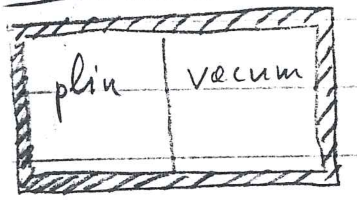
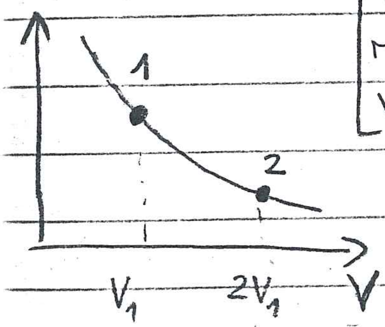
W/97/3-5M



Izolirana posoda je na sredini pregrajena s steno. V levem delu posode je 1 kg idealnega plina pri temperaturi 100 °C in tlaku $2 \cdot 10^5 \frac{N}{m^2}$, v desnem delu posode pa je vakuum. Če pregrado na sredini posode odstranimo, se plin razširi po celi posodi. Določi tlak in temperaturo v ravnovesju!



$p_1 = 2 \cdot 10^5 \, N/m^2$

$T_1 = 100 °C$

$V_2 = 2 V_1$

$Q \to 0$ (ker sistem izoliran)

$$\Delta W_n = Q + A = 0$$

A je nič, ker sistem ne opravi dela glede na vakuum

$$\Delta W_n = c_v m \Delta T = 0$$

$$\Downarrow$$

$$\Delta T = 0$$

$$\Downarrow$$

$$p_1 V_1 = p_2 V_2 \Rightarrow p_2 = p_1 \left(\frac{V_1}{V_2}\right) = p_1 \left(\frac{1}{2}\right) = 10^5 \frac{N}{m^2}$$

1993

3. Kompresor zajame 1 m^3 zraka pri temperaturi 30^oC in tlaku 10^5 N/m^2 in ga stisne izotermno na tlak 10^6 N/m^2. Koliko toplote je treba pri tem odvesti ? Za koliko se spremeni entropija in notranja energija zraka ?

$V_1 = 1\ m^3$
$T = 303\ K$
$p_1 = 10^5\ N/m^2$
} izotermno, $p_2 = 10^6\ N/m^2$

$$\boxed{p_1 V_1 = p_2 V_2} \Rightarrow \frac{V_2}{V_1} = \frac{p_1}{p_2}$$

$$\boxed{\Delta W_n = 0} = A + Q \Rightarrow \boxed{Q = -A}$$

$$A = -\int_{V_1}^{V_2} p\,dV = -\int_{V_1}^{V_2} \frac{m}{M} RT \frac{1}{V} dV = -\frac{m}{M} RT \ln\frac{V_2}{V_1} = \qquad pV = \frac{m}{M}RT$$

$$= \frac{m}{M} RT \ln\frac{p_2}{p_1} = p_1 V_1 \ln\frac{p_2}{p_1} = 10^5 \cdot \ln 10 = 2.3 \cdot 10^5\ J$$

