Часть 1

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

Шифр: **21206345**

ID профиля: **354165**

Вариант 4

Чистовик

1\. Дано:

$\alpha = 45^\circ$

$H = 10$ м

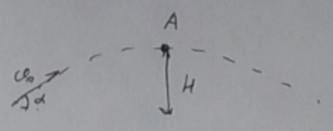
v_0 - ?

v - ?

Решение:

$H = v_0 t \sin\alpha - \frac{gt^2}{2}$

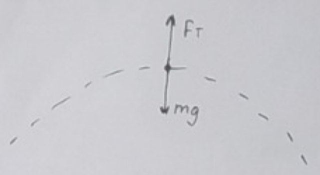
$v_0 \sin\alpha = gt \qquad t = \frac{v_0 \sin\alpha}{g}$



$H = \frac{v_0^2 \sin^2\alpha}{g} - \frac{v_0^2 \sin^2\alpha}{2g} = \frac{v_0^2 \sin^2\alpha}{2g} \qquad v_0 = \sqrt{\frac{2gH}{\sin^2\alpha}} = \sqrt{\frac{\cancel{2} \cdot 10 \cdot 10 \cdot 4}{\cancel{2}}} = \underline{20 м/с}$

R - радиус кривизны в т. A. в т. A центростр. ускорение $a_1 = g$

$a_1 = \frac{v_0^2 \cos^2\alpha}{R} \qquad R = \frac{v_0^2 \cos^2\alpha}{g}$



$mg - F_T = \frac{mg}{2} = ma_2 \qquad a_2 = \frac{g}{2}$

$a_2 = \frac{v^2}{R}$

$v = \sqrt{a_2 R} = \sqrt{\frac{\cancel{g} v_0^2 \cos^2\alpha}{2\cancel{g}}} = \sqrt{\frac{20^2 \cdot \cancel{2}}{4 \cdot \cancel{2}}} = \underline{10 м/с}$

Ответ: $v_0 = 20$ м/с; $v = 10$ м/с

Черновик

Дано:

$R = 8$ см

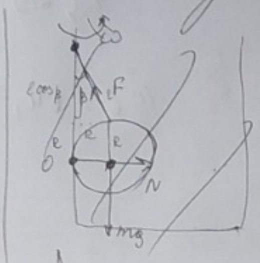
$l = 8$ см

$m = 5,2$ кг

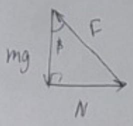
$\alpha = 60°$

F - ?

T - ?



Решение:

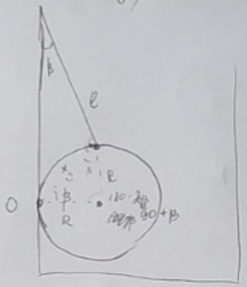


~~прав. мом. отн. О:~~

~~$mgR =$~~

~~$F + mg / \cos\beta$~~ $\sin\beta = \frac{l}{R}$

~~отн. R~~ -



$2R\cos\beta = x. \quad \operatorname{tg}\beta = \frac{x}{l} = \frac{2R\cos\beta}{l}$

$\sin\beta = \frac{2R\cos^2\beta}{l} \quad l\sin\beta = 2R - 2R\sin^2\beta$

прав. мом. отн. О: $mgR = Fx$

$2 \cdot 8\sin^2\beta + 8\sin\beta - 2 \cdot 8 = 0.$

$D = 1 + 2 \cdot 4 \cdot 2 = 9.$

$\sin\beta = \frac{-1 \pm 3}{4} = \frac{2}{4} = \frac{1}{2}.$

$a = \omega^2 R.$

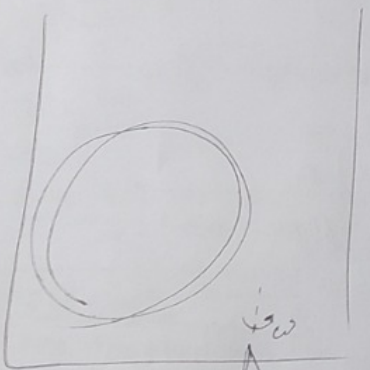
$mgR = F \cdot 2R\cos\beta$

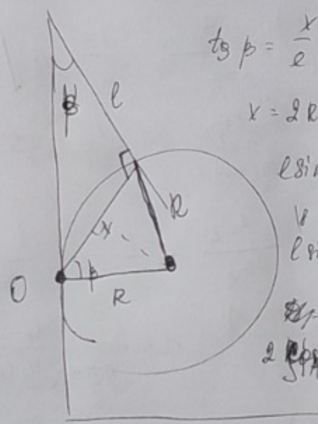
$\omega = \frac{2\pi}{T}$

$\cos\beta = \frac{\sqrt{3}}{2}$

$F = \frac{mg}{2\cos\beta} = \frac{5,2 \cdot 10 \cdot 2}{2 \cdot \sqrt{3}} = 30$ Н не получ.

