8.307 $V = l \cdot b \cdot h = 4{,}0m \cdot 2{,}5m \cdot 2{,}7m = 27m^3$

$\rho = 1{,}29 \frac{kg}{m^3}$ $\quad m = \rho V = 1{,}29 \frac{kg}{m^3} \cdot 27m^3 = \underline{34{,}83\,kg}$

$pV = NkT$

$N = \frac{pV}{kT} = \frac{1{,}01 \cdot 10^5 Pa \cdot 27m^3}{1{,}38 \cdot 10^{-23} \frac{J}{K} \cdot (273+22)K} = \underline{6{,}7 \cdot 10^{26}}$

$T_2 = T_1 + 5K = 300K$

$N_2 = \frac{pV}{kT_2} = \frac{N_1 k T_1}{k T_2} = \frac{N_1 T_1}{T_2} \Rightarrow \frac{N_2}{N_1} = \frac{T_1}{T_2} = \frac{295K}{300K}$

$\frac{N_2}{N_1} = 0{,}983$

Dvs. Tap $= (1 - 0{,}983) \cdot 100\% = 1{,}67\%$

$\Delta N = N \cdot 0{,}0167 = 6{,}7 \cdot 10^{26} \cdot 0{,}0167 = \underline{1{,}1 \cdot 10^{25}}$

$\Delta m = m \cdot 0{,}0167 = 34{,}83\,kg \cdot 0{,}0167 = \underline{0{,}58\,kg}$

8.310 Partialtrykket er trykket fra én gass i en gassblanding.

O_2: $V_A = 20dm^3$ $\quad p_A = 30 \cdot 10^3 Pa$

N_2: $V_B = 30dm^3$ $\quad p_B = 60 \cdot 10^3 Pa$ $\qquad T = 293K$

$V_3 = 30dm^3$ $\quad p_3 = ?$

$\frac{p_A V_A}{T} = \frac{p_{A3} \cdot V_3}{T}$

$p_A V_A = p_{A3} V_3$

$p_{A3} = p_A \cdot \frac{V_A}{V_3}$

$p_3 = p_{A3} + p_{B3} =$

$= p_A \frac{V_A}{V_3} + p_B$

$= 30 \cdot 10^3 Pa \cdot \frac{20 \cancel{dm^3}}{30 \cancel{dm^3}} + 60 \cdot 10^3 Pa$

$= \underline{80\,kPa}$

8.311 2,00 mol H_2 1,00 mol O_2 $V = 50,0\,dm^3$

$T = 30°C$

a) $pV = nRT$

H_2: $p_{H_2O} = \frac{nRT}{V} = \frac{2,00\,mol \cdot 8,31\,\frac{J}{Kg\,mol} \cdot 303K}{50,0 \cdot 10^{-3}\,m^3} = \underline{1,01 \cdot 10^5\,Pa}$ (1,00717 Pa)

O_2: $p_{O_2} = \frac{1}{2} \cdot 1,00717\,Pa = \underline{0,504 \cdot 10^5\,Pa}$

b) $p = p_{H_2} + p_{O_2} = (1,00711 + 0,504) \cdot 10^5\,Pa = \underline{1,51 \cdot 10^5\,Pa}$

c) $m_{H_2} = n \cdot m_{molar} = 2,00\,mol \cdot (1,008 \cdot 2)\,\frac{g}{mol} = 4,03\,g$

$m_{O_2} = 1,00\,mol \cdot 2 \cdot 16,00\,\frac{g}{mol} = 32,00\,g$

$m_{tot} = m_{H_2O} + m_{O_2} = 4,03\,g + 32,00\,g = \underline{36,0\,g}$

d) $\underline{2,00\,mol}$ (ett H_2-molekyl til hvert H_2O-molekyl)
(1,00 mol O_2 gir 2,00 mol O-atomer)

e) $\underline{36,0\,g}$ som før.