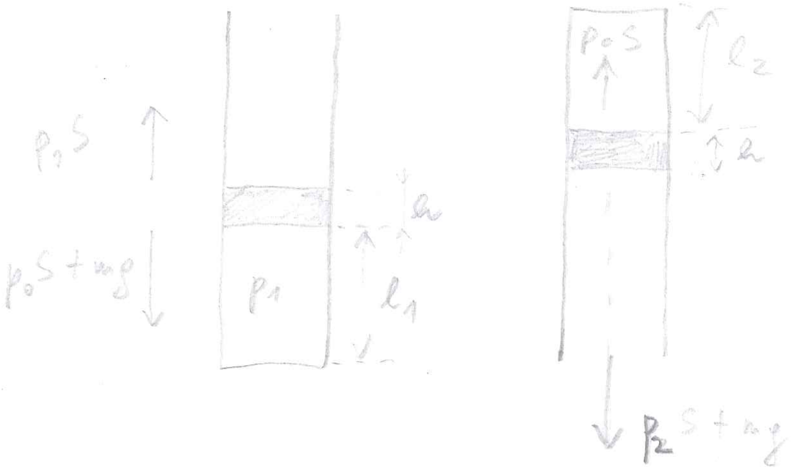
$$\boxed{Q = -2.3 \cdot 10^5\ J}$$

$$\Delta W_n = c_v m \Delta T = 0$$

$$\Delta S = \frac{Q}{T} = -759{,}1\ J/K \qquad dS \geq \frac{dQ}{T}$$

Izpit 1991 PE5

7. Tanka, dolga steklena cevka je napolnjena z zrakom. Cevka je na enem krajišču zataljena, na drugem krajišču pa zaprta z 2 cm dolgim živosrebrnim stolpcem (ρ_{Hg} = 13,6 g/cm^3). Ko stoji cevka navpično z zataljenim krajiščem na tleh, je dolžina zračnega stolpca v cevki 16 cm. Cevko previdno zasučemo za 180°, tako da je zataljeno krajišče zgoraj. Nova dolžina zračnega stolpca je 17 cm. Kolikšen je zračni tlak v okolici ?



$\rho = 13600\ kg/m^3$
$h = 2\ cm$
$l_1 = 16\ cm$
$l_2 = 17\ cm$, $g = 9{,}8\ ms^{-2}$

$p_0 = ?$

(1) $p_1 S = p_0 S + mg$ (2) $p_2 S + mg = p_0 S$

$V_1 = S \cdot l_1$
$V_2 = S \cdot l_2$

$p_1 V_1 = p_2 V_2 \Rightarrow$ (3) $p_1 l_1 = p_2 l_2$ $\{p_1, p_2, p_0\} = ?$

(1)(2) $\Rightarrow p_1 S - mg = p_2 S + mg$

$S \cdot p_2 \frac{l_2}{l_1} - mg = p_2 S + mg \Rightarrow S \cdot p_2 l_2 - mg l_1 = p_2 S l_1 + mg l_1$

$S \cdot p_2 (l_2 - l_1) = mg (l_2 + l_1)$, $m = \rho V = \rho \cdot S \cdot h$

$$p_2 = \rho g h (l_2 + l_1)/(l_2 - l_1)$$

$$p_0 = 8{,}8 \cdot 10^4\ N/m^2$$

3. Dve jeklenki vsebujeta enako maso plina pri temperaturi 7°C in tlaku $1{,}04\cdot10^{7}$ Pa. Jeklenki sta povezani s tanko cevko z ventilom za odpiranje prehoda skozi cevko, ki je na začetku zaprt. Nato plin v levi jeklenki segrejemo za 1°C in odpremo ventil v cevki. Kolikšen bo pretok skozi kapilaro v trenutku, ko je 0,1 % mase toplejšega plina v levi jeklenki že izteklo v desno jeklenko. Dolžina cevke je l=2 m, radij cevke r= 0,05 mm, viskoznost plina pa je $\eta=2\cdot10^{-5}$ kg/(m·s). Za volumski pretok plina po cevki velja približno enačba : $\Phi_V = (\pi\cdot r^4\cdot\Delta p)/(8\cdot\eta\cdot l)$, kjer je Δp razlika tlakov med obema koncema cevke.

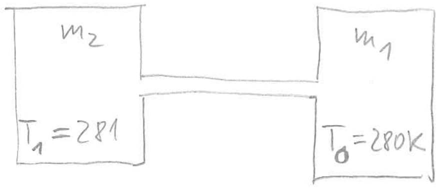
$T_0 = 280\,K$, $T_1 = 281\,K$

$p_0 = 1{,}04\cdot10^{7}\,Pa$

$l = 2\,m$

$r = 5\cdot10^{-5}\,m$

$\eta = 2\cdot10^{-5}\,kg/(m\cdot s)$, $\frac{\Delta m}{m} = 0{,}001$



$\phi_V = \frac{\pi r^4 \cdot \Delta p}{8\eta\cdot l}$

$$p = \frac{1}{V}\frac{m}{M}RT$$

$\Delta T = T_2 - T_1$

$\frac{\Delta m}{m} = +0{,}001$

$\frac{\Delta T}{T} = \frac{1}{280}$

leve posode

$$dp_1 = -\frac{1}{V}\frac{R}{M}T\,dm + \frac{1}{V}\frac{m}{M}R\,dT$$

$$\Delta p_1 = -\frac{1}{V}\frac{R}{M}Tm\frac{\Delta m}{m} + \frac{1}{V}\frac{m}{M}R\,\Delta T$$

