

Øving 8 - Erlend Sørhe

-1,7 kJ

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

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

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

$$\underline{w = 0}$$

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

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

3. isoterm utvidelse 25°C $1 \rightarrow 2 \text{ dm}^3$, $\Delta T = 0$

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

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

2) Varmer trengs for $\Delta T = 50^\circ\text{C}$ 1 kg C_2H_6 ved:

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

$$q_r = C_p \cdot \Delta T \cdot n$$

$$n = \frac{m}{M_n} = \frac{1000 \text{ g}}{30,07 \text{ g/mol}} = 33,24 \text{ mol}$$

$$q_r = C_p \cdot 50 \text{ K} \cdot 33,24 \text{ mol}$$

$$C_p = 53 \text{ J/(K} \cdot \text{mol)}$$

$$q_r = 88,09 \text{ kJ}$$

$$\Delta U = n \cdot C_v \Delta T = (C_p - R) 50 \text{ K} \cdot n \quad C_v \approx C_p - R$$

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

$$\Delta H = q_r = 88,09 \text{ kJ}$$

$$\Delta U = q_r + w \Rightarrow w = \Delta U - q_r = -13,34 \text{ kJ}$$

$$\underline{w = -13,34 \text{ kJ}}$$

$$\underline{q_r = 88,09 \text{ kJ}, \Delta U = 74,76 \text{ kJ}, \Delta H = 88,09 \text{ kJ}, w = -13,34 \text{ kJ}}$$

b) V er konstant

$$q_v = C_v \cdot \Delta T \cdot n = (C_p - R) \Delta T \cdot n = 74,76 \text{ kJ}$$

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

ΔH , uendret

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

$$\underline{q_v = 74,76 \text{ kJ}, \Delta U = 74,76 \text{ kJ}, \Delta H = 88,09 \text{ kJ}, w = 0}$$

3) Varmetap i systemet er 0

$$q_{\text{for}} = q_{\text{eller}}$$

$$\underbrace{q_{\text{metall}} + q_{\text{vann}}}_{\text{for}} = \underbrace{q_m + q_v}_{\text{eller}} \Rightarrow \Delta q_m + \Delta q_v = 0 \Rightarrow \Delta q_m = -\Delta q_v$$

$$\begin{aligned} \Delta q_m &= C_p \cdot \Delta T \cdot n \\ &= (75 \cdot 22 \cdot 4,164) \\ &= 686,9 \text{ J} \end{aligned}$$

$$\begin{aligned} n(\text{H}_2\text{O}) &= \frac{75 \text{ g}}{18,015 \text{ g/mol}} = 4,164 \\ C_p(\text{H}_2\text{O}) &= 75 \text{ J/mol}\cdot\text{K} \end{aligned}$$

$$\begin{aligned} \Delta q_m &= -\Delta q_v \\ &= -686,9 \text{ J} \end{aligned}$$

$$m \cdot C_p \cdot \Delta T = -686,9 \text{ J}$$

$$C_p = \frac{-686,9 \text{ J}}{\Delta T \cdot m} = \frac{-686,9 \text{ J}}{75,62 \cdot 46,2 \text{ g}} = 0,2 \text{ J/}^\circ\text{C}\cdot\text{g}$$

$$\underline{C_p(\text{metall}) = 0,2 \text{ J/}^\circ\text{C}\cdot\text{g}}$$

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

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

$$\Rightarrow \Delta H_s^\circ(M) = \Delta H_{\text{vap}}^\circ(M) + \Delta H_m^\circ(M)$$

$$\Rightarrow \underline{\Delta H_{\text{vap}}^\circ(M) = \Delta H_s^\circ(M) - \Delta H_m^\circ(M)}$$

$$\begin{aligned} 5) \text{ Fra 4): } \Delta H_{\text{vap}}^\circ &= \Delta H_{\text{sub}}^\circ - \Delta H_m^\circ \\ &= (50 - 6,0) \text{ kJ/mol} = 44 \text{ kJ/mol} \end{aligned}$$

$$P = 1000 \text{ W} = 1000 \text{ J/s}, V = 1 \text{ L} \approx 1000 \text{ g H}_2\text{O}$$

$$n_{\text{H}_2\text{O}} = \frac{1000 \text{ g}}{18,015 \text{ g/mol}} = 55,55 \text{ mol}$$