8.313 $p = 101,3 \cdot 10^3\,Pa$ $T = 273K$ $V = 1,00\,m^3$

$pV = nRT$

$n = \frac{p}{RT} = \frac{101,3 \cdot 10^3\,Pa \cdot 1,00\,m^3}{8,31\,\frac{J}{Kg\,mol} \cdot 273K} = 44,652\,mol$ per m^3

$m = n \cdot m_{molar}$

a) $m = 44,652\,mol \cdot (12,01 + 2 \cdot 16,00)\,\frac{g}{mol} = 1965\,g$ (CO_2)

dvs. $\underline{\rho = 1,97\,\frac{kg}{m^3}}$

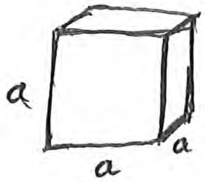
b), c) tilsvarende

8.314 N_2, O_2, H_2O H_2O har lavest molekylmasse. Dermed vil luft der noen av N_2 og O_2-molekylene er erstattet med H_2O-molekyler ha lavere tetthet.

N_2 : $2 \cdot 14,01\,u = 28,02\,u$ O_2 : $2 \cdot 16,00\,u = 32,00\,u$

H_2O : $(2 \cdot 1,008 + 16,00)\,u = 18,016\,u$ (er den minste)

8.315



$V = a^3 = (0{,}100\,m)^3 = 1{,}00 \cdot 10^{-3}\,m^3$

$m_{molar} = 28{,}9\,\frac{g}{mol}$ $\quad p = 101{,}3\,kPa$

$T = 300\,K$

a) $pV = nRT$

$$n = \frac{pV}{RT} = \frac{101{,}3 \cdot 10^3\,Pa \cdot 1{,}00 \cdot 10^{-3}\,m^3}{8{,}31\,\frac{J}{K\,mol} \cdot 300\,K} = 0{,}040633\,mol$$

$$m = n \cdot m_{molar} = 0{,}040633\,mol \cdot 28{,}9\,\frac{g}{mol} = \underline{1{,}17\,g}$$

b) $G = mg = 1{,}17 \cdot 10^{-3}\,kg \cdot 9{,}81\,\frac{N}{kg} = \underline{11{,}5 \cdot 10^{-3}\,N}$

c) $F = pA = pa^2 = 101{,}3 \cdot 10^3\,\frac{N}{m^2} \cdot (0{,}100\,m)^2 = 1013\,N = \underline{1{,}01\,kN}$

d) Molekylene har stor fart og dermed stor total kinetisk energi ved kollisjon med veggen.

$$\left(\begin{aligned} E_K &= \tfrac{3}{2}kT \\ \tfrac{1}{2}mv^2 &= \tfrac{3}{2}kT \\ v^2 &= \frac{3kT}{m} \\ v &= \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3 \cdot 1{,}38 \cdot 10^{-23}\,\frac{J}{K} \cdot 300\,K}{28{,}9 \cdot 1{,}66 \cdot 10^{-27}\,kg}} = 507\,\frac{m}{s} \end{aligned} \right)$$

8.316 Vis at $\rho = \frac{Mp}{RT}$ $\quad$ M er molar masse til gassmolekylene

$\rho = \frac{m}{V}$ og $pV = nRT$

$\Downarrow$

$V = \frac{nRT}{p}$

Dette gir $\rho = \frac{m}{\frac{nRT}{p}} = \frac{mp}{nRT}$

men $M = \frac{m}{n}$ (gassens masse delt på antall mol den består av)

Dette gir dermed

$$\underline{\rho = \frac{Mp}{RT}}$$

8.317 $m = 100g$ He $T = 293K$ $p = 101{,}3 kPa$

$V = ?$

$pV = nRT$ og $n = \frac{m}{m_{mol}} = \frac{100g}{4{,}003 g/mol}$

$V = \frac{nRT}{p}$ $= 24{,}981 \, mol$

$$V = \frac{24{,}981 mol \cdot 8{,}31 \frac{J}{K \cdot mol} \cdot 293K}{101{,}3 \cdot 10^3 \frac{N}{m^2}} = \underline{0{,}600 m^3}$$

8.318 $pV^\gamma = p_0 V_0^\gamma$ vis at dette kan gi $\frac{T^\gamma}{p^{\gamma-1}} = \frac{T_0^\gamma}{p_0^{\gamma-1}}$

ved hjelp av tilstandslikninga

$pV = nRT$.

