Øving 8 - Erlend Sørlie

-1,7 kJ

1) Beregn arbeidet w som gjøres på 1 mol gass når:

1. $\Delta p = 1$ atm, $V_{konst} \Rightarrow \Delta V = 0$

$w = -p\Delta V = p \cdot 0 = 0$

$\underline{w = 0}$

2. $w = -p \cdot \Delta V = -101{,}325\,kPa \cdot 1\,dm^3 = -101{,}33\,J$

$\underline{w = -101{,}33\,J}$

3. isoterm utvidelse 25°C 1 - 2 dm^3, $\Delta T = 0$

$p = \frac{nRT}{V}$, $w = -p\Delta V = -\int_1^2 p\,dV = -\int_1^2 \frac{nRT}{V}\,dV = -nRT\int_1^2 \frac{1}{V}\,dV$

$= -nRT\left[\ln V\right]_1^2 = nRT(\ln 2 - \ln 1) = nRT \cdot \ln 2 = \underline{1{,}7\,kJ}$

2) Varme trengs for $\Delta T = 50°C$ 1 kg C_2H_6 ved:

a) $p = 2{,}00$ atm

$q_p = C_p \cdot \Delta T \cdot n$ $\qquad n = \frac{m}{M_n} = \frac{1000\,g}{30{,}07\,g/mol} = 33{,}24\,mol$

$q_p = C_p \cdot 50\,K \cdot 33{,}33\,mol$ $\qquad C_p = 53\,J/(K \cdot mol)$

$\underline{q_p = 88{,}09\,kJ}$

$\Delta U = n \cdot C_V \Delta T = (C_p - R)50\,K \cdot n$ $\qquad C_V \approx C_p - R$

$\underline{\Delta U = 74{,}76\,kJ}$

$\underline{\Delta H = q_p = 8809\,kJ}$

$\Delta U = q_p + W \Rightarrow W = \Delta U - q_p = -13{,}34\,kJ$

$\underline{W = -13{,}34\,kJ}$

$\underline{q_p = 88{,}09\,kJ,\ \Delta U = 74{,}76\,kJ,\ \Delta H = 88{,}09\,kJ,\ W = -13{,}34\,kJ}$

b) V er konstant

$q_V = C_V \cdot \Delta T \cdot n = (C_p - R)\Delta T \cdot n = 74{,}76\,kJ$

ΔU, lik forrige oppgave, ingen av faktorene er endret.

ΔH, uendret

$W = -p \cdot \Delta V$, $\Delta V = 0 \Rightarrow W = 0$

$\underline{q_V = 74{,}75\,kJ, \Delta U = 74{,}75\,kJ, \Delta H = 88{,}09\,kJ, W = 0}$

3) Varmetap i systemet er 0

$q_{før} = q_{etter}$

$q_{metall} + q_{vann} = q_m + q_v \Rightarrow \Delta q_m + \Delta q_v = 0 \Rightarrow \Delta q_m = -\Delta q_v$

før etter

$\Delta q_w = C_p \cdot \Delta T \cdot n$ $\quad n(H_2O) = \frac{75\,g}{18,02\,g/mol} = 4,164$

$= (75 \cdot 22 \cdot 4,164)$ $\quad C_p(H_2O) = 75\ (J/mol \cdot K)$

$= 686,9\ J$

$\Delta q_m = -\Delta q_v$

$= -686,9\ J$

$m \cdot C_p \cdot \Delta T = -(686,9\ J)$

$C_p = \frac{-686,9\,J}{\Delta T \cdot m} = \frac{-699\,J}{-75,65 \cdot 46,2\,g} = 0,2\ J/(°C \cdot g)$

$C_p(metall) = 0,2\ J/(°C \cdot g)$

4) Hess lov sier at summen av delreaksjoners entalpiendring er lik entalpiendring til rx. Dermed blir summen av smeltentalpien og fordampningsentalpien.