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

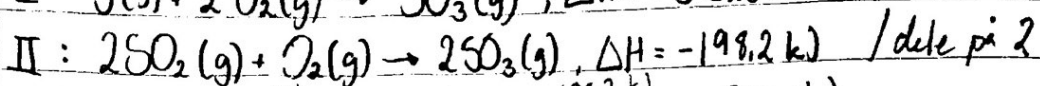
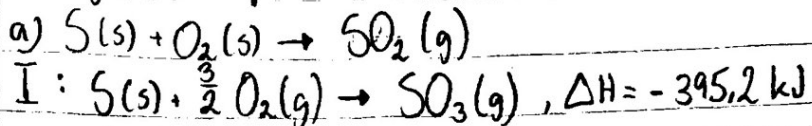
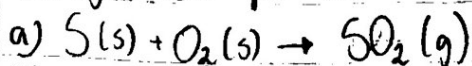
$$q_{\text{vap}} = \Delta H_{\text{vap}}^\circ \cdot n = 44 \text{ kJ/mol} \cdot 55,55 \text{ mol} = 2444,5 \text{ kJ}$$

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

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

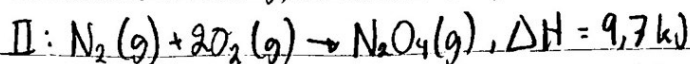
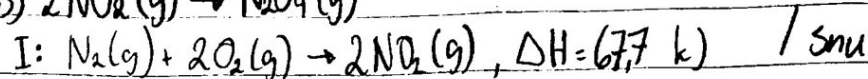
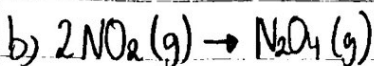
$$\underline{t = 47 \text{ min}}$$

6 Beregni ΔH for rx.



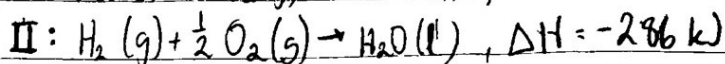
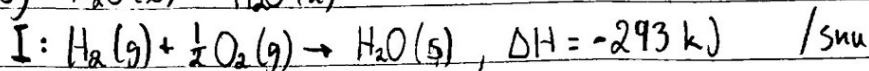
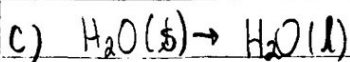
$$\Delta H_{\text{tot}} = I - \frac{II}{2} = -395,2 \text{ kJ} + \frac{198,2 \text{ kJ}}{2} = -296,1 \text{ kJ}$$

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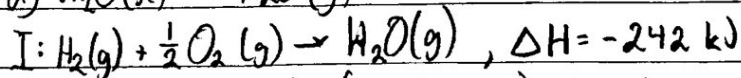
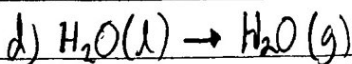
$$\Delta H_{\text{tot}} = II + (-I) = 9,7 \text{ kJ} - 67,7 \text{ kJ} = -58 \text{ kJ}$$

$$\Delta H_{\text{tot}} = 58 \text{ kJ}$$



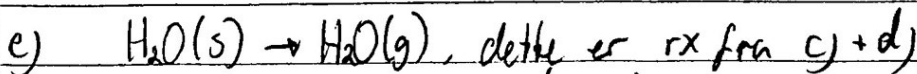
$$\Delta H_{\text{tot}} = -I + II = 293 \text{ kJ} - 286 \text{ kJ} = 7 \text{ kJ}$$

$$\Delta H_{\text{tot}} = 7 \text{ kJ}$$



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

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



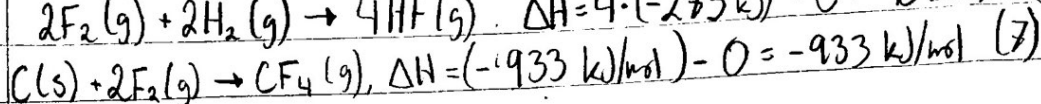
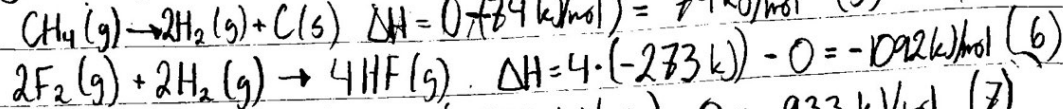
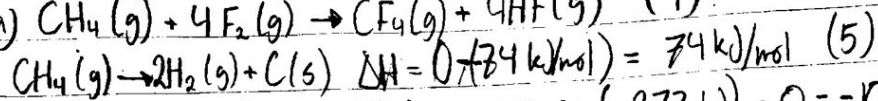
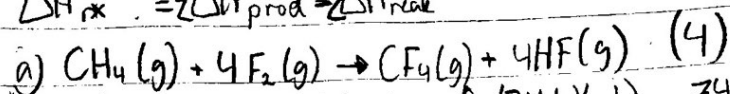
$$\Rightarrow \Delta H_{\text{tot}} = \Delta H(c) + \Delta H(d) = (7 + 44) \text{ kJ} = 51 \text{ kJ}$$