Vi får: $V = \frac{nRT}{p}$

Dette gir: $$p \cdot \left(\frac{nRT}{p}\right)^\gamma = p_0 \left(\frac{nRT_0}{p_0}\right)^\gamma$$

Vi deler på
$(nR)^\gamma$ på begge sider og får:

$$p \cdot \left(\frac{T}{p}\right)^\gamma = p_0 \cdot \left(\frac{T_0}{p_0}\right)^\gamma$$

$$\frac{p \cdot T^\gamma}{p^\gamma} = \frac{p_0 T_0^\gamma}{p_0^\gamma}$$

$$\underline{\frac{T^\gamma}{p^{\gamma-1}} = \frac{T_0^\gamma}{p_0^{\gamma-1}}}$$

8.319 Toatomig gass $T_1 = 290K$ $p_1 = 100 \cdot 10^3 Pa$

dvs. $\gamma = 1,40$ $V_1 = 1,000 m^3$

adiabatisk kompresjon til $V_2 = \frac{1}{2} \cdot V_1$

a) $pV = nRT$

$$n = \frac{pV}{RT} = \frac{100 \cdot 10^3 \frac{N}{m^2} \cdot 1,000 m^3}{8,31 \frac{J}{K \cdot mol} \cdot 290K} = 41,495 mol = \underline{41,5 mol}$$

b) $p_1 V_1^\gamma = p_2 V_2^\gamma$

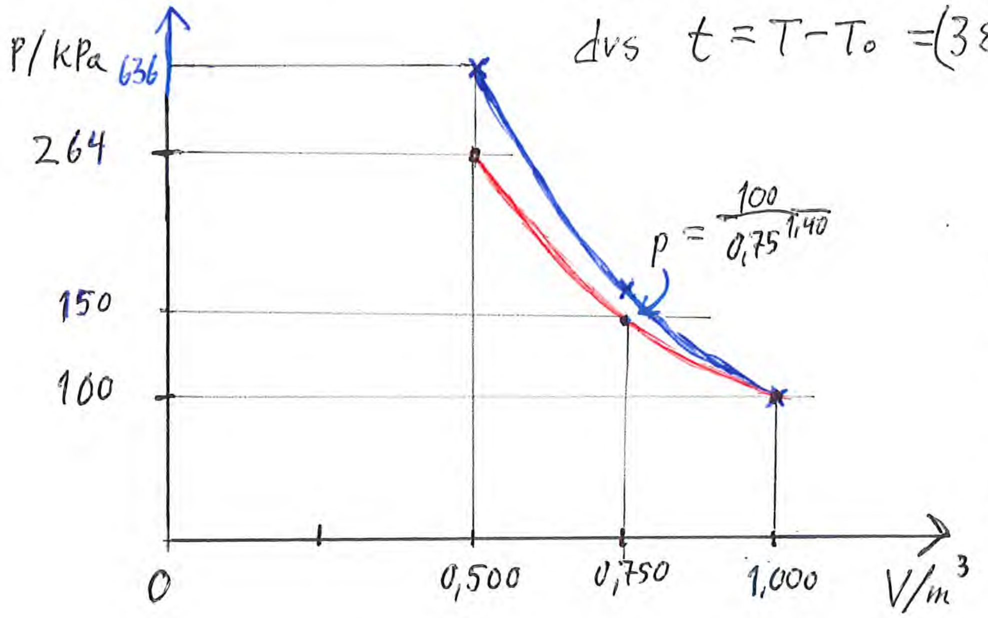
$$p_2 = p_1 \cdot \left(\frac{V_1}{V_2}\right)^\gamma = 100 \cdot 10^3 Pa \cdot \left(\frac{V_1}{\frac{1}{2}V_1}\right)^{1,40} = 100 kPa \cdot 2^{1,40}$$
$$= \underline{264 kPa}$$

$pV = nRT$

$$\frac{pV}{nR} = T \text{ gir } T = \frac{264 \cdot 10^3 \frac{N}{m^2} \cdot \frac{1}{2} \cdot 1,000 m^3}{41,495 mol \cdot 8,31 \frac{J}{K \cdot mol}} = 382,8K$$

dvs $t = T - T_0 = (383 - 273)°C$
$= \underline{110°C}$

c)



