Часть 1

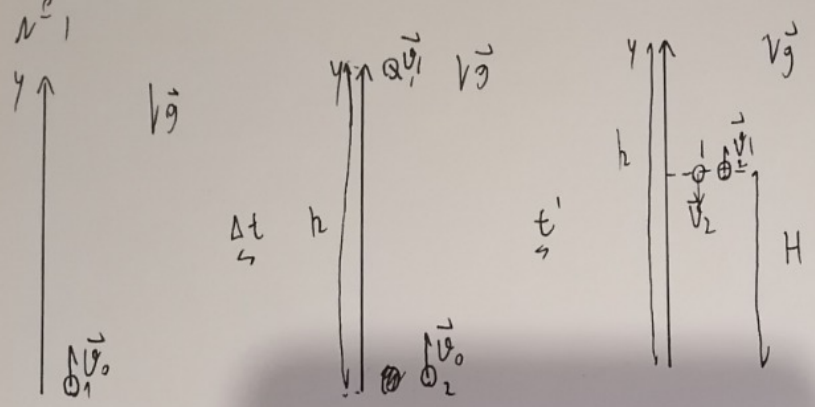
Олимпиада: **Физика, 10 класс (1 часть)**

Шифр: **21206424**

ID профиля: **873100**

Вариант 1

Чистовик



Дано:

g

H

$v_{01} = v_{02} = v_0$

t', v_0, $s_{01} = ?$

Реш-ие:

$0 = v_0 - g\Delta t$

$h = v_0 \Delta t - \frac{g\Delta t^2}{2}$

$v_{11} = 0$

$h - H = v_{11} \cdot t' + \frac{gt'^2}{2}$

$H = v_0 t' - \frac{gt'^2}{2}$

$s_{01} = 2h - H$

$\Rightarrow$

$\Delta t = \frac{v_0}{g}$

$h = \frac{2v_0\Delta t - g\Delta t^2}{2}$

$h - H = \frac{gt'^2}{2}$

$H = v_0 t' - \frac{gt'^2}{2}$

$s_{01} = 2h - H$

$\Rightarrow$

$h = \frac{v_0^2}{2g}$

$h = v_0 t'$ где

$H = v_0 t' - \frac{gt'^2}{2}$

$s_{01} = 2h - H$

$\Rightarrow$

$h = \frac{v_0^2}{2g}$

$t' = \frac{v_0}{2g}$

$H = v_0 t' - g\frac{t'^2}{2}$

$s_{01} = 2h - H$

$\Rightarrow$

$h = \frac{v_0^2}{2g}$

$t' = \frac{v_0}{2g}$

$H = \frac{3v_0^2}{8g}$

$s_{01} = 2h - H$

$\Rightarrow$

$v_0 = 2\sqrt{\frac{2}{3}Hg}$

$h = \frac{4}{3}H$

$t' = \sqrt{\frac{2H}{3g}}$

$s_{01} = 2h - H$

$\Rightarrow$

$v_0 = 2\sqrt{\frac{2}{3}Hg}$

$t' = \sqrt{\frac{2H}{3g}}$

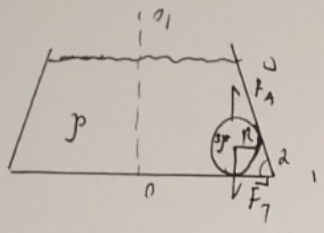
$s_{01} = \frac{5}{3}H$

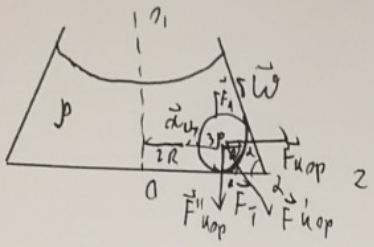
Ответ: $t' = \sqrt{\frac{2H}{3g}}$, $v_0 = 2\sqrt{\frac{2}{3}Hg}$, $s_{01} = \frac{5}{3}H$

(1)

Чистовик.

