} = \cancel{\frac{m}{n} \cdot \frac{p}{RT}} = \frac{Mp}{RT}$

$\frac{m}{\frac{nR \cdot T}{p}}$

$M = 0,8 \cdot 28,0 + 0,2 \cdot 32,0$

$22,4 + 6,4 = 28,8$

$\rho_{lucht} = \frac{28,8 \cdot 1,0 \cdot 10^5}{8,3145 \cdot 294} = \frac{28,8 \cdot 10^5}{2444,463}$

$= \boxed{0,01178 \cdot 10^5}$

$\rho_{ballon} = \frac{28,8 \cdot 1,0 \cdot 10^5}{8,3145 \cdot 338} = \frac{28,8}{2810,301} = \boxed{0,010248 \cdot 10^5}$

(zie vorige bladzijde)

$m_{opgetild} = 523,6 \cdot 0,01178 \cdot 10^5 - 523,6 \cdot 0,010248 \cdot 10^5$

$= 6,168 \cdot 10^5 - 5,3658 \cdot 10^5$

$= 616800 - 536580$

$= \underline{80220\ \cancel{k}g}$

$(= 8,0 \cdot 10^4\ g)$

3½

(e) $\rho_{lucht} = \frac{28{,}8 \cdot 0{,}8 \cdot 10^5}{8{,}3145 \cdot 294} = \frac{23{,}04 \cdot 10^5}{2444{,}463}$

$= 9{,}425 \cdot 10^{-3}$

$\rho_{ballon} = \frac{28{,}8 \cdot 0{,}8 \cdot 10^5}{8{,}3145 \cdot 338} = \frac{23{,}04 \cdot 10^5}{2810{,}301} = 8{,}2 \cdot 10^{-3}$

$m_{opgetild} = 9{,}425 \cdot 10^{-3} \cdot 523{,}6 - 523{,}6 \cdot 8{,}2 \cdot 10^{-3}$

$= 4{,}93493 - 4{,}3$

$= 0{,}63493 \text{ g} = 0{,}63 \cdot 10^4 \text{ g}$

(f) Zelfde ~~zelo~~ formule, ander molair volume

$\rho_{lucht} = 0{,}01178 \cdot 10^5$

$\rho_{ballon} = \frac{M \cdot p}{R \cdot T}$

$M = 4{,}0 \text{ g/mol}$

$= \frac{4{,}0 \cdot 1{,}0 \cdot 10^5}{8{,}3145 \cdot 294{,}0} = 1{,}636 \cdot 10^2$

$m_{opgetild} = 0{,}01178 \cdot 10^5 \cdot 523{,}6 - 1{,}636 \cdot 10^2 \cdot 523{,}6$

$m_{opgetild} = 6{,}168 \cdot 10^5 - 856{,}6 \cdot 10^2$

$= 616800 - 85660$

$= 531140 \text{ g}$

$= 5{,}3 \cdot 10^5 \text{ g}$

2a De interne energie (U) van een geïsoleerd systeem is constant. ($dU = dq + dw$)

1 ~~8~~

b Als er binnen een geïsoleerd systeem een spontante verandering plaatsvindt dan neemt de entropie altijd toe. ($\Delta S_{tot} > 0$)

1

c $Fe_2O_3 + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$

$T = 298{,}15\,K$

$\Delta G < 0$ als hij spontaan is

$\Delta G = \Delta H - T\Delta S$

$\Delta H = 3 \cdot -285{,}83 - (824{,}2)$

$= -857{,}49 - 824{,}2$

$\neq -1681{,}69\ kJ/mol \neq -1681{,}69 \cdot 10^3\ J/mol$

$1\frac{1}{2}$ $\Delta S = 2 \cdot 27{,}28 + 3 \cdot 69{,}91 - (3 \cdot 130{,}68 + 1 \cdot 87{,}40)$

- eenheid
- rekenfout

$54{,}56 + 209{,}73 - 479{,}44$

$264{,}29 - 479{,}44$

$\Delta S = -215{,}15\ J/K\,mol$

$\Delta G = -1681{,}69 \cdot 10^3 - 298{,}15 \cdot (-215{,}15)$

~~$\Delta G = 62465{,}3 \not< 0$ en dus niet spontaan.~~

d ~~$\Delta_{vap} S^\theta = \frac{\Delta_{vap} H^\theta}{T_{vap}}$~~

$\Delta G = -1681{,}69 \cdot 10^3 + 64146{,}9$

$\Delta G = -1617543{,}1 < 0$

dus hij is spontaan

Thermodynamica

2d

$$\Delta_{vap} S^{\theta}(H_2O) = \frac{\Delta_{vap} H^{\theta}}{T_{vap}}$$

1½

$$= \frac{40{,}66 \cdot 10^3}{373{,}15} = 0{,}10896 \cdot 10^3$$

$$= 108{,}96 \text{ J/Kmol}$$

e entropieën bij elkaar zoeken en gebruiken dat

$$S(T_2) = S(T_1) + \int_{T_1}^{T_2} \frac{C_{p,m}}{T} dT$$

$$= S(T_1) + C_{p,m} \ln \frac{T_2}{T_1}$$

$H_2O \rightarrow 3 \cdot 69{,}91 + 3 \cdot 75{,}29 \ln \frac{373{,}15}{298{,}15} \overset{3\times}{+} 108{,}96 = 369{,}37$