1,732





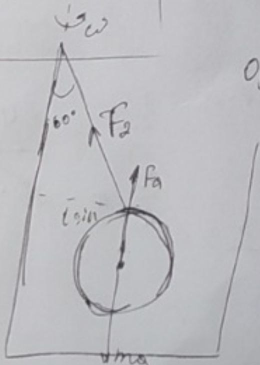
$\operatorname{tg}\beta = \frac{x}{l} =$

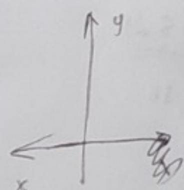
$x = 2R\cos\beta$

$l\sin\beta = \frac{2R\cos^2\beta}{R}$

$l\sin\beta + 2R\sin^2\beta - 2R = 0.$

$2\sin^2\beta + \sin\beta - 2 = 0.$





Oy: ~~mg~~

$F_a + F_2\cos 60° = mg$

Ox: $ma = F_2\sin 60°$

$D = 1 + 2 \cdot 2 \cdot 4 = 17$

$\sin\beta = \frac{-1 + \sqrt{17}}{4} = 0,78$

$\cos\beta = 0,62,482$

Черновик

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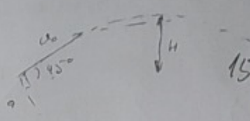
№1

3 Дано: $\alpha = 45°$; $H = 10$ м; $v_0 - ?$; $v - ?$

Решение

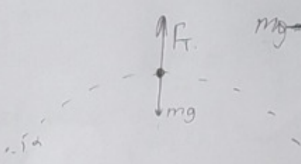
$H = v_0 t \sin\alpha - \frac{gt^2}{2}$

$v_0 \sin\alpha = gt \quad t = \frac{v_0 \sin\alpha}{g}$



$156 - 64{,}3072$

$H = \frac{v_0^2 \sin^2\alpha}{g} - \frac{v_0^2 \sin^2\alpha}{2g} = \frac{v_0^2 \sin^2\alpha}{2g} \quad v_0 = \sqrt{\frac{2gH}{\sin^2\alpha}} = \sqrt{\frac{2\cdot 10 \cdot 10 \cdot 4}{2}} = 10 \cdot 2 = 20$ м/с



$mg - F_T = \frac{mg}{2} = ma \quad a = \frac{g}{2}$

$a = g$

$a = \frac{v_0^2}{R}$

$a = \frac{v^2}{R} \quad R =$

$gR = v_0^2$

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

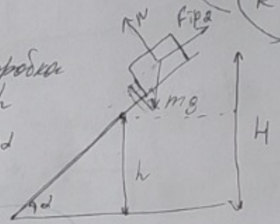
№2

Дано: $\cos\alpha = \frac{24}{25}$; $h = 1{,}4$ м; $\mu_1 = 0{,}5$; $\mu_2 = 0{,}06$; $v_0 = 0$; $v_{max} - ?$; $S - ?$

Решение: Предположим, изначально коробка бегла на высоте $H > h$

$ma_2 = mg\sin\alpha - F_{тр_2}$

$F_{тр_2} = \mu_2 N \quad N = mg\cos\alpha \quad a_2 = g\sin\alpha - \mu_2 g\cos\alpha$



тогда на высоте h скорость коробки равна: $\frac{(H-h)}{\sin\alpha} = \frac{v^2 - v_0^2}{2a_2} = \frac{v^2}{2a_2} \quad v = \sqrt{\frac{(H-h)\cdot 2a_2}{\sin\alpha}}$

$\frac{h}{x} = \sin\alpha$

~~$ma_1 = mg\sin\alpha - F_{тр}$~~ $ma_1 = F_{тр_1} - mg\sin\alpha \quad a_1 = \mu_1 g\cos\alpha - g\sin\alpha$