$$\Delta p_1 = -p_0\frac{\Delta m}{m} + p_0\frac{\Delta T}{T} = p_0\left(-\frac{\Delta m}{m} + \frac{\Delta T}{T}\right)$$

desne posode

$$\Delta p_2 = p_0\frac{\Delta m}{m}$$

0,00357 — 0.002

SKUPAJ

$$\Delta p_{1,2} = \Delta p_1 - \Delta p_2 = p_0\left(\frac{\Delta T}{T} - 2\frac{\Delta m}{m}\right) = 0{,}157\cdot p_0$$

⇓

$$\phi_V = 10^{-9}\,m^3/s$$

1. V nekem meteorološkem modelu opišemo atmosfero z enačbo p/ρ = konstanta, kjer je p tlak in ρ gostota zraka. Oceni gostoto zraka na višini 3000 m od morske gladine, če je tlak pri morski gladini je 10^5 Pa, temperatura pa 20°C. Masa kilomola zraka je 27 kg. Zrak obravnavamo kot idealen plin.

$g = 10\ \mathrm{m\,s^{-2}}$

$h = 3000\ \mathrm{m}$

$p_0 = 10^5\ \mathrm{Pa}$

$T = 293\ \mathrm{K}$

$M = 27\ \mathrm{kg/kmol}$

$$p/\rho = \frac{R}{M} T \quad \Downarrow \quad \rho = p \frac{M}{RT}$$

$$\left\{ pV = \frac{m}{M} RT \quad \Downarrow \quad p/\rho = \frac{R}{M} T \right\}$$

$$dp = -\rho g\, dh$$

$$\frac{dp}{p} = -\frac{Mg}{RT} dh$$

$$p = p_0 \exp\left[-\frac{Mg}{RT} h\right]$$

$$\Downarrow$$

$$\rho = \rho_0 \exp\left[-\frac{Mg}{RT} \cdot h\right] = \left(\frac{p_0 M}{RT}\right) \cdot \exp\left[-\frac{Mg}{RT} \cdot h\right] =$$

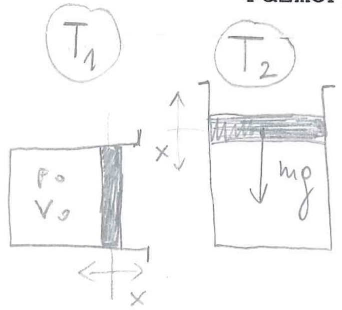
$$= 0.796\ \mathrm{kg/m^3}$$ ✓

poševno ležečem

1. V cilindru preseka 1 cm^2 je z batom mase 0,4 kg zaprt zrak z volumnom 1 dm^3. Bat se lahko giblje po cilindru skoraj brez trenja. Zunanji tlak je 10^5 Pa. Če je cilinder položen horizontalno je nihajni čas bata T_1, če ga izmaknemo iz ravnovesne lege. Če pa je cilinder položen vertikalno, je njegov nihajni čas T_2. Kolikšno je razmerje T_2/T_1 ? Temperatura med nihanjem je konstantna.

$g = 10\ m s^{-2}$

1992



$x = x_0 \cos(\omega t)$

$\ddot{x} = -\omega^2 x$

$S = 10^{-4}\ m^2$

$m = 0,4\ kg$

$p_0 = 10^5\ Pa$

$V_0 = 10^{-3}\ m^3$

$$mg = S(p_{n0} - p_0)$$

$$\Downarrow$$

$$p_{n0} = p_0 + \frac{mg}{S} = 1,4 \cdot 10^5\ Pa$$

$$p_{n0} V_{n0} = p_0 V_0$$

$$\Downarrow$$

$$V_{n0} = \frac{p_0 V_0}{p_{0n}} = 0.714 \cdot 10^{-3}\ m^3$$

$V = h \cdot S$

$$pV = konst.$$

$$\Downarrow$$

$$p\,dV + V\,dp = 0 \Rightarrow dp = -p\frac{dV}{V} = -p \cdot \frac{x \cdot S}{V} = -\frac{p}{V} \cdot S \cdot x$$