1

$Fe \rightarrow 2 \cdot 27{,}28 + 2 \cdot 25{,}10 \cdot \ln \frac{373{,}15}{298{,}15} \pm 105{,}24$

$H_2 \rightarrow 3 \cdot 130{,}68 + 3 \cdot 28{,}82 \cdot \ln \frac{373{,}15}{298{,}15} \pm 403{,}3$

$Fe_2O_3 \rightarrow 1 \cdot 87{,}40 + 1 \cdot 103{,}85 \ln \frac{373{,}15}{298{,}15} = 106{,}8$

rekenfoute

$369{,}37 + 105{,}21 - 403{,}3 - 106{,}8 = \Delta S = -35{,}49$

Zelfde voor ΔH alleen geldt nu $H(T_2) = H(T_1) + C_p \cdot \Delta T$

H_2O $3 \cdot -285{,}83 + 3 \cdot 75{,}29 \cdot 75 = \cancel{47894{,}26}$
$+40{,}66 \cdot 10^3$ $\cancel{16382{,}76}$ $56742{,}76$

Fe $2 \cdot 75 \cdot 25{,}10 = 3765$

H_2 $3 \cdot 28{,}82 \cdot 75 = 6484{,}5$

eenheden!

Fe_2O_3 $-824{,}2 + 1 \cdot 75 \cdot 103{,}85$
$= 6964{,}55$

$$\Delta H = \cancel{16082{,}76}\ \overset{56742{,}76}{} + 3765 - (6484{,}5 + 6964{,}55)$$

$$\cancel{19847{,}76} \quad - \quad 13449{,}05$$

$$\Delta H = 60507{,}76$$

$$\Delta H = 47058{,}76$$

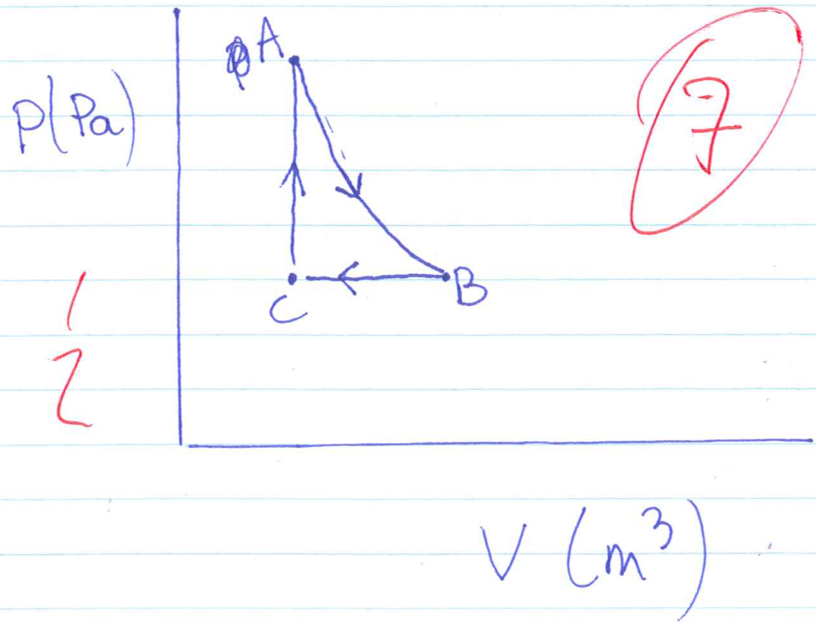
$$\Delta G = \Delta H - T\Delta S$$

$$\Delta G = 47058{,}76 - 373{,}15 \cdot (-35{,}49)$$

$\Delta G = 60301{,}85\ \rbrack > 0$ dus niet spontaan na temperatuurverhoging

3a

(schematisch)



7

1
2

b ΔU en ΔS zijn toestandsfuncties, dus geldt na één omloop $\Delta U = 0$ en $\Delta S = 0$

1
2

(C)