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$F_{тр_1} = \mu_1 N = \mu_1 mg\cos\alpha$

$\sin\alpha = \frac{7}{25}$

$\frac{h}{\sin\alpha} = \frac{v_к^2 - v^2}{2a_1} = \frac{-v^2}{2a_1} \quad \frac{h}{\sin\alpha} = \frac{(H-h)\cdot 2a_2}{\sin\alpha \cdot (\mu_1 g\cos\alpha - g\sin\alpha)\cdot 2}$

$h = \frac{(H-h)\cdot g(\sin\alpha - \mu_2\cos\alpha)}{g(\mu_1\cos\alpha - \sin\alpha)} \Rightarrow H = \frac{h(\mu_1\cos\alpha - \sin\alpha)}{\sin\alpha - \mu_2\cos\alpha} + h = \frac{1{,}4\left(0{,}5\cdot\frac{24}{25} - \frac{7}{25}\right)}{\frac{7}{25} - 0{,}06\cdot\frac{24}{25}} + 1{,}4 =$

$= \frac{1{,}4 \cdot 25}{5 \cdot 5{,}56} + 1{,}4 = 2{,}66$ м. $\quad S = \frac{H}{\sin\alpha} = \frac{2{,}66\cdot 25}{7} = 9{,}5$ м $\quad \frac{1{,}4\cdot 5\cdot 25}{25\cdot 5{,}56}$

$v = \sqrt{}$

$\frac{20}{2} = 10$

$\frac{5{,}56}{25}$

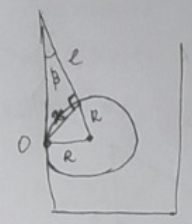
49, 2/91

Чистовик

3. Дано:

$R = 8$ см;
$l = 8$ см;
$m = 5{,}2$ кг
$\alpha = 60°$

F - ?
T - ?



Решение:

$\operatorname{tg}\beta = \frac{x}{l}$ $\qquad x = 2R\cos\beta$

$l\sin\beta = 2R\cos^2\beta$

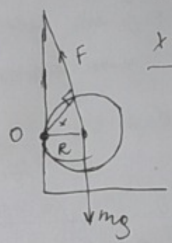
$2R\sin^2\beta + l\sin\beta - 2R = 0$

$D = 1 + 2\cdot2\cdot4 = 17$

$\sin\beta = \frac{-1+\sqrt{17}}{4} = 0{,}78$

$\cos\beta = \sqrt{1-\sin^2\beta} = 0{,}626$

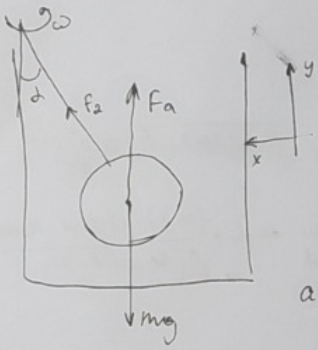
$x = 2R\cos\beta$



Прав. мом. отн. O:

$mgR = Fx$

$F = \frac{mgR}{2R\cos\beta} = \frac{5{,}2\cdot10}{2\cdot0{,}626} = 41{,}61$ Н



$Oy: F_a + F_2\cos\alpha = mg$ $\qquad F_a = \rho_в g\cdot\frac{4}{3}\pi R^3$

$Ox: ma = F_2\sin\alpha$

$F_2 = \frac{mg - \frac{4}{3}\rho_в g\pi R^3}{\cos\alpha}$

$ma = \left(mg - \frac{4}{3}\rho_в g\pi R^3\right)\operatorname{tg}\alpha$

$a = \omega^2 r$ $\qquad$ ~~...~~ $\qquad r = l\sin\alpha$

$\omega = \frac{2\pi}{T}$

$a = \frac{(3mg - 4\rho_в g\pi R^3)\operatorname{tg}\alpha}{3m} = \frac{4\pi^2\cdot l\sin\alpha}{T^2}$

$T = \sqrt{\frac{4\pi^2 l\cdot3m}{(3mg - 4\rho_в g\pi R^3)\cos\alpha}} = \sqrt{\frac{4\cdot3{,}14^2\cdot0{,}08\cdot3\cdot5{,}2}{(3\cdot5{,}2\cdot10 - 4\cdot10^3\cdot10\cdot3{,}4\cdot(0{,}08)^3)\cdot0{,}5}} = 1{,}04$ с

