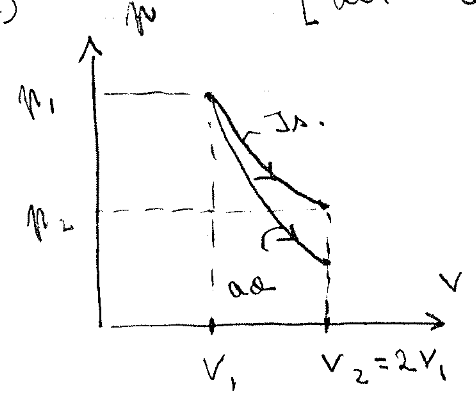
Oppg 1. Løsn

a) $W = \int_{V_1}^{2V_1} p\,dV = p_1V_1\int_{V_1}^{2V_1}\frac{dV}{V} = p_1V_1\ln 2 \approx \underline{0{,}7\,p_1V_1}$

b) $W_{ad} = p_1V_1^{5/3}\int_{V_1}^{2V_1}\frac{dV}{V^{5/3}} = \frac{3}{2}\,p_1V_1^{5/3}\left[-\frac{1}{V^{2/3}}\right]_{V_1}^{2V_1}$

$= \frac{3}{2}\,p_1V_1\left[1-\frac{1}{2^{2/3}}\right] \approx \underline{0{,}55\,p_1V_1}$

c) [alt: $Q = 0 \Rightarrow W_{ad} = -\Delta U = U_1 - U_2$]



Areal under isoterm > areal under adiabat ∴

$W > W_{ad}$ som over.

d) Trykk: Fra molekylenes støt mot veggene

Temp: Mål for midlere kinetiske molekylenergi

Isoterm: Konst $T \Rightarrow$ konst$\langle K \rangle \Rightarrow$ konst fart.

Trykk avtar fordi molekylene støter <u>sjeldnere</u> mot veggene når V øker

Adiabat: Utført arbeid på bekostning av indre energi ∴ K avtar ⇒ fart avtar

Trykk avtar av samme grunn som ovenfor. <u>I tillegg</u> <u>mindre impuls</u> til veggene ved hvert støt.

Oppg 2

$$\text{a)}\quad N_1/N = C e^{-\frac{E_1}{\theta}} = C \qquad N_2/N = C e^{-\frac{E_2}{\theta}} = C e^{-\frac{\varepsilon}{\theta}}$$

(2)

$$1 = N_1/N + N_2/N \Rightarrow C^{-1} = 1 + e^{-\frac{\varepsilon}{\theta}} \quad ∴$$

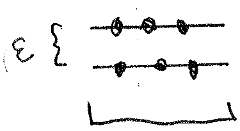
$$\underline{\underline{N_1 = \frac{N}{1+e^{-\varepsilon/\theta}}}} \qquad \underline{\underline{N_2 = \frac{N}{1+e^{\varepsilon/\theta}}}}$$

$$\text{b)}\quad \bar{E} = \frac{N_1}{N}\underbrace{E_1}_{0} + \frac{N_2}{N}\underbrace{E_2}_{\varepsilon} \Rightarrow \underline{\underline{\bar{E} = \frac{\varepsilon}{1+e^{\varepsilon/\theta}}}}$$

$$U = N\bar{E} = \underline{\underline{\frac{N\varepsilon}{1+e^{\varepsilon/\theta}}}}$$

$$C_V = \frac{\partial U}{\partial T} = k\frac{\partial U}{\partial \theta} \Rightarrow \underline{\underline{C_V = Nk\left(\frac{\varepsilon}{\theta}\right)^2 \frac{e^{\varepsilon/\theta}}{(1+e^{\varepsilon/\theta})^2}}}$$

$$\text{c)}\quad \theta \gg \varepsilon \Rightarrow e^{\varepsilon/\theta} \approx 1 \quad e^{-\varepsilon/\theta} \approx 1 \Rightarrow$$

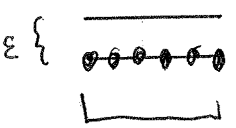


Likefordeling

$$\underline{N_1 \approx N/2}, \quad \underline{N_2 \approx N/2}, \quad \underline{U \approx N\varepsilon/2}, \quad \underline{C_V \approx \tfrac{1}{4}Nk\left(\tfrac{\varepsilon}{\theta}\right)^2}$$

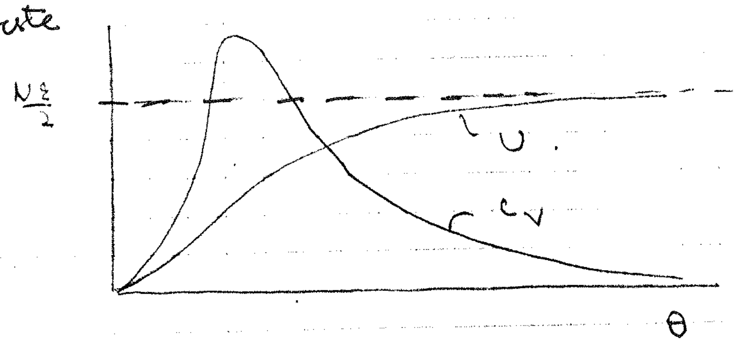
$$\theta \ll \varepsilon \Rightarrow e^{\varepsilon/\theta} \gg 1 \quad e^{-\varepsilon/\theta} \ll 1 \Rightarrow$$

$$\underline{N_1 \approx N}, \quad \underline{N_2 \approx N e^{-\varepsilon/\theta} \approx 0}$$



$$U \approx N\varepsilon e^{-\varepsilon/\theta} \approx 0 \qquad C_V \approx Nk\left(\frac{\varepsilon}{\theta}\right)^2 e^{-\varepsilon/\theta}.$$