№2





Дано:

w

$r_{оо_1-ш} = 2R$

$r_ш = R$

α ($tg\alpha = 2$)

g

$R_1 = N_1$

$R_2 = N_2$

$p_ж = p$ $p_ш = 3p$

$N_1, N_2 = ?$

Реш-ие:

$F_т = m_ш \cdot g$

$m_ш = V_ш \cdot 3p$

$V_ш = \frac{4}{3}\pi R^3$

$F_A = p \cdot g \cdot V_ш$

$R_1 = F_т - F_A$

$N_1 = R_1$

$R_2 = F_т - F_A + F''_{кор}$

$F'_{кор} = F_{кор} \cdot \cos\alpha$

$F''_{кор} = F'_{кор} \cdot \sin\alpha \Rightarrow$

$F_{кор} = |a_ц| \cdot m_ш$

$a_ц = \frac{v^2_{вращ.}}{r_{вращ.}}$

$r_{вращ.} = r_{оо_1-ш} + b_ш$

$b_ш = 2R_ш$

$v_{вращ.} = \frac{C_{окр}}{t}$

$w = \frac{2\pi}{t}$

$C_{окр} = 2\pi r_{вращ.}$

$N_2 = N_1$

$N_1 = 2p \cdot g \cdot \frac{4}{3}\pi R^3$

$N_2 = N_1 + F''_{кор}$

$F''_{кор} = F_{кор} \cdot \sin\alpha \cos\alpha$

$F_{кор} = m_ш \cdot 4\pi R^3 p |a_ц| \Rightarrow$

$a_ц = \frac{v^2_{вращ.}}{r_{вращ.}}$

$r_{вращ.} = 4R$

$v_{вращ.} = 4wR$

$\Rightarrow \begin{cases} N_1 = \frac{8}{3}\pi R^3 pg \\ N_2 = \frac{8}{3}\pi R^3 pg + F''_{кор} \Rightarrow \\ F''_{кор} = 4\pi R^3 p \cdot 4w^2 R \sin\alpha\cos\alpha \end{cases}$

$\Rightarrow \begin{cases} N_1 = \frac{8}{3}\pi R^3 pg \\ N_2 = 8\pi R^3 p \left(\frac{1}{3}g + 2w^2 R \sin\alpha\cos\alpha\right) \end{cases}$ ($\sin\alpha\cos\alpha = \frac{1}{2}\sin 2\alpha$)

$= 8\pi R^3 p \left(\frac{1}{3}g + 4w^2 R \sin^2\alpha\right)$

Ответ: $N_1 = \frac{8}{3}\pi R^3 pg$, $N_2 = 8\pi R^3 p \left(\frac{1}{3}g + 2w^2 R \sin\alpha\cos\alpha\right) = 8\pi R^3 p \left(\frac{1}{3}g + 4w^2 R \sin^2\alpha\right)$

(2)

Чистовик

№ 3

Дано:

$m_1 = 3$ г

$T = 81^\circ C = T_1 = T_2$

$V_1 = 3{,}5 V_2$

$p_2 = p_1 \cdot 1{,}8$

$p_{нас} = 2{,}5 \cdot 10^5$ Па.

$M = 18$ г/моль

$R = 8{,}31$ Дж/К·моль

$p_1, V_2 = ?$

СИ

$3 \cdot 10^{-3}$ кг

354 К

$18 \cdot 10^{-3}$ кг/моль

Реш-ие:

$$\begin{cases} p_1 V_1 = \frac{m_1}{M} \cdot RT \\ p_2 V_2 = \frac{m_2}{M} \cdot RT \end{cases} \Rightarrow \begin{cases} p_1 V_1 = \frac{m_1}{M} RT \\ p_2 V_2 = \frac{m_2}{M} \cdot RT \\ \frac{p_1 V_1}{m_1} = \frac{p_2 V_2}{m_2} \end{cases} \Rightarrow \begin{cases} p_1 V_1 = \frac{m_1}{M} RT \\ p_2 V_2 = \frac{m_2}{M} RT \\ m_2 = m_1 \frac{1{,}8 p_1 \cdot V_2}{p_1 \cdot 3{,}5 V_2} \end{cases} \Rightarrow$$