$pV^\gamma = p_0 V_0^\gamma$

$p = \frac{Konst}{V^\gamma}$

$p = \frac{Konst}{V^{1,40}}$

d) $T = 290K$ $p = 100 \cdot 10^3 Pa$ $V = 1,000 m^3$ og adiabatisk kompresjon

$n = \frac{pV}{RT} = \underline{41,5 mol}$ som i a)

e) $p_2 = p_1 \cdot \left(\frac{V_1}{\frac{1}{2}V_1}\right)^\gamma = 100 kPa \cdot 2^{1,67} = \underline{318 kPa}$

$$T_2 = \frac{pV}{nR} = \frac{318 \cdot 10^3 \cdot \frac{1}{2} \cdot 1,000}{41,495 \cdot 8,31} K = \underline{461 K} \quad (188°C)$$

8.320 $n = 1{,}00\,\text{mol}$ $\gamma = 1{,}67$ $T = 273\,\text{K}$ $p = 101{,}3\,\text{kPa}$

a) $pV = nRT$

$$V = \frac{nRT}{p} = \frac{1{,}00\,\text{mol}\cdot 8{,}31\frac{\text{J}}{\text{K}\cdot\text{mol}}\cdot 273\,\text{K}}{101{,}3\cdot 10^3\frac{\text{N}}{\text{m}^2}} = 0{,}022395\,\text{m}^3$$
$$= \underline{22{,}4\,\text{dm}^3}$$

b) $V_2 = 2\cdot V_1$ Finn ny p og T

1. isobar prosess $\frac{p_2V_2}{T_2} = \frac{p_1V_1}{T_1}$ og $p_2 = p_1 = \underline{101{,}3\,\text{kPa}}$

$$\frac{2V_1}{T_2} = \frac{V_1}{T_1} \Rightarrow \frac{T_2}{2} = \frac{T_1}{1} \Rightarrow T_2 = 2\cdot T_1 = \underline{546\,\text{K}}$$

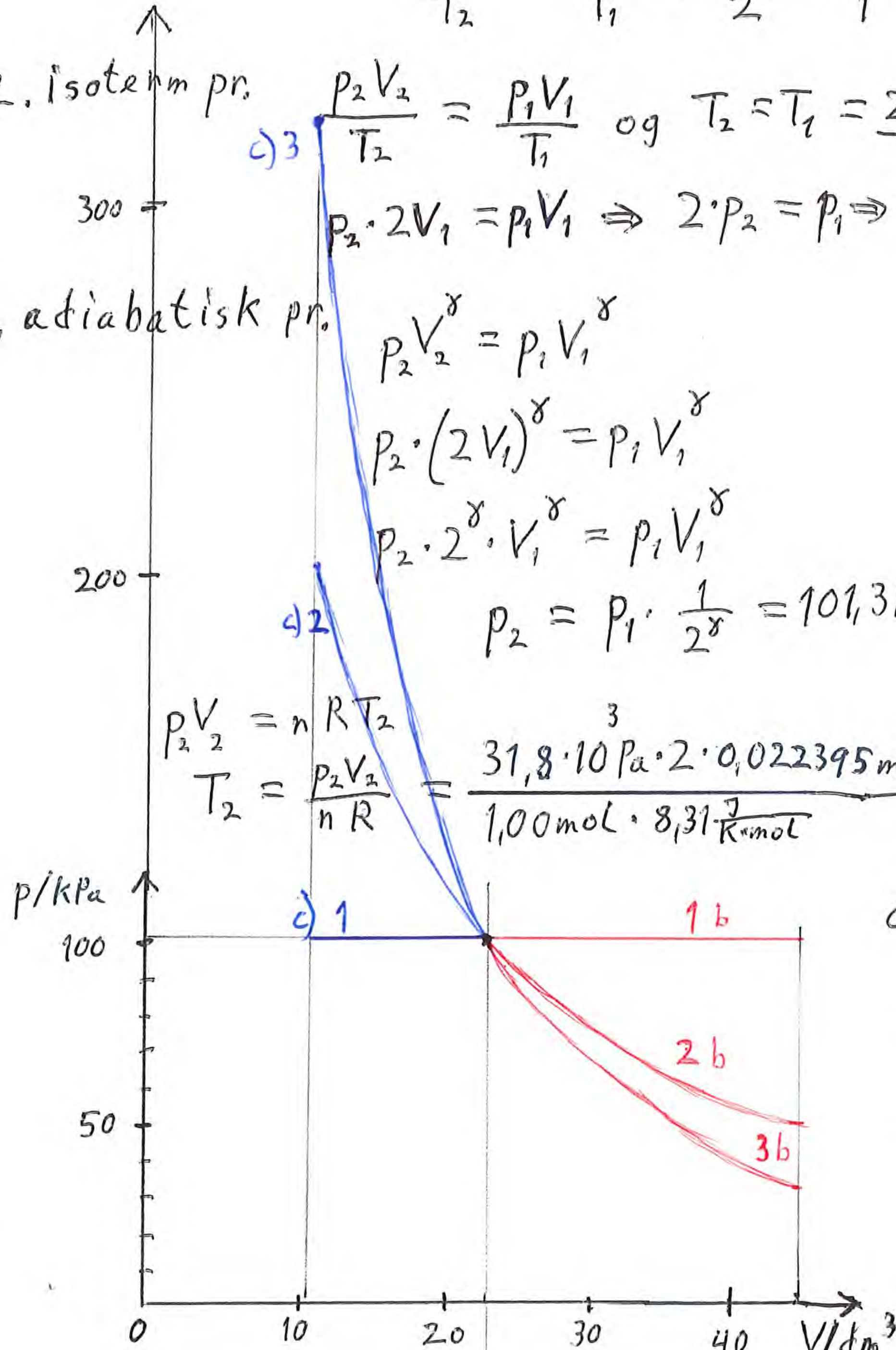
2. isoterm pr. $\frac{p_2V_2}{T_2} = \frac{p_1V_1}{T_1}$ og $T_2 = T_1 = \underline{273\,\text{K}}$