Ответ: $F = 41{,}61$ Н; $T = 1{,}04$ с

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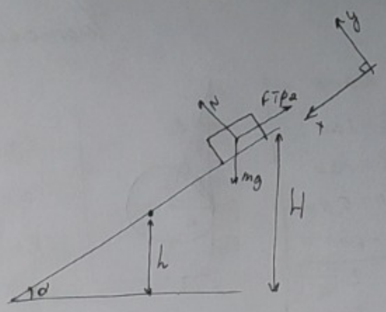
Чистовик



2. Дано:

$\cos\alpha = \frac{24}{25}$

$h = 1,4$ м

$\mu_1 = 0,5$

$\mu_2 = 0,06$

$v_0 = 0$

---

v_{max} - ?

S - ?

Решение

~~Предположение, изначально~~

II з-н. Ньют. для момента, когда коробка на высоте $> h$.

$ma_2 = mg\sin\alpha - F_{тр_2}$ (Ox)

$F_{тр_2} = \mu_2 N$ $\quad N = mg\cos\alpha$ (Oy) $\quad a_2 = g\sin\alpha - \mu_2 g\cos\alpha$

На высоте h скорость коробки максимальна, т.к. далее скорость коробки будет уменьшаться до полной остановки. Эта скорость равна $\frac{(H-h)}{\sin\alpha} = \frac{v_{max}^2 - v_0^2}{2a_2} = \frac{v_{max}^2}{2a_2}$

$$v_{max}^2 = \frac{(H-h)\cdot 2a_2}{\sin\alpha} = \frac{(H-h)\cdot 2g(\sin\alpha - \mu_2\cos\alpha)}{\sin\alpha}$$

II з-н. Ньют. для коробки на высоте h.

Ox: $ma_1 = mg\sin\alpha - F_{тр_1}$

Oy: $F_{тр_1} = \mu_1 N = \mu_1 mg\cos\alpha$ $\quad a_1 = g\sin\alpha - \mu_1 g\cos\alpha \quad \sin\alpha = \sqrt{1-\cos^2\alpha} = 7/25$

$$\frac{h}{\sin\alpha} = \frac{v_к^2 - v^2}{2a_1} \quad v_к = 0 \Rightarrow \frac{h}{\sin\alpha} = \frac{(H-h)\cdot 2a_2}{\sin\alpha\cdot(\mu_1 g\cos\alpha - g\sin\alpha)\cdot 2} \Rightarrow h = \frac{(H-h)\cdot g(\sin\alpha - \mu_2\cos\alpha)}{g(\mu_1\cos\alpha - \sin\alpha)}$$

$$H = \frac{h(\mu_1\cos\alpha - \sin\alpha)}{\sin\alpha - \mu_2\cos\alpha} + h = \frac{1,4\left(0,5\cdot\frac{24}{25} - \frac{7}{25}\right)}{\frac{7}{25} - 0,06\cdot\frac{24}{25}} + 1,4 = 2,66 \text{ м}$$

$$S = \frac{H}{\sin\alpha} = \frac{2,66\cdot 25}{7} = 9,5 \text{ м.}$$

$$v_{max} = \sqrt{\frac{(H-h)\cdot 2\cdot g\cdot(\sin\alpha - \mu_2\cos\alpha)}{\sin\alpha}} = \sqrt{\frac{(2,66-1,4)\cdot 2\cdot 10\cdot\left(\frac{7}{25} - 0,06\cdot\frac{24}{25}\right)}{\frac{7}{25}}} = 4,47 \text{ м/с}$$

Ответ: $v_{max} = 4,47$ м/с ; ~~[illegible]~~ $S = 9,5$ м

Часть 2

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

Шифр: **21206345**

ID профиля: **354165**

Вариант 4

Черновик

№4

Дано:
$m = 10г$
$t_0 = 20°C$
$P_0 = 1,0 \cdot 10^5 Па$
$Q = 33 кДж$
$Q_1 - ?$
$V - ?$

Решение:

$Q_1 = cm(t_{100} - t_0)$ $t_{100} = 100°C$

$Q_1 = 4180 \cdot 0,01 \cdot 80 = 3344 Дж$ 273

$Q = Q_1 + rm_1$

$m_1 = \frac{Q - Q_1}{r} = \frac{33 \cdot 10^3 - 3344}{2,26 \cdot 10^6} = 0,013 кг$