$$\Rightarrow \begin{cases} m_2 = m_1 \frac{18}{35} \\ p_1 V_1 = \frac{m_1}{M} RT \\ p_2 V_2 = \frac{m_2}{M} RT \end{cases} \Rightarrow$$ Некоторая часть воды конденсировалась $\Rightarrow$

$$\Rightarrow \begin{cases} p_2 = p_{нас} = 1{,}8 p_1 \\ V_2 = \frac{18 m_1 RT}{35 M p_2} \end{cases} \Rightarrow \begin{cases} p_1 = \frac{p_{нас}}{1{,}8} \\ V_2 = \frac{18 m_1 RT}{35 M p_{нас}} \end{cases} \Rightarrow \begin{cases} p_1 = \frac{2{,}5 \cdot 10^5 \text{ Па}}{1{,}8} \approx 27777{,}78 \text{ Па} \\ V_2 = \frac{18 \cdot 3 \cdot 10^{-3} \text{ кг} \cdot 8{,}31 \frac{\text{Дж}}{\text{К} \cdot \text{моль}} \cdot 354 \text{ К}}{35 \cdot 18 \cdot 10^{-3} \text{ кг/моль} \cdot 2{,}5 \cdot 10^5 \text{ Па}} \approx 5{,}042 \cdot 10^{-3} \text{ м}^3 \end{cases}$$

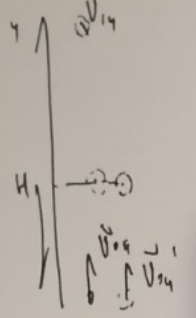
Ответ: $p_1 = 27777{,}78$ Па, $V_2 = 5{,}042 \cdot 10^{-3}$ м^3

(3)

Чернови

№1

$V_{0y} = V_{0y}'$



$h = \frac{V_{0y}^2}{2g}$ $\quad h - H = \frac{gt'^2}{2}$ $\quad \frac{V_{0y}^2}{2g} = V_{0y}t'$

$V_{0y} = gt''$ $\quad H = V_{0y}t' - \frac{gt'^2}{2}$ $\quad t' = \frac{V_{0y}}{2g}$

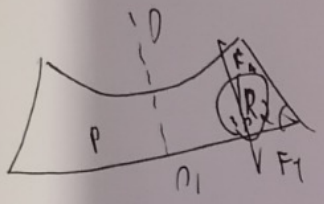
$h = \frac{V_{0y}^2}{2g} - \frac{g \cdot V_{0y}^2}{2 \cdot 4g^2} = \frac{3V_{0y}^2}{8g}$

$V_{0y} = 2\sqrt{\frac{2}{3}Hg}$

$t' = \sqrt{\frac{2H}{3g}}$

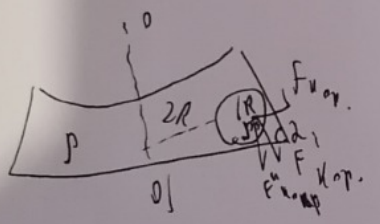
$h - H = \frac{1}{3}H$

№2.



$\begin{cases} F_T = mg \\ m = V_w \rho \\ V_w = \frac{4}{3}\pi R^3 \\ F_A = V_w \cdot g \rho \\ \vec{R} = F_T - F_A \end{cases}$ $\Rightarrow R = \frac{4}{3}\pi R^3 \cdot 3\rho g - \frac{4}{3}\pi R^3 \rho g =$

$= \frac{8}{3}\pi R^3 \rho g = N_1$



$F'_{нор} = F_{нор} \cos\alpha$.

$F''_{нор} = F'_{нор} \cdot \sin\alpha$.