$$p_2\cdot 2V_1 = p_1V_1 \Rightarrow 2\cdot p_2 = p_1 \Rightarrow p_2 = \tfrac{1}{2}p_1 = \underline{50{,}7\,\text{kPa}}$$

3. adiabatisk pr.

$$p_2V_2^{\gamma} = p_1V_1^{\gamma}$$
$$p_2\cdot(2V_1)^{\gamma} = p_1V_1^{\gamma}$$
$$p_2\cdot 2^{\gamma}\cdot V_1^{\gamma} = p_1V_1^{\gamma}$$
$$p_2 = p_1\cdot\frac{1}{2^{\gamma}} = 101{,}3\,\text{kPa}\cdot\frac{1}{2^{1{,}67}} = \underline{31{,}8\,\text{kPa}}$$

$$p_2V_2 = nRT_2$$
$$T_2 = \frac{p_2V_2}{nR} = \frac{31{,}8\cdot 10^3\,\text{Pa}\cdot 2\cdot 0{,}022395\,\text{m}^3}{1{,}00\,\text{mol}\cdot 8{,}31\frac{\text{J}}{\text{K}\cdot\text{mol}}} = \underline{172\,\text{K}}$$



d) 1. $p_2 = 101{,}3\,\text{kPa}$
$T_2 = \tfrac{1}{2}T_1 = 137\,\text{K}$

2. $T_2 = 273\,\text{K}$
$p_2 = 2p_1 = 202{,}6\,\text{kPa}$

3. $p_2 = p_1\cdot 2^{1{,}67} = 322\,\text{kPa}$
$T_2 = 434\,\text{K}$
$\left(T_2 = \frac{p_2\cdot 0{,}5V_1}{nR}\right)$

8.321 $W = \int_{V_1}^{V_2} p\,dV$

a) $W_{isokor} = \int_{V_1}^{V_2} p\,dV = \int_{V_1}^{V_1} p\,dV = \underline{0}$ null bevegelse $V_2 = V_1 \Rightarrow$ null arbeid

b) $W_{isobar} = \int_{V_1}^{V_2} p\,dV = p\int_{V_1}^{V_2} dV = p\left[V\right]_{V_1}^{V_2} = p(V_2 - V_1)$

c) $W_{isoterm} = \int_{V_1}^{V_2} p\,dV$ og $pV = nRT$ gir $p = \frac{nRT}{V}$ og

$$\int_{V_1}^{V_2} \frac{nRT}{V}\,dV = nRT\int_{V_1}^{V_2} \frac{dV}{V} = nRT\left[\ln V\right]_{V_1}^{V_2}$$

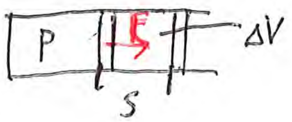
$$= nRT(\ln V_2 - \ln V_1)$$

$$= \underline{nRT \ln \frac{V_2}{V_1}}$$

8.322

a) $W = F\cdot s$ og $p = \frac{F}{A}$ gir $F = pA$

Arbeid = Kraft vinkelrett på overflaten av ~~et legeme~~ ganger hvor langt legemet flytter seg i den retningen.