$$m\ddot{x} = S\,dp = -S^2 \frac{p}{V} x \Rightarrow \omega = \frac{2\pi}{T} = \sqrt{\frac{S^2 p}{mV}} \Rightarrow T = 2\pi\sqrt{\frac{mV}{S^2 p}}$$

$$\frac{T_2}{T_1} = \sqrt{\frac{V_{n0} \cdot p_0}{p_{n0} \cdot V_0}} = 0,714$$

✓

1

površinska napetost

2. Pri napihovanju milnega mehurčka z radijem 2 cm opravimo delo $4\cdot 10^{-4}$ J. Za koliko se razlikujeta gostoti zraka v mehurčku in izven njega, če je temperatura zraka v mehurčku in izven njega enaka 300 K ? Molska masa zraka je 29 kg/kmol.

$$A = 2\gamma \cdot 4\pi r^2 \Rightarrow \gamma = \frac{A}{8\pi r^2}$$

$$(p_{NOT} - p_{ZUN})\cdot \pi r^2 = 2\pi r \gamma = \frac{2\pi r A}{4\, 8\pi r^2}$$

$$p_{NOT} = p_{ZUN} + \frac{A}{4\pi r^3}$$

$$p_{NOT}\cdot V = \frac{m}{M} R T$$

$$p_{NOT} = \frac{\rho_N R T_{NOT}}{M} \qquad \rho_N = \frac{M p_{NOT}}{R T_{NOT}}$$

$$p_{ZUN} = \frac{\rho_{ZUN} R T_{ZUN}}{M} \qquad \rho_Z = \frac{M p_{ZUN}}{R T_{ZUN}}$$

$$\rho_N - \rho_Z = \frac{M}{RT}(p_{NOT} - p_{ZUN}) = \frac{M}{RT}\frac{A}{4\pi r^3} =$$

$$= \frac{29 \quad 4.10^{-4}}{8300 \quad 300 \quad 4\pi \quad 0.01^3} = 3.7\cdot 10^{-4}\ \frac{kg}{m^3}$$

FOR FOR kolokvij 90/91 PE 9

6. V neki posodi je 12 g metana in 55 g ogljikovega dioksida. Skupni pritisk pri temperaturi 27 °C je $2 \cdot 10^5$ Nm^{-2}. Kolikšna sta parcialna tlaka obeh plinov in kakšen je volumen posode ?
(atomske mase : H = 1, C = 12, O = 16 , R = 8300 J/K)

$pV = nRT$ $\qquad n = n_1 + n_2$ $\qquad$ (M) metan CH_4 = 16 kg | kmol

$V = \frac{nRT}{p}$ $\qquad n = \frac{m}{M} = \frac{12 \cdot 10^{-3} \text{ kg kmol}}{16 \text{ kg}} = 0{,}75 \cdot 10^{-3}$ kmol

$V = \frac{2 \cdot 10^{-3} \text{ kmol} \cdot 8{,}3 \cdot 10^3 \text{ J} \cdot 300 \text{ K m}^2}{\text{kmol K } 2 \cdot 10^5 \text{ N}}$ $\qquad$ (M) CO_2 = 44 kg | kmol

$n = \frac{m}{M} = \frac{55 \cdot 10^{-3} \text{ kg kmol}}{44 \text{ kg}} = 1{,}25 \cdot 10^{-3}$ kmol

$V = 25 \cdot 10^{-3} \text{ m}^3$ = 25 litrov

$p_1 = \frac{n_1 RT}{V} = \frac{0{,}75 \cdot 10^{-3} \text{ kmol} \cdot 8{,}3 \cdot 10^3 \text{ J} \cdot 300 \text{ K}}{\text{K kmol } 25 \cdot 10^{-3} \text{ m}^3 \text{ m}^2} = 7{,}5 \cdot 10^4 \text{ N} \cdot \text{m}^{-2}$