$F''_{нор} = F_{нор} \cos\alpha \sin\alpha$ $\left(= \frac{1}{2} F_{нор} \sin 2\alpha\right)$

$V_w = \frac{W}{\pi} \cdot 2\pi R = 2WR$

$F_{нор} = \rho \pi r a_{ц.}$

$a_{ц.} = \frac{V_w^2}{r} = \frac{4}{3}W^2 R$

$(r = \frac{4}{3}R)$

$F''_{нор} = 4\pi R^3 \rho \cdot \frac{4}{3} W^2 R \cdot \cos\alpha \sin\alpha$

$N_2 = N_1 + F''_{нор} = \frac{8}{3}\pi R^3 \rho g + \frac{16}{3}\pi R^4 \rho W^2 \cos\alpha \sin\alpha$

$\left(= \frac{8}{3}\pi R^3 \rho \left(\frac{1}{2}g + \frac{2}{3}R W^2 \cos\alpha \sin\alpha\right)\right.$

(1)

Черновик.

№3

$m_1 = 5\text{г} = 5 \cdot 10^{-3}\text{кг}$

$T = 31^\circ\text{C} = 304\text{К}$

$V_1 = 3{,}5\,V_2$

$p_2 = 1{,}8\,p_1$

$p_{нас} = 35 \cdot 10^5\ \text{Па}$

$M = 18 \cdot 10^{-3}\ \text{кг/моль}$

$R = 8{,}31\ \text{Дж/моль}\cdot\text{К}$

$p_1 V_1 = \frac{m_1}{M} \cdot R T$

$p_2 V_2 = \frac{m_2}{M} R T$

$\frac{p_1 V_1}{m_1} = \frac{p_2 V_2}{m_2}$ $\quad \frac{V_1}{m_1} = \frac{1{,}8\,V_2}{3{,}5\,m_2}$, $m_2 = m_1 \frac{1{,}8}{3{,}5}$

$p_2 = p_{нас}$.

$p_1 = \frac{p_2}{1{,}8} = \frac{35 \cdot 10^5\ \text{Па}}{1{,}8} \approx 27777{,}78\ \text{Па}$.

$V_2 = \frac{m_2 R T}{M \cdot p_{нас}} = \frac{1{,}8\,m_1 \cdot R \cdot T}{3{,}5\,M \cdot p_{нас}} = \frac{1{,}8 \cdot 5 \cdot 10^{-3}\ \text{кг} \cdot 8{,}31\ \text{Дж/кг}\cdot\text{моль} \cdot 304\ \text{К}}{3{,}5 \cdot 18 \cdot 10^{-3}\ \text{кг/моль} \cdot 35 \cdot 10^5\ \text{Па}} \approx$

$\approx 0{,}01765\ \text{м}^3$

(2)

Часть 2

Олимпиада: **Физика, 10 класс (2 часть)**

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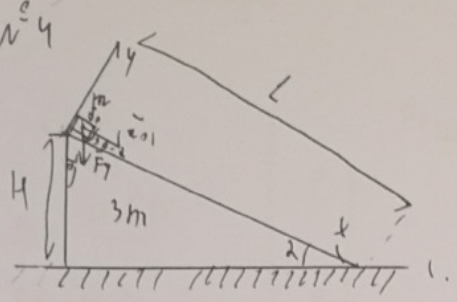
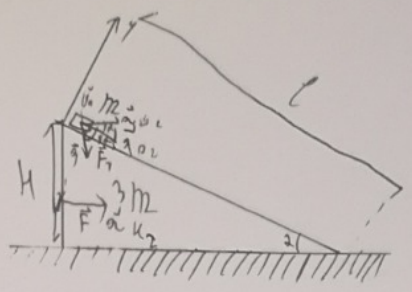
Вариант 1

Чистовик:

№4





Дано:

$m_ш = m$

$m_к = 3m$

H

$V_{0_1} = V_{0_2} = 0$

$\cos\alpha = \frac{4}{5}$

g

$F = 2mg$

$t_1, t_2, a_{к_2} = ?$

Реш-ие:

$l = \frac{H}{\sin\alpha}$

$\sin\alpha = \sqrt{1-\cos^2\alpha}$

$a_{o_1} = g\sin\alpha$

$l = V_{0_1}t_1 + \frac{a_{o_1}t_1^2}{2}$

$F = 2mg$

$F = (m_ш + m_к)a_2$ (по II закону Ньютона)

$a_2 = a_{ш_2} = a_{к_2}$

$a_{o_2} = g\sin\alpha + a_{к_2}\cos\alpha$

$l = V_{0_2}t_2 + \frac{a_{o_2}t_2^2}{2}$

$\Rightarrow$

$\frac{H}{\sin\alpha} = \frac{g\sin\alpha t_1^2}{2}$

$\sin\alpha = \sqrt{1-\cos^2\alpha}$

$a_2 = \frac{2mg}{4m} = \frac{g}{2}$

$a_{к_2} = a_2$

$a_{o_2} = g\sin\alpha + a_{к_2}\cos\alpha$

$\frac{H}{\sin\alpha} = \frac{a_{o_2}t_2^2}{2}$

$\Rightarrow$

$t_1 = \frac{1}{\sin\alpha}\sqrt{\frac{2H}{g}}$

$\sin^2\alpha = \sqrt{1-\cos^2\alpha}$

$a_{к_2} = \frac{g}{2}$

$a_{o_2} = g\left(\sin\alpha + \frac{\cos\alpha}{2}\right)$

$\frac{H}{\sin\alpha} = \sqrt{\frac{2H}{\sin\alpha \cdot a_{к_2}}}t_2^2$

$\Rightarrow$

$t_1 = \frac{1}{\sqrt{1-\cos^2\alpha}}\sqrt{\frac{2H}{g}} = \frac{1}{\sqrt{1-\frac{4^2}{5^2}}}\sqrt{\frac{2H}{g}} = \frac{5}{3}\sqrt{\frac{2H}{g}}$

$a_{к_2} = \frac{g}{2}$

$t_2 = \sqrt{\frac{2H}{\sqrt{1-\cos^2\alpha}\cdot\left(g\left(\sqrt{1-\cos^2\alpha} + \frac{\cos\alpha}{2}\right)\right)}} = \sqrt{\frac{2H}{\sqrt{1-\frac{4^2}{5^2}}\cdot\left(g\left(\sqrt{1-\frac{4^2}{5^2}} + \frac{4}{5\cdot 2}\right)\right)}} =$

$= \sqrt{\frac{2H}{g\cdot\frac{3}{5}}} = \sqrt{\frac{10H}{3g}}$

Ответ: $t_1 = \frac{5}{3}\sqrt{\frac{2H}{g}}$; $a_{к_2} = \frac{g}{2}$; $t_2 = \sqrt{\frac{10H}{3g}}$

(1)

Чистовик

№ 5.

Дано:

$i = 3$

$p_2 = \frac{102\%}{100\%} p_1$

~~$V_2 = \frac{102\%}{100\%} V_1$~~

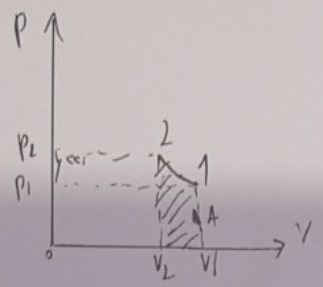
$V_2 = \frac{99\%}{100\%} V_1$

$\frac{2\%}{100\%} p_1 \ll 1$

$\frac{1\%}{100\%} V_1 \ll 1$

Как изменилась температура газа, $\frac{(T_2 - T_1) \cdot 100\%}{T_1}$, $\frac{Q}{A'}$ — ?