For en innestengt gassmengde bak et stempel som kan gli friksjonsfritt blir arbeidet som gassen utfører på omgivelsene lik arbeidet som gassen utfører på stempelet ettersom stempelet dytter vekk lufta utenfor stempelet (dvs. omgivelsene).

Dette gir $W = F\cdot s = pAs = p\Delta V$ der ΔV er endringen i volumet til den innestengte gassmengden.

$\Delta V = A\cdot s$

der A = arealet av stempelet

Hvis trykket endrer seg ubetydelig under volumendringen dV får vi $W = p\Delta V$

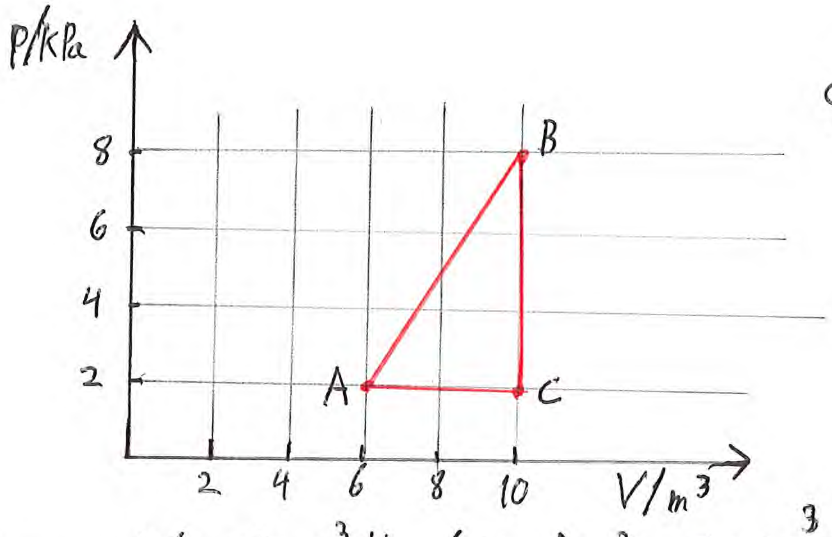
og hvis p endrer seg mer kan vi dele legge sammen arealet av mange smale søyler slik at $W = p_1\Delta V + p_2\Delta V + p_3\Delta V + \cdots$.

Dette gir det totale arealet under grafen når søylene er smale nok.

Hvis ΔV er negativt betyr det at omgivelsene gjør et arbeid på stempelet. Arbeidet den innestengte gassen da gjør blir negativt.

b) Hvis volumet av den innestengte gassmengden avtar, er arbeidet som gassen utfører negativt.

c)



c) $W_{AB} = \frac{1}{2}(2+8)\cdot$

c) $W_{AB} = \frac{1}{2}(2+8)\cdot 10^3 \frac{N}{m^2}\cdot(10-6)\,m^3 = 20\cdot 10^3\,J = \underline{20\,kJ}$

$W_{BC} = \underline{0}$ (V uendret)

$W_{CA} = 2\cdot 10^3 \frac{N}{m^2}\cdot(6-10)\,m^3 = -8\cdot 10^3\,J = \underline{-8\,kJ}$

d) $W_{AB} + W_{BC} + W_{CA} = 20\,kJ + 0\,kJ - 8\,kJ = \underline{12\,kJ}$

$W_{areal} = \frac{1}{2}\cdot(8-2)\cdot 10^3 \frac{N}{m^2}\cdot(10-6)\,m^3 = \underline{12\,kJ}$

8.323 $n = 1{,}00\,mol$ $\gamma = 1{,}67$ $T_1 = 273$ $p_1 = 101{,}3\,kPa$

a) Se 8.320. $V_1 = 0{,}022395\,m^3$ og $V_2 = 2V_1$

1. isobar prosess $W = p(V_2 - V_1) = 101{,}3\cdot 10^3 \frac{N}{m^2}\cdot(0{,}022395\,m^3)$