$p_2 = \frac{n_2 RT}{V} = \frac{1{,}25 \cdot 10^{-3} \text{ km} \cdot 8{,}3 \cdot 10^3 \text{ J} \cdot 300 \text{ K}}{\text{kmol K } 25 \cdot 10^{-3} \text{ m}^3} = 12{,}5 \cdot 10^4 \text{ N} \cdot \text{m}^{-2}$

p celotni $= 20 \cdot 10^4 \text{ N} \cdot \text{m}^{-2} = 2 \cdot 10^5 \text{ N} \cdot \text{m}^{-2}$

$p_1 V_1 = \frac{m_1}{M_1} RT$

$p_2 V_2 = \frac{m_2}{M_2} RT$

$(p_1 + p_2) V = \left(\frac{m_1}{M_1} + \frac{m_2}{M_2} \right) RT$

1. Pri izgorevanju 1 kg ogljika polovica izgori v CO, polovica pa v CO_2. Kolikšen je tlak 1 m^3 nastale plinske zmesi, ki ima temperaturo 100°C ? (M_C = 12 kg/kmol, M_O = 16 kg/kmol)

1995

A-Z

$C + O = CO$

$12 + 16 = 28$

$$\frac{m_{CO}}{28} = \frac{0.5\,kg}{12}$$

$\Downarrow$

$m_{CO} = 1.167\,kg$

$C + O_2 = CO_2$

$12 + 32 = 44$

$$\frac{m_{CO_2}}{44} = \frac{0.5\,kg}{12}$$

$\Downarrow$

$m_{CO_2} = 1.833\,kg$

$$p_{CO} = \frac{m_{CO}}{M_{CO}} \cdot \frac{RT}{V} = 1.29 \cdot 10^5\,N/m^2$$

$$p_{CO_2} = \frac{m_{CO_2}}{M_{CO_2}} \cdot \frac{RT}{V} = 1.29 \cdot 10^5\,N/m^2$$

$$p = p_{CO} + p_{CO_2} = 2.58 \cdot 10^5\,N/m^2$$

DRUGI NAČIN:

$$p \cdot V = \frac{m}{M} RT$$

$$pV = \frac{N \cdot m_1}{N_A \cdot m_1} \cdot R \cdot T = N \cdot k \cdot T \Rightarrow p = \frac{N}{V} kT$$

$m_c = 1\,kg$

$M_c = 12\,kg$

$$p = \frac{1}{V} \frac{m_c}{M_c} RT$$

~~tudi izpit~~ 1992 Elektrijada 1991

PE4

M.

U jednom meteorološkom modelu opišemo atmosferu sa jednačinom p/ρ^2 = konstanta. Odrediti visinu težišta takve atmosfere, ako je $g = 10\ m/s^2$ konstantan. Pritisak na površini zemlje je $p_o = 10^5$ Pa, a temperatura je T = 0°C. Kilomolska masa zraka je M = 27 kg, R = 8300 J/kg.

Izpit 1991/92

a) 7546 m
b) 9320 m
c) 8392 m
d) 9981 m
e) ni jedan od gornjih rezultata nije tačan

$$\bar{z} = \frac{\int z\rho\, dz}{\int \rho\, dz}$$: po definiciji povprečja (1)

$$dp = -\rho g\, dz$$: tlak zaradi gravitacije (vzrok atmosfere) (2)

$$pV = \frac{m}{M}RT$$: plinska enačba (3)

Najprej dobimo izraz za $\rho(z)$:

$$pV = \frac{m}{M}RT \Rightarrow p = \frac{\rho RT}{M} \Rightarrow dp = \frac{RT}{M}d\rho$$

$$\frac{RT}{M}d\rho = -\rho g\, dz \Leftarrow dp = dp$$

$$\frac{d\rho}{\rho} = -\frac{Mg}{RT}dz$$

$$\ln\frac{\rho}{\rho_0} = -\frac{Mgz}{RT} \Longrightarrow \frac{\rho}{\rho_0} = e^{-\frac{Mgz}{RT}} = e^{-\alpha z} \qquad \alpha = \frac{Mg}{RT}$$

Iz (1):

$$\int_0^\infty z\rho\, dz = \int z\rho_0 e^{-\alpha z}dz = \rho_0 \frac{e^{-\alpha z}}{\alpha^2}(-\alpha z - 1)\Big|_0^\infty = \frac{\rho_0}{\alpha^2}$$

$$\int_0^\infty \rho\, dz = \int \rho_0 e^{-\alpha z}dz = -\frac{1}{\alpha}\rho_0 e^{-\alpha z}\Big|_0^\infty = \frac{\rho_0}{\alpha}$$

$$\bar{z} = \frac{\rho_0}{\alpha^2}\frac{\alpha}{\rho_0} = \frac{1}{\alpha} = \frac{RT}{Mg} = \frac{8300 \cdot 273}{27 \cdot 10} = 8392\ m$$

Odrediti visinu težišta atmosfere .....