Решение:



$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$p_1 V_1 = \frac{m_1}{M} R T_1$

$p_2 V_2 = \frac{m_2}{M} R T_2$ ⇒

$\Delta U = Q + A$

$A' = -A$

$\Delta U = \frac{i}{2} \frac{m}{M} R \Delta T$

$\Delta T = T_2 - T_1$

$T_2 = T_1 \frac{p_2 V_2}{p_1 V_1}$

$A' \approx p_1 \Delta V$ (т.к. $0{,}02 p_1 \ll 1$)

$\Delta V = V_2 - V_1$

$Q = \Delta U + A'$

$\Delta U = \frac{i}{2} \frac{m_2}{M} R (T_2 - T_1)$

$p_1 V_1 = \frac{m_2}{M} R T_1$

$1{,}02 p_1 V_2 = \frac{m_2}{M} R T_2$

$T_2 = T_1 \frac{1{,}02 p_1 \cdot 0{,}99 V_1}{p_1 \cdot V_1} =$

$= 1{,}0098 T_1$

$A' = \frac{m_2}{M} \cdot R \left(\frac{T_2}{1{,}02} - T_1 \right)$ ⇒

$Q = \frac{i}{2} \frac{m_2}{M} R (T_2 - T_1) + A'$

⇒ Температура увеличилась

$\frac{(T_2 - T_1)}{T_1} \cdot 100\% = 0{,}98\%$

$A' = \frac{m_2}{M} R \left\{ T_1 \left(\frac{1{,}0098}{1{,}02} - 1 \right) = \frac{m_2}{M} R T_1 \cdot (-0{,}01) \right.$

$Q = \frac{i}{2} \frac{m_2}{M} R (1{,}0098 T_1 - T_1) + A' = \frac{i}{2} \frac{m_2}{M} R \cdot 0{,}0098 T_1 + A'$

⇒ $T \uparrow$

$\frac{T_2 - T_1}{T_1} \cdot 100\% = 0{,}98\%$

$Q = \left(\frac{i}{2} \cdot 0{,}0098 - 0{,}01 \right) \frac{m_2}{M} R T_1 = \left(\frac{3}{2} \cdot 0{,}0098 - 0{,}01 \right) \cdot \frac{m_2}{M} \cdot R T_1 = 0{,}0047 \frac{m_2}{M} R T_1$ ⇒

$A' = -0{,}01 \frac{m_2}{M} R T_1$

⇒ $T \uparrow$

$\frac{T_2 - T_1}{T_1} \cdot 100\% = 0{,}98\%$

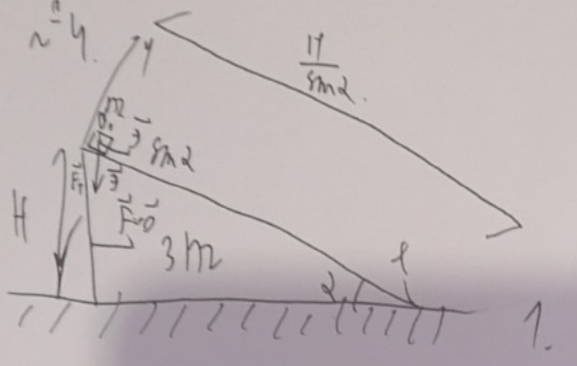
$\frac{Q}{A'} = \frac{0{,}0047 \frac{m_2}{M} R T_1}{-0{,}01 \frac{m_2}{M} R T_1} = -0{,}47$

Ответ: $T \uparrow$; $\frac{T_2 - T_1}{T_1} = 0{,}98\%$; $\frac{Q}{A'} = -0{,}47$

2

Черновик.

№4.