$= \underline{2{,}27\,kJ}$

2. isoterm pr. $W = nRT\ln\left(\frac{V_2}{V_1}\right) = 1{,}00\,mol\cdot 8{,}31\frac{J}{K\cdot mol}\cdot 273\,K\cdot\ln 2$

$= \underline{1{,}57\,kJ}$

3. adiabatisk pr. $W = \int_{V_1}^{V_2} p\,dV$ og $pV^\gamma = p_1V_1^\gamma$

$\Downarrow$

$p = \frac{p_1V_1^\gamma}{V^\gamma}$

Dette gir $W = \int_{V_1}^{V_2} \frac{p_1V_1^\gamma}{V^\gamma}\,dV$ og ut fra $p_1V_1 = nRT_1$ får vi

$p_1 = \frac{nRT_1}{V_1}$

som igjen gir $W = \int_{V_1}^{V_2} \left(\frac{nRT_1}{V_1}\right) \cdot \frac{V_1^{\gamma}}{V^{\gamma}} \, dV$

$$= nRT_1 \int_{V_1}^{V_2} \frac{V_1^{\gamma-1}}{V^{\gamma}} \, dV = nRT_1 \cdot V_1^{\gamma-1} \int_{V_1}^{V_2} V^{-\gamma} dV$$

$$= nRT_1 V_1^{\gamma-1} \frac{1}{1-\gamma} \left[V^{1-\gamma} \right]_{V_1}^{V_2} = nRT_1 V_1^{\gamma-1} \cdot \frac{1}{(1-\gamma)} \left(V_2^{1-\gamma} - V_1^{1-\gamma} \right)$$

$$= \frac{nRT_1}{1-\gamma} \left(V_1^{\gamma-1} \cdot V_2^{-(\gamma-1)} - V_1^{1-\gamma} \cdot V_1^{\gamma-1} \right)$$

$$= \frac{nRT_1}{-(\gamma-1)} \left(\frac{V_1^{\gamma-1}}{V_2^{\gamma-1}} - V_1^{0} \right) = \frac{nRT_1}{\gamma-1} \left(-\left(\frac{V_1}{V_2}\right)^{\gamma-1} - (-1) \right)$$

$$= \frac{nRT_1}{\gamma-1} \left(1 - \left(\frac{V_1}{V_2}\right)^{\gamma-1} \right)$$

Dette gir $W = \frac{1{,}00 \, mol \cdot 8{,}31 \frac{J}{K mol} \cdot 273 K}{1{,}67 - 1} \left(1 - \left(\frac{V_1}{2 \cdot V_1}\right)^{1{,}67-1} \right)$

$$= \frac{8{,}31 \cdot 273}{0{,}67} \cdot \left(1 - \left(\frac{1}{2}\right)^{0{,}67} \right) J = 1257 \, J = \underline{1{,}26 \, kJ}$$

b) $V_2 = \frac{1}{2} V_1$ 1. isobar pr. $W = p(V_2 - V_1) = p \cdot (-\frac{1}{2} V_1)$

$$= 101{,}3 \cdot 10^3 \frac{N}{m^2} \cdot \left(-\frac{1}{2}\right) \cdot 0{,}022395 \, m^3$$

$$= -1134 \, J = \underline{-1{,}13 \, kJ}$$

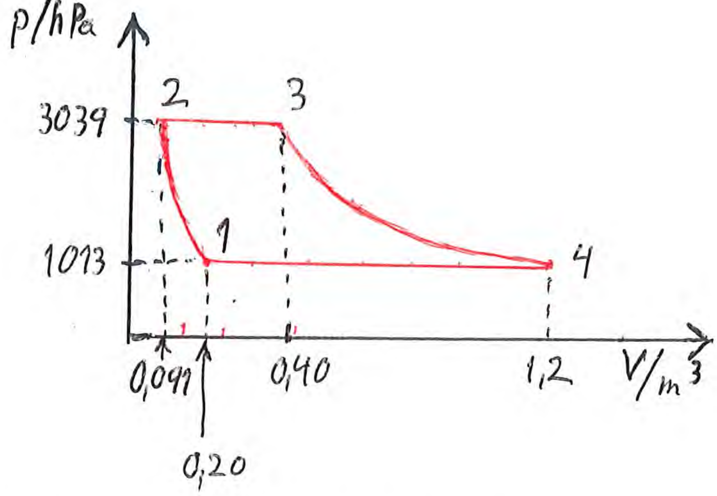
2. isoterm pr. $W = nRT \ln\left(\frac{V_2}{V_1}\right) = 1{,}00 \cdot 8{,}31 \cdot 273 \cdot \ln\left(\frac{1}{2}\right) J$