$\Delta H_{reak} = \sum \Delta H_{delreak} \Rightarrow \Delta H^\circ_{sub}(M) = \sum \Delta H^\circ_{delreak}(M)$

$\Rightarrow \Delta H^\circ_s(M) = \Delta H^\circ_{vap}(M) + \Delta H^\circ_m(M)$

$\Rightarrow \Delta H^\circ_{vap}(M) = \Delta H^\circ_s(M) - \Delta H^\circ_m(M)$

5) Fra 4): $\Delta H^\circ_{vap} = \Delta H^\circ_{sub} - \Delta H^\circ_m$

$= (50 - 6,0)\,kJ/mol = 44\ kJ/mol$

$P = 1000\ W = 1000\ J/s$, $V = 1\ L \approx 1000\ g\ H_2O$

$n_{H_2O} = \frac{1000\,g}{18\,g/mol} = 55,55...\ mol$

$q_p = n \cdot C_p \cdot \Delta T = (55,55 \cdot 75 \cdot 90)\,J = 375\,kJ$

$q_{vap} = \Delta H^\circ_{vap} \cdot n = 44\,kJ/mol \cdot 55,55\,mol = 2444,5\,kJ$

$q_{tot} = q_p + q_{vap} = 375\,kJ + 2444,5\,kJ = 2819,5\,kJ$

$t = \frac{q_{tot}}{P} = \frac{2819,5\,kJ}{1000\,J} = 2819,5\,s \approx 47\,min$

$t = 47\,min$

6 Beregn. ΔH for rx.

a) $S(s) + O_2(s) \rightarrow SO_2(g)$

I: $S(s) + \frac{3}{2} O_2(g) \rightarrow SO_3(g)$, $\Delta H = -395{,}2\ kJ$

II: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$, $\Delta H = -198{,}2\ kJ$ / dele på 2

$\Delta H_{tot} = I - \frac{II}{2} = -395{,}2\ k) + \frac{198{,}2\ kJ}{2} = -296{,}1\ k)$

$\underline{\Delta H_{tot} = -296{,}1\ kJ}$

b) $2NO_2(g) \rightarrow N_2O_4(g)$

I: $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$, $\Delta H = 67{,}7\ k)$ / snu

II: $N_2(g) + 2O_2(g) \rightarrow N_2O_4(g)$, $\Delta H = 9{,}7\ kJ)$

$\Delta H_{tot} = II + (-I) = 9{,}7k) - 67{,}7k) = -58\ k)$

$\underline{\Delta H_{tot} = 58\ k)}$

c) $H_2O(s) \rightarrow H_2O(l)$

I: $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(s)$, $\Delta H = -293\ k)$ / snu

II: $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(l)$, $\Delta H = -286\ k)$

$\Delta H_{tot} = -I + II = 293\ k) - 286\ k) = 7\ k)$

$\underline{\Delta H_{tot} = 7\ k)}$

d) $H_2O(l) \rightarrow H_2O(g)$

I: $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g)$, $\Delta H = -242\ kJ$

$\Delta H_{tot} = I + (-II) = (-242 + 286)\ k) = 44\ k)$

$\underline{\Delta H_{tot} = 44\ kJ}$

e) $H_2O(s) \rightarrow H_2O(g)$, dette er rx fra c) + d)

$\Rightarrow \Delta H_{tot} = \Delta H(c)) + \Delta H(d)) = (7 + 44)\ k) = 51\ k)$

$\underline{\Delta H_{tot} = 51\ k)}$

7) a) Oppgi standard tilstander ved 298K (= 25°C)
Oksygen: (g), NH_3: (g), jern: (s), karbon (s), CH_4: (g),
bor: (s), CO_2: (g), CH_3OH: (l), vann: (l)

b)
Alle rene stoffer/bindelser har
$\Delta H^\circ = 0$
De andre stoffene er dannet
gjennom eksoterme reaksjoner
ettersom $\Delta H^\circ < 0$

Stoff	ΔH° / kJ/mol
$O_2(g)$	0
$NH_3(g)$	-46
$Fe(s)$	0
$C(s)$	0
$CH_4(g)$	-74
$B(s)$	0
$CO_2(g)$	-394
$CH_3OH(g)$	-201
$H_2O(g)$	-286

8 $\Delta H^\circ_{rx} = \sum \Delta H^\circ_{prod} - \sum \Delta H^\circ_{reak}$

a) $CH_4(g) + 4F_2(g) \rightarrow CF_4(g) + 4HF(g)$ (4)