$a = g\sin\alpha$

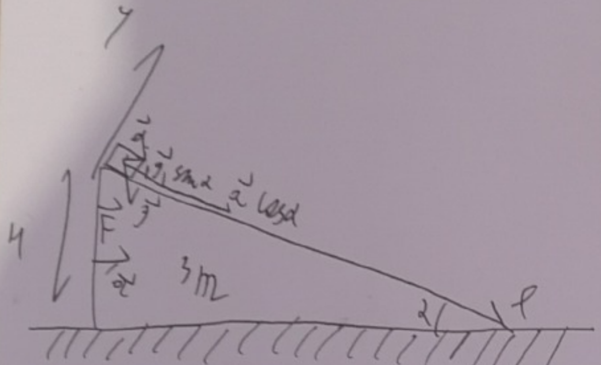
$L = \frac{H}{\sin\alpha}$ $\Rightarrow$ $\frac{H}{\sin\alpha} = \frac{gt^2\sin\alpha}{2}$ $\Rightarrow$

$v_0 = 0$

$L = v_0t + \frac{at^2}{2}$

$\Rightarrow \sqrt{\frac{2H}{g\sin^2\alpha}} = t$

$t = \sqrt{\frac{2H}{g(1-\cos^2\alpha)}} = \frac{5}{3}\sqrt{\frac{2H}{g}}$



$F = 2mg = 4ma$ (по II. зак. Ньютона 4a) $\Rightarrow$

$\Rightarrow a = \frac{g}{2}$

$a = g\sin\alpha + a\cos\alpha = g(\sin\alpha + \frac{\cos\alpha}{2})$

$L = \frac{H}{\sin\alpha}$ $\Rightarrow$ $\frac{H}{\sin\alpha} = \frac{t^2 g(\sin\alpha + \frac{\cos\alpha}{2})}{2}$ $\Rightarrow$

$v_0 = 0$

$L = v_0t + \frac{a_0t^2}{2}$ $\Rightarrow \frac{5H}{3} = \frac{t^2g}{2}$ $\Rightarrow$

$\Rightarrow t = \sqrt{\frac{10H}{3g}}$

№5.

Дано:

$i = 3$

$p_2 = p_1 \cdot 1{,}02$

$V_1 = V_2 \cdot 1{,}01$

$(0{,}02p_1 \ll 1)$

$(0{,}01V_2 \ll 1)$

$\frac{T_2}{T_1} \cdot 100\%$, $\frac{Q}{A'} = ?$

Реш-ие:

$p_1V_1 = \frac{m}{M} \cdot R \cdot T_1$

$p_2V_2 = \frac{m}{M} \cdot R \cdot T_2$

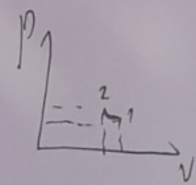
$\Delta U = Q + A$

$A' = -A$

$\Delta U = \frac{i}{2} \cdot \frac{m}{M} \cdot R \cdot \Delta T$

$\Delta T = T_2 - T_1$

$A' = p\Delta V$



$\Rightarrow$ $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ $\Rightarrow$ $\frac{T_2}{T_1} = \frac{p_2V_2}{p_1V_1} = \frac{p_1V_2 \cdot 1{,}02}{1{,}01 \cdot p_1V_2}$

$\approx 1{,}0099$

$\frac{T_2}{T_1} \cdot 100\% = 100{,}99\%$

Увеличилось на 0,99%.

$Q = \Delta U + A'$ $(\Delta p \ll 1)$

$A' \approx p_2V_2 - p_1V_1 = \frac{m}{M} R\Delta T$

$\Delta U = \frac{3}{2} \frac{m}{M} \cdot R \cdot \Delta T \Rightarrow Q = \frac{5}{2} \frac{m}{M} \cdot R\Delta T$

$A' = p\Delta V = \frac{-0{,}02 \frac{m}{M} RT_1}{1{,}02}$ $\quad A' = 0{,}0099 \cdot T_1$

$Q = \frac{3}{2}\frac{m}{M} RT_1 \cdot 0{,}0099 - \frac{0{,}02}{1{,}02}\frac{m}{M} RT_1$ $\quad \frac{Q}{A'} = \frac{-0{,}0147}{\frac{-0{,}02}{1{,}02}} = 0{,}2447$

$\frac{Q}{A'} = \frac{\frac{5}{2}}{1} = \frac{5}{2}$.

(2)

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