$$= \underline{-1{,}57 \, kJ}$$

3. adiabatisk pr. $W = \frac{nRT_1}{\gamma-1} \left(1 - \left(\frac{V_1}{\frac{1}{2} V_1}\right)^{\gamma-1} \right)$

$$= \frac{1{,}00 \cdot 8{,}31 \cdot 273}{0{,}67} \cdot \left(1 - 2^{0{,}67} \right) = \underline{-2{,}00 \, kJ}$$

8.324



$T_1 = 300K$ 1–2 adiabatisk
3–4 isoterm
2–3 og 4–1 isobar

a) Stoffmengde $pV = nRT$

$$n = \frac{pV}{RT} = \frac{1013 \cdot 10^2 \frac{N}{m^2} \cdot 0{,}20\,m^3}{8{,}31 \frac{J}{K \cdot mol} \cdot 300K} = 8{,}126\,mol$$

dvs. $\underline{8{,}1\,mol}$

b) 2. $T = ?$ $p = 3039 \cdot 10^2\,Pa$ $V = 0{,}091\,m^3$

$pV = nRT$

$$T = \frac{pV}{nR} = \frac{3039 \cdot 10^2 \frac{N}{m^2} \cdot 0{,}091\,m^3}{8{,}126\,mol \cdot 8{,}31 \frac{J}{K \cdot mol}} = 409{,}5\,K$$

dvs. $\underline{0{,}41\,kK}$ (ca 410K)

3. $T = ?$ $$T = \frac{pV}{nR} = \frac{3{,}039 \cdot 10^5 \frac{N}{m^2} \cdot 0{,}40\,m^3}{8{,}126 \cdot 8{,}31 \frac{J}{K}} = 1800\,K$$

dvs. $\underline{1{,}8\,kK}$

4. $T = T_3 = \underline{1{,}8\,kK}$ (isoterm endring)

$\gamma = 1{,}4$

c) $$W_{1-2} = \frac{nRT_1}{\gamma - 1}\left[1 - \left(\frac{V_1}{V_2}\right)^{\gamma-1}\right] = \frac{8{,}126 \cdot 8{,}31 \cdot 300}{0{,}40}\left[1 - \left(\frac{0{,}20}{0{,}091}\right)^{0{,}40}\right] J$$

$$= -18{,}75\,kJ = \underline{-0{,}019\,MJ}$$

$$W_{2-3} = p(V_3 - V_2) = 3{,}039 \cdot 10^5 \frac{N}{m^2} \cdot (0{,}40 - 0{,}091)\,m^3 = 93{,}905\,kJ$$

$$= \underline{0{,}094\,MJ}$$

$$W_{3-4} = nRT_3 \ln\left(\frac{V_4}{V_3}\right) = 8{,}126\,\text{mol} \cdot 8{,}31\,\frac{\text{J}}{\text{K}\cdot\text{mol}} \cdot 1800\,\text{K} \cdot \ln\left(\frac{1{,}2}{0{,}40}\right)$$

$$= 133{,}534\,\text{kJ} = 0{,}1335\,\text{MJ}$$

$$= \underline{0{,}13\,\text{MJ}}$$

$$W_{4-1} = p(V_2 - V_1) = 1{,}013 \cdot 10^5\,\frac{\text{N}}{\text{m}^2} \cdot (0{,}20 - 1{,}20)\,\text{m}^3 = -0{,}1013\,\text{MJ}$$

$$= \underline{-0{,}10\,\text{MJ}}$$

d) $W = W_{1-2} + W_{2-3} + W_{3-4} + W_{4-1}$

$$= -0{,}019\,\text{MJ} + 0{,}094\,\text{MJ} + 0{,}13\,\text{MJ} - 0{,}10\,\text{MJ}$$

$$= 0{,}105\,\text{MJ} \quad \text{dvs} \quad \underline{0{,}11\,\text{MJ}}$$