PE1

Plinska enačba

Imamo 3 g vodika pod tlakom $4.10^5 N/m^2$ in pri temperaturi $1800^\circ C$.
Vodik ohlajamo, dokler se mu pritisk in volumen ne zmanjšata na polovico prvotne vrednosti. Izračunaj : a.) končno temperaturo plina
b.) končen volumen plina

a.) Začetni tlak, volumen in temperatura plina so povezani s končnimi p, V in T s plinsko enačbo

$$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$$

z ozirom na nalogo je $p_2 = \frac{p_1}{2}$ in $V_2 = \frac{V_1}{2}$

Če v enačbi pišemo namesto $p_2 = \frac{p_1}{2}$ in $V_2 = \frac{V_1}{2}$ dobimo

$$\frac{p_1V_1}{T_1} = \frac{p_1}{2}\frac{V_1}{2T_2} \Rightarrow T_2 = \frac{T_1}{p_1V_1}\cdot\frac{p_1V_1}{2\cdot 2} = \frac{T_1}{4} = \frac{2073}{4} = \boxed{518,2\ K}$$

b.) končen volumen plina, dobimo iz plinske enačbe

$$pV = nRT = \frac{m}{M}RT$$

$$V_2 = \frac{mRT_2}{Mp_2} = \frac{3\cdot10^{-3}\ kg \cdot 8,3\cdot10^{3}\ Nm \cdot 518,2\ K\ kmol\ m^2}{kmol\ K\ \cdot 2\ kg\ \cdot 2\cdot10^{5}\ N} = \boxed{32\cdot10^{-3}\ m^3}$$

32 litrov

kolokviji 80/81

PE 11

2. Pri izgorevanju 1 kg ogljika, polovica izgori v CO, polovica pa v CO_2. Kakšen je ~~totalni~~ tlak v 1 m^3 ~~[illegible]~~ tako nastale plinske zmesi, če ima nastala zmes temperaturo 100^oC? (M–ž)

(atomske mase : H = 1, C = 12, O = 16, R = 8300 J/K)

Rešitev: a.)

$C + O = CO$ $\quad$ $12 + 16 = 28$ $\quad$ $0{,}5 \rightarrow x$

$\frac{x}{28} = \frac{0.5}{12} \Rightarrow$ $x = \frac{0{,}5 \cdot 28}{12} = 1{,}167$

$m_{CO} = 1{,}167\,kg$

$C + O_2 = CO_2$ $\quad$ $12 + 32 = 44$ $\quad$ $0{,}5 \rightarrow x$

$x = \frac{0{,}5 \cdot 44}{12} = 1{,}833$

$m_{CO_2} = 1{,}833\,kg$

$$p_{CO} = \frac{m_{CO} RT}{M_{CO} \cdot V} = \frac{1{,}167\,kg \cdot 8{,}3 \cdot 10^3\,J \cdot 373\,K\,kmol}{kmol\,K\;28\,kg\;1\,m^3} = 1{,}29 \cdot 10^5\,N/m^2$$

$$p_{CO_2} = \frac{m_{CO_2} RT}{M_{CO_2} V} = \frac{1{,}835\,kg \cdot 8{,}3 \cdot 10^3\,J \cdot 373\,K}{kmol\,K\;44\,kg \cdot 1\,m^3} = 1{,}29 \cdot 10^5\,N/m^2$$

$$p_{tot} = p_{CO} + p_{CO_2} = 2{,}58 \cdot 10^5\,N/m^2$$

ali

$$pV = \frac{m}{M} RT \Rightarrow p = \frac{m_c RT}{M_c V} =$$

$$= \frac{1\,kg \cdot 8{,}3 \cdot 10^3\,J \cdot 373\,K\,kmol}{kmol\,K\;12\,kg\;1\,m^3} = 2{,}58 \cdot 10^5\,N/m^2$$