$m_1 > m \Rightarrow$ вся вода испарится, и пар начнет нагреваться

$Q = Q_1 + rm + c_p m(t_к - t_{100})$

$t_к = \frac{Q - Q_1 - rm}{c_p m} + t_{100} = \frac{33 \cdot 10^3 - 3344 - 2,26 \cdot 10^6 \cdot 0,01}{2200 \cdot 0,01} = 320,73 °C$

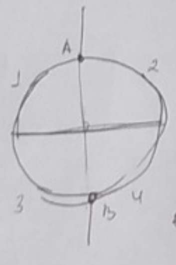
$T_к = t_к + 273$ моль $= \frac{кг}{г}$ $\frac{m}{M}$

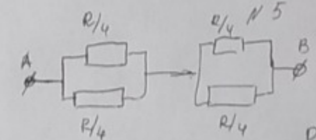
$P_0 V = \nu R T_к$

$\nu = \frac{m}{M_в}$ $M_в = 0,018$ кг/моль

$V = \frac{\nu R T_к}{P_0} = \frac{mR(t_к + 273)}{M_в \cdot P_0} = 2,741 \cdot 10^{-3} м^3$

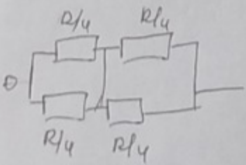
№5



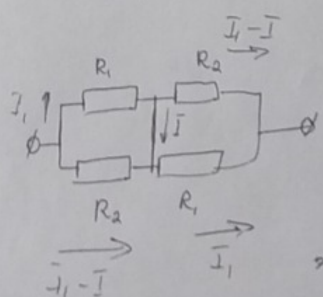


$I_0 = \frac{U}{R_0}$ $R_0 = \frac{R/4 \cdot R/4}{R/4 + R/4} \cdot 2 = \frac{18 \cdot 18 \cdot 2}{18 + 18} = \frac{18 \cdot 18 \cdot 2}{36} =$

$P = IU = \frac{U^2}{R_0} = \frac{24^2}{18} = 32 Вт$ ~18 Ом



$R_0 = \frac{((R/4) \cdot 2)^2}{R/4 \cdot 4} = \frac{R^2}{4} \cdot \frac{1}{R} = \frac{R}{4}$, $\frac{360}{90} = 4$



$R_1 = R \cdot \frac{\alpha}{360°}$

$\cancel{R_2 = R \cdot \frac{180 - \alpha}{360°}}$ $R_2 = (R - 2R_1)$

$\frac{R\beta}{360°}$

$I_1 = I_0 \frac{R_2}{R_1 + R_2} = I_0 \frac{R/2 - 2R_1}{R/2}$ $I_1 - I = I_0 \frac{R_1}{R_1 + R_2}$

21206345 (U354165 M1283617)

$$I_1 = I_0' \frac{R/2 - R_1}{R/2} \qquad I_1 - I = I_0' \frac{R_1}{R/2} \qquad \frac{I_1}{I_2} = \frac{R_2}{R_1}$$

$$I_0' - \frac{R_1 I_0'}{R/2} - I = I_0' \frac{R_1}{R/2} \qquad I_0' = \frac{U}{R_0'} \qquad R_0' = \frac{R_1 R_2}{R_1 + R_2} \cdot 2 = \frac{2R_1 (R/2 - R_1)}{R/2}$$

$$I_0' = \frac{UR}{2 \cdot 2R_1 (R/2 - R_1)}$$

$$I_0' - I = 2 I_0' \frac{R_1}{R/2}$$

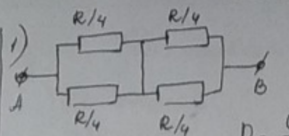
$$4U + IR$$

$$\frac{UR}{2R_1 R - 4R_1^2} - I = \frac{U R R_1}{2R_1 (R/2 - R_1) \cdot (R/2)}$$

$$\frac{UR}{2R_1 R - 4R_1^2} - I = \frac{2U}{R + 2R_1}$$

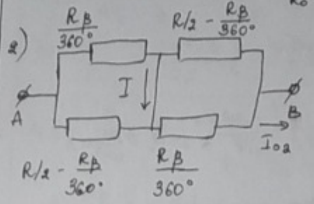
~~[illegible]~~ Черновик

5. Дано:
$R = 72$ Ом
$U = 24$ В
$\alpha = 90^\circ$
$I = 0{,}5$ А
$P - ?$
$\beta - ?$
$P_2 - ?$