$$\Delta H_{\text{tot}} = 51 \text{ kJ}$$

- 7) a) Oppgi standardtilstander ved 298 K (= 25°C)
 Oksygen: (g), NH₃: (g), jern: (s), karbon (s), CH₄: (g),
 bor: (s), CO₂: (g), CH₃OH: (l), vann: (l)

b)	stoff	ΔH° / kJ/mol
Alle rene stoffforbindelser her	O ₂ (g)	0
$\Delta H^\circ = 0$	NH ₃ (g)	-46
De andre stoffene er dannet	Fe (s)	0
gjennom eksoterme reaksjoner	C (s)	0
etter som $\Delta H^\circ < 0$	CH ₄ (g)	-74
	B (s)	0
	CO ₂ (g)	-394
	CH ₃ OH (g)	-201
	H ₂ O (g)	-286

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



Alternativ vei: $\Delta H_{rx} = \Delta H(5) + \Delta H(6) + \Delta H(7)$
 $= (74 - 1092 - 933) \text{ kJ/mol}$

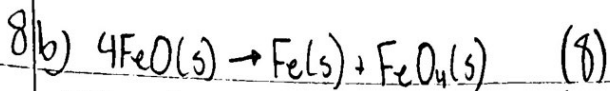
$\Delta H_{rx} = -1951 \text{ kJ/mol}$

direkte: $\sum \Delta H^\circ_{prod} = \Delta H^\circ_{\text{CF}_4} + 4 \Delta H^\circ_{\text{HF}} = ((-933) + 4 \cdot (-273)) \text{ kJ/mol}$

$\sum \Delta H^\circ_{reak} = \Delta H^\circ(\text{CH}_4) + 4 \Delta H^\circ(\text{F}_2) = (-74) + 4 \cdot 0 \text{ kJ/mol}$

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

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



$$4\text{FeO}(s) \rightarrow 2\text{O}_2(g) + 4\text{Fe}(s), \Delta H = (0 - 4(-272)) \text{ kJ/mol} = 1088 \text{ kJ/mol} \quad (9)$$

$$2\text{O}_2(g) + 3\text{Fe}(s) \rightarrow \text{Fe}_3\text{O}_4(s), \Delta H = (-1118) - 0 \text{ kJ/mol} = -1118 \text{ kJ/mol} \quad (10)$$

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

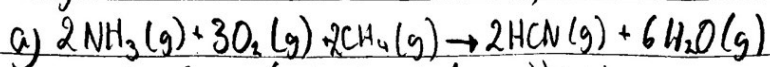
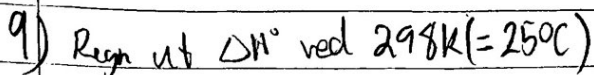
$$\Delta H_{\text{rx}} = -30 \text{ kJ/mol}$$

Direkte: $\sum \Delta H^\circ(\text{prod}) = (0 + (-1118) \text{ kJ/mol}) = -1118 \text{ kJ/mol}$

$$\sum \Delta H^\circ(\text{reak}) = 4 \cdot (-272) \text{ kJ/mol} = -1088 \text{ kJ/mol}$$

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

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

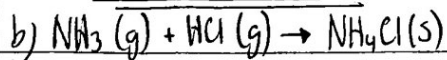


$$\sum \Delta H^\circ_{\text{prod}} = (2 \cdot 135 + 6 \cdot (-242)) \text{ kJ/mol} = -1182 \text{ kJ/mol}$$

$$\sum \Delta H^\circ_{\text{reak}} = (2 \cdot (-46) + 3 \cdot 0 + 2 \cdot (-74)) \text{ kJ/mol} = -290 \text{ kJ/mol}$$

$$\Delta H = -1182 \text{ kJ/mol} - (-290 \text{ kJ/mol}) = -942 \text{ kJ/mol}$$

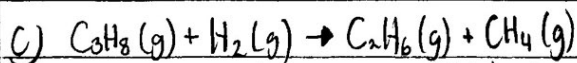
$$\Delta H = -942 \text{ kJ/mol}$$



$$\sum \Delta H^\circ_{\text{prod}} = -314 \text{ kJ/mol}$$

$$\sum \Delta H^\circ_{\text{reak}} = ((-46) + (-92)) \text{ kJ/mol} = -138 \text{ kJ/mol}$$

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



$$\sum \Delta H^\circ_{\text{prod}} = ((-84) + (-74)) \text{ kJ/mol}$$

$$\sum \Delta H^\circ_{\text{reak}} = ((-105) + 0) \text{ kJ/mol}$$

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