$$pV = \frac{m}{M} RT \qquad R = k \cdot N_A$$

$$pV = \frac{N \cdot m_1}{N_A \cdot m_1} RT = NkT$$

$$p = \frac{N}{V} k \cdot T$$

3. Dva balona napolnjena s plinom iste vrste sta povezana s cevko, katere ventil je spočetka zaprt. V prvem balonu volumna $3\cdot10^{-3}$ m^3 je tlak $1,2\cdot10^5$ Pa, v drugem balonu volumna 10^{-3} m^3 pa je tlak $0,9\cdot10^5$ Pa. Kolikšen bo končni tlak v balonih, ko odpremo ventil. Temperatura v balonih je ves čas enaka in se ne menja s časom.

Jednačina stanja gasa u balonima prije nego što se slavina otvori je

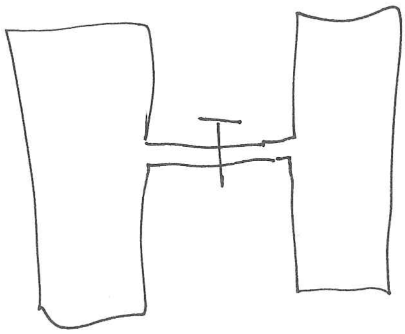
$$p_1V_1=\frac{m_1}{\mu}RT \qquad (1)$$

$$p_2V_2=\frac{m_2}{\mu}RT. \qquad (2)$$

Kada se slavina otvori, jednačina stanja gasa je

$$p\,(V_1+V_2)=\frac{m_1+m_2}{\mu}RT. \qquad (3)$$

$p=1,125\cdot10^5$ Pa.



1992 $g = 10\,\mathrm{m\,s^{-2}}$ Fizika I

5. V nekem meteorološkem modelu opišemo atmosfero z enačbo p/ρ = konstanta, kjer je p tlak in ρ gostota zraka. Ocenite lego težišča take atmosfere! Tlak pri površini zemlje je 10^5 Pa, temperatura pa 0°C, masa kilomola zraka je 27 kg.

M – Ž

$p_0 = 10^5\ \mathrm{Pa}$

$T_0 = 273\ \mathrm{K}$

$M = 27\ \mathrm{kg/kmol}$

$$pV = \frac{m}{M}RT \Rightarrow \boxed{p/\rho = \frac{RT}{M}} \Downarrow T = \text{konst.} \Downarrow dp = \frac{RT}{M}d\rho$$

$$\boxed{dp = -\rho g\, dz} \Rightarrow \int_{\rho_0}^{\rho}\frac{d\rho}{\rho} = \int_0^z \frac{M}{RT} g\, dz$$

$$\boxed{\rho = \rho_0 \exp\left[-\frac{Mg}{RT}\cdot z\right] = \rho_0 \exp(-\alpha \cdot z)} \quad \alpha = \frac{Mg}{RT}$$

$$\bar{z} = \frac{\int z\,dm}{m} = \frac{\int z\rho\,dz}{\int \rho\,dz} = \frac{1}{\alpha} = \frac{RT}{Mg} = \underline{\underline{8392\ m}}\ \checkmark$$

$$\int_0^\infty z\rho\,dz = \rho_0\int_0^\infty z e^{-\alpha z}dz = \left[-z\frac{1}{\alpha}e^{-\alpha z} + \int \frac{1}{\alpha}e^{-\alpha z}dz\right]\rho_0\Big|_0^\infty =$$

$$= \rho_0\left[-\frac{z}{\alpha}e^{-\alpha z} - \frac{1}{\alpha^2}e^{-\alpha z}\right]\Big|_0^\infty = -\rho_0\frac{e^{-\alpha z}}{\alpha^2}(\alpha z + 1)\Big|_0^\infty = \frac{\rho_0}{\alpha^2}$$

$$\int_0^\infty \rho\,dz = \int_0^\infty \rho_0 e^{-\alpha z}dz = -\frac{1}{\alpha}\rho_0 e^{-\alpha z}\Big|_0^\infty = \frac{\rho_0}{\alpha}$$