$CH_4(g) \rightarrow 2H_2(g) + C(s)$ $\Delta H = (0 + 74\ kJ/mol) = 74\ kJ/mol$ (5)

$2F_2(g) + 2H_2(g) \rightarrow 4HF(g)$ $\Delta H = 4 \cdot (-273\ k) - 0 = -1092\ kJ/mol$ (6)

$C(s) + 2F_2(g) \rightarrow CF_4(g)$, $\Delta H = (-933\ kJ/mol) - 0 = -933\ kJ/mol$ (7)

Alternativ vei: $\Delta H_{rx} = \Delta H(5) + \Delta H(6) + \Delta H(7)$

$= (74 - 1092 - 933)\ kJ/mol$

$\Delta H_{rx} = -1951\ kJ/mol$

direkte: $\sum \Delta H^\circ_{prod} = \Delta H^\circ_{CF_4} + 4\,\Delta H^\circ_{HF} = ((-933) + 4 \cdot (-273))\ kJ/mol$

$\sum \Delta H^\circ_{reak} = \Delta H^\circ(CH_4) + 4\Delta H^\circ(F_2) = (-74) + 4 \cdot 0)\ kJ/mol$

$\Delta H_{reak} = \Delta H^\circ_{prod} - \Delta H^\circ_{reak} = -1951\ kJ/mol$, metodene gir samme svar

$\Delta H_{reak} < 0 \Rightarrow$ eksoterm

8 b) $4FeO(s) \rightarrow Fe(s) + Fe_3O_4(s)$ (8)

$4FeO(s) \rightarrow 2O_2(g) + 4Fe(s)$, $\Delta H = (0 - 4(-272))\,kJ/mol = 1088\,kJ/mol$ (9)

$2O_2(g) + 3Fe(s) \rightarrow Fe_3O_4(s)$, $\Delta H = (-1118 - 0)\,kJ/mol = -1118\,kJ/mol$ (10)

Alternativ: $\Delta H_{rx} = \Delta H_9 + \Delta H_{10} = (1088 - 1118)\,kJ/mol$

$\underline{\Delta H_{rx} = -30\,kJ/mol}$

Direkte: $\Sigma \Delta H°(prod) = (0 + (-1118))\,kJ/mol = -1118\,kJ/mol$

$\Sigma \Delta H°(reak) = 4 \cdot (-272)\,kJ/mol = -1088\,kJ/mol$

$\Delta H_{rx} = -1118\,kJ/mol - (-1088\,kJ/mol) = -30\,kJ/mol$

$\underline{\Delta H_{rx} = -30\,kJ/mol$, metodene gir samme svar, $\Delta H < 0 \Rightarrow$ eksoterm}

9) Regn ut $\Delta H°$ ved 298K (= 25°C)

a) $2NH_3(g) + 3O_2(g) + 2CH_4(g) \rightarrow 2HCN(g) + 6H_2O(g)$

$\Sigma \Delta H°_{prod} = (2 \cdot 135 + 6 \cdot (-242))\,kJ/mol = -1182\,kJ/mol$

$\Sigma \Delta H°_{reak} = (2 \cdot (-46) + 3 \cdot 0 + 2 \cdot (-74))\,kJ/mol = -240\,kJ/mol$

$\Delta H = -1182\,kJ/mol - (-240\,kJ/mol) = -942\,kJ/mol$

$\underline{\Delta H = -942\,kJ/mol}$

b) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

$\Sigma \Delta H°_{prod} = -314\,kJ/mol$

$\Sigma \Delta H°_{reak} = ((-46) + (-92))\,kJ/mol = -138\,kJ/mol$

$\underline{\Delta H = -176\,kJ/mol}$

c) $C_3H_8(g) + H_2(g) \rightarrow C_2H_6(g) + CH_4(g)$

$\Sigma \Delta H°_{prod} = ((-84) + (-74))\,kJ/mol$

$\Sigma \Delta H°_{reak} = ((-105) + 0)\,kJ/mol$

$\underline{\Delta H = -53\,kJ/mol}$