$A \rightarrow B$

$p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$

$\gamma = \frac{C_{p,m}}{C_{V,m}}$

$\gamma = \frac{\frac{5}{2}R}{\frac{3}{2}R} = \frac{5}{2} \cdot \frac{2}{3} = \frac{10}{6} = \frac{5}{3}$

adiabatisch Dus $\rightarrow$ $V_1 T_1^{c} = V_2 T_2^{c}$

$\hookrightarrow c = \frac{C_{p,m}}{R} = \frac{\frac{5}{2}R}{R} = \frac{5}{2}$

$1 \cdot T_A^{\frac{5}{2}} = 2 \cdot T_2^{\frac{5}{2}}$

$\hookrightarrow \left(\frac{T_A}{T_B}\right)^{\frac{5}{2}} = \frac{2}{1} \Rightarrow \frac{T_A}{T_B} = 2^{\frac{2}{5}}$

$= 1,32$

Gewone Gaswet $\frac{\cancel{p_B} \cdot V_B}{T_B} = \frac{\cancel{p_C} \cdot V_C}{T_C}$

$\frac{\cancel{0,379\,p_A} \cdot V_B}{T_A/1,32} = \frac{\cancel{p_2} V_a}{T_C} = \frac{V_B/2}{T_C}$

2

$\frac{V_B}{T_A/1,32} = \frac{V_B/2}{T_C} \Rightarrow \frac{1}{T_A/1,32} = \frac{\frac{1}{2}}{T_C}$

$\frac{1}{2}(T_A/1,32) = T_C$

$\frac{T_A}{T_C} = \frac{1}{(1/2)/1,32} = 2,64$

(d) $\gamma = \frac{C_{p,m}}{C_{v,m}}$

Adiabatisch proces A→B

$$p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$$

$$\hookrightarrow 1 \cdot 1 = 0{,}379 \cdot 2^{\gamma}$$

$$\frac{1}{0{,}379} = 2^{\gamma}$$

$$2{,}64 = 2^{\gamma}$$

$$\log_2 2{,}64 = \gamma$$

$$\frac{0{,}4216}{\log 2} = 1{,}4 = \gamma$$

2

$$\frac{C_{p,m}}{C_{v,m}} = 1{,}4$$

$$C_{p,m} - C_{v,m} = R$$

$$C_{p,m} = R + C_{v,m}$$

$$\frac{R + C_{v,m}}{C_{v,m}} = 1{,}4 \rightarrow 1{,}4\, C_{v,m} = R + C_{v,m}$$

$$0{,}4\, C_{v,m} = R$$

$$C_{v,m} = 20{,}786\ J/K/mol$$

$$= 20{,}789\ J/K/mol$$

$$1{,}4 \cdot 20{,}786 = $$

$$\underline{29{,}1 = C_p}$$

~~De getekende kringloop~~

Stap 1 $\Delta S_{tot} = 0$

dus $q = 0$ §

Stap 2 $\rightarrow q_2$

Stap 3 $\rightarrow q_3$

1/2

$q_2 + q_3 = 0$ (toestandsvergelijking)

$q_2 = -0{,}379\, p_1 (V_{A} - V_{B})$

$q_2 = -0{,}379\, p_1 (V_1 - \frac{V_1}{2})$

$\boxed{q_2 = +0{,}379\, p_1 V_1}$

$\boxed{q_3 = -0{,}379\, p_1 V_1}$

8

~~ΔU~~ Stap 4 $\rightarrow$ ~~ΔU~~

Stap 1 $\Delta U = W_{ad}$

$W_{ad} =$ [redacted]

$W_{ad} = \Delta U$

$W_{ad} = C_V \cdot \Delta T$

1

$W_{ad} = \frac{3}{2} R \left(\frac{T_A}{1{,}32} - T_a\right)$

$W_{ad} = \frac{3}{2} R(-0{,}24\, T_a)$

$W_{ad} = -0{,}36\, R\, T_a$

~~Wad~~ $T_a = \frac{p \cdot V}{R}$

$W_{ad} = -0{,}36\, p_1 V_1$

Stap 2

$$w = -p \cdot \Delta V$$

$$w = -0{,}379p\,(V_A - 2V_a)$$

$$w = 0{,}379\,p_1 V_a$$

Stap 3 $\quad w = 0$

geen volumevergroting

$$0{,}379\,p_1 V_1 - 0{,}36\,p_1 V_1 = 0{,}019\,p_1 V_1$$

$$w = 0{,}019\,p_1 V_1$$

~~waar~~

9

$$\varepsilon = \frac{|w|}{q_{opgenomen}} \qquad q_{opgenomen} = 0{,}379\,p_1 V_1$$

1

$$w = 0{,}019\,p_1 V_1 \qquad \frac{w}{q_{opgenomen}} = \frac{0{,}019}{0{,}379}$$

$$\varepsilon = 0{,}05 \ (\hat{=}\ 5\%)$$