Alle i laveste nivå



Oppg. 3. Løsn

a)

$$\left.\begin{array}{ll} \text{1. HS} & q_K + W = q_V \\ \text{2. HS} & -q_K/T_K + q_V/T_V \geq 0 \end{array}\right\}$$

$$q_V \geq q_K \frac{T_V}{T_K} \Rightarrow \quad W > q_K \frac{T_V}{T_K} - q_K$$

$$W_{min} = q_K \left(\frac{T_V}{T_K} - 1 \right) = q_K \frac{T_V - T_K}{T_K}$$

b) $\quad$ Effektivitet $= \dfrac{\text{Res.}}{\text{Kostn}} = \dfrac{\text{Fjernet varme}}{\text{brukt arbeid}}$

$$\underline{\varepsilon_{max} = \frac{q_K}{W_{min}} = \frac{T_K}{T_V - T_K}}$$

$T_K = -15°C = 258\,K \qquad T_V = 20°C = 293\,K$

$$\varepsilon_{max} = \frac{258}{293-258} = \frac{258}{35} \approx \underline{7{,}4}$$

c) $\varepsilon = \varepsilon_{max}/2 = 3{,}7$.

$W = 250 \cdot 0.15 = 37{,}5\ W = 37{,}5\ J/s.$

Varme som lekker inn må fjernes:

$$\underline{q = q_K = \varepsilon W} = 3{,}7 \cdot 37{,}5 \approx \underline{138\ J/s}$$

Oppg 4. Løsn

a) Konstant temperatur $T = -13^\circ C = 260\,K$

Tilført varme $Q = 3000 \cdot 10^{-3} = 3\,J.$

$$\Delta S = \frac{Q}{T} = \frac{3}{260} = \underline{1.15 \cdot 10^{-2}\,J/K}$$

$$S = k \ln W \Rightarrow$$

$S_{før} = k \ln W_{før}$ $\quad S_{etter} = k \ln W_{etter}$

$$\Delta S = k \ln \frac{W_{etter}}{W_{før}}$$

$$W_{etter}/W_{før} = e^{\Delta S/k} = 10^{0.43\,\Delta S/k} \Rightarrow$$

$$\underline{W_{etter}/W_{før} \approx 10^{3.6 \cdot 10^{20}} \ggg 1.}$$

b)

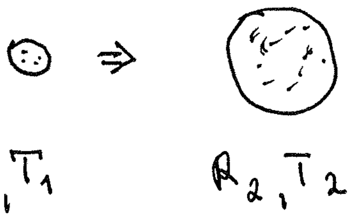
Alle mikrotilstander forekommer like ofte. Minimal sjangse for å finne systemet i en av de $W_{før}$ tilstandene.

Antall molekyler $N = \frac{M}{m_{H_2O}} \approx \frac{10^{-6}}{3 \cdot 10^{-26}} \approx 3 \cdot 10^{19}$

Antall måter å plassere disse på i flasken $\gg$ antall måter å plassere et snøfnugg på i flasken.

Oppg. 5 løsn

a)



Adiabat $pV^{\gamma} = \text{konst.}$

Gasslov $pV = NkT$.

Kombinasjon

$$(T/V)\cdot V^{\gamma} = \text{konst.}$$

$$TV^{\gamma-1} = \text{konst.}$$

$$V = \frac{4\pi}{3}R^3 \Rightarrow TR^{3(\gamma-1)} = \text{konst.} \qquad \underline{RT^{\frac{1}{3(\gamma-1)}} = \text{konst.}}$$

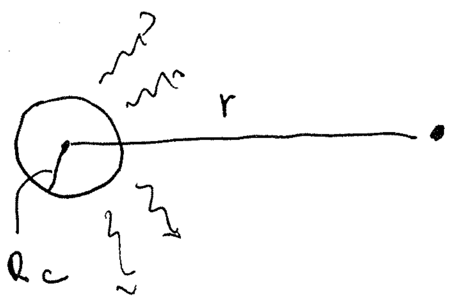
Anvendt på gasskulen:

$$R_2 T_2^{\frac{1}{3(\gamma-1)}} = R_1 T_1^{\frac{1}{3(\gamma-1)}} \qquad \underline{R_2 = R_1\left(\frac{T_1}{T_2}\right)^{\frac{1}{3(\gamma-1)}}}$$

$$\gamma = 1{,}4 \quad T_1/T_2 = 100 \quad R_1 = 15\ \text{m} \Rightarrow$$

$$\underline{R_2 \approx 700\ \text{m}}$$

b)



Energibevarelse:

$$\underbrace{I(R_c)\cdot 4\pi R_c^2}_{\text{Alt fra Capella pr. sek.}} = I(r)\cdot 4\pi r^2$$

$$R_c = r\left[\frac{I(r)}{I(R_c)}\right]^{1/2} = r\left[\frac{I(r)}{\sigma T_c^4}\right]^{1/2} \Rightarrow$$

$$\underline{R_c \approx 7\cdot 10^9\ \text{m} \approx 10\,R_\odot}$$