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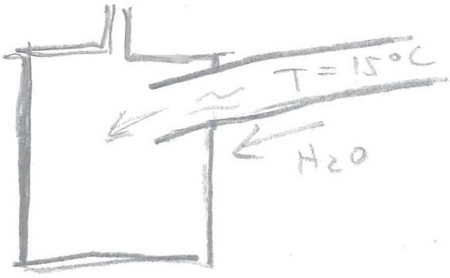
2. Iz kotla, v katerega doteka voda s temperaturo 15 °C, hočemo dobiti vsako uro 45 m^3 vodne pare s temperaturo 100 °C in tlakom 10^5 Nm^{-2}. Kolikšno moč mora imeti grelna naprava ? ($q_{izp} = 2{,}26\cdot 10^{6}$ J/kg, $c_{p,vode}$ = 4200 J/kgK , R = 8300 J/(kmol·K), M = 18 kg/kmol).



$V_p = 45\ m^3$

$T = 100\,°C \to 373\,K$

$p = 10^5\ Nm^{-2}$

$M_{H_2O} = 18$
$R = 8300\ J/K$
$q_i = 2.26\cdot 10^6$
$c_p = 4.2\cdot 10^3$

$$\underbrace{m_v c_p (85)}_{\text{segrevanje } H_2O} + \underbrace{m_v q_i}_{\text{izparevanje}} = Q_T$$

$$pV_p = \frac{m_v}{M} RT$$

$$P = \frac{Q_T}{3600\,s}$$

$$m_v = \frac{pV_pM}{RT} = 26.16\ kg$$

$$P = \frac{\overbrace{m_v c_p (85)}^{9.3\cdot 10^6} + \overbrace{m_v \cdot q}^{59.12\cdot 10^6}}{3600\,s} = 19\cdot 10^3\ W$$

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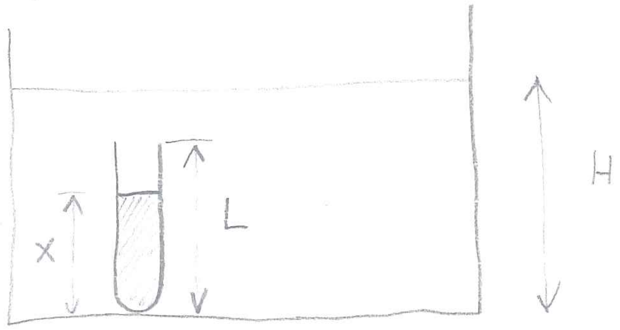
6. Epruveta višine L = 0,3 m je na vrhu neprodušno zaprta s premičnim zelo lahkim čepom (tlak v epruveti je enak zunanjemu zračnemu tlaku). Kolikšna bo višina zračnega stolpca v epruveti, če jo postavimo v posodo, ki je napolnjeno z živim srebrom do višine H = 1m. Epruveto postavimo vertikalno s čepom navzgor tako, da se dotika dna posode. Temperatura zraka v epruveti se ne spremeni.
(ρ_{Hg} = 13600 kg/m^3, $p_{zunanji}$ = 10^5 Pa)

$L = 0.3\,m$

$H = 1\,m$

$\rho_{Hg} = 13600\,kg/m^3$

$p_z = 10^5\,Pa$



pV = konst. :

$$\underbrace{\left[p_z + \rho_{Hg}\, g\,(H - x)\right]}_{p} \cdot \underbrace{(x \cdot S)}_{V} = \underbrace{p_z \cdot L S}_{p \cdot V}$$

$$x^2 - x\left(H + \frac{p_z}{\rho_{Hg} \cdot g}\right) + \frac{p_z L}{\rho_{Hg}\, g} = 0$$

$$x_{1/2} = \frac{1}{2}\left(H + \frac{p_z}{\rho_{Hg} \cdot g}\right) \pm \sqrt{\frac{1}{4}\left(H + \frac{p_z}{\rho_{Hg} \cdot g}\right)^2 - \frac{p_z \cdot L}{\rho_{Hg} \cdot g}}$$

$$x_{1/2} = 0.88\,m - 0.74\,m = \underline{0.14\,m}$$