1)


$\cancel{R_0 = \frac{R/4 \cdot R/4}{R/4}}$ $R_0 = \frac{((R/4)\cdot 2)^2}{R/4 \cdot 4} = \frac{R}{4} = \frac{72}{4} = 18$ Ом

$P = \frac{U^2}{R_0} = \frac{24^2}{18} = 32$ Вт

2)


$I_{02} = \frac{U}{R_{02}}$ $\cancel{R_{02}}$ Пусть $\frac{R\beta}{360^\circ} = R_1$

$R_{02} = \frac{R_1 \cdot (R/2 - R_1)}{R_1 + R/2 - R_1} = \frac{R_1(R/2 - R_1)}{R/2}$

$I_1 = I_{02}\frac{R/2 - R_1}{R/2}$ $I_2 = I_1 - I = I_{02}\frac{R_1}{R/2}$ $I_{02} = \frac{UR}{2R_1(R/2 - R_1)}$

$I_{02} - \frac{R_1 I_{02}}{R/2} - I = \frac{I_{02}R_1}{R/2}$ $I_{02} - I = \frac{4R_1 I_{02}}{R}$

$\frac{UR}{2R_1(R/2 - R_1)} - I = \frac{{}^2\cancel{4}R_1 UR}{\cancel{R}\cdot 2R_1(R/2 - R_1)} = \frac{2U}{R/2 - R_1}$ $I = \frac{U}{R/2 - R_1}\left(\frac{R}{2R_1} - 2\right) = \frac{U}{R/2 - R_1}\left(\frac{R - 4R_1}{2R_1}\right)$

$IRR_1 - 2IR_1^2 = UR - 4UR_1$ $R_1^2 - R_1 \cdot 132 + 1728 = 0.$ D.

$I_1 = I_{02}\cdot\frac{R/2 - R_1}{R/2}$ $I_2 = I_{02}\frac{R_1}{R/2}$ $I_1 - I_2 = I_2$

$I_{02}\left(\frac{R/2 - R_1 - R_1}{R/2}\right) = I$ $I = I_{02}\left(\frac{R - 4R_1}{R}\right)$ $I_{02} = \frac{UR}{2R_1(R/2 - R_1)}$

10512

$I = \frac{U\cancel{R}(R - 4R_1)}{2R_1(R/2 - R_1)\cancel{R}} = \frac{UR - 4UR_1}{R_1R - 2R_1^2}$

17424

6912

$IR_1R - 2IR_1^2 = UR - 4UR_1$ $R_1^2 \cdot \underbrace{2\cdot 0{,}5}_{1} - R_1\overbrace{(4\cdot 24 + 0{,}5\cdot 72)}^{132} + \overbrace{24\cdot 72}^{1728} = 0.$

$D = 10512$

$I_{02} = 2{,}759$ $R_{02} = 8{,}7$ $R_1 =$

$R_1 = 14{,}736.$

$I_1 = 1{,}629$

$\cancel{I_{02} = 2{,}7}$

$I_2 = 1{,}13$

21206345 (U354165 M1283617)

Чистовик

5. Дано:

$R = 72$ Ом

$U = 24$ В

$\alpha = 90°$

$I = 0,5$ A

P - ?

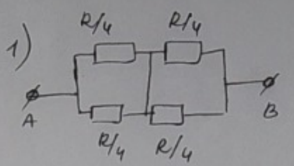
β - ?

P_2 - ?

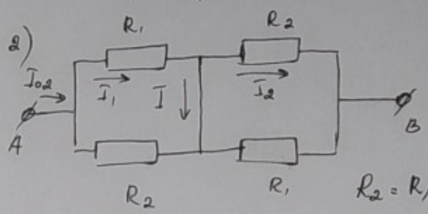
Решение:

$$R_0 = \frac{\left((R/4)\cdot 2\right)^2}{R/4 \cdot 4} = \frac{R^2}{4R} = \frac{R}{4}$$

$$P = \frac{U^2}{R_0} = \frac{24^2 \cdot 4}{72} = 32 \text{ Вт}$$



$$I_{02} = \frac{U}{R_{02}} \quad R_{02} = \frac{R_1(R/2 - R_1)}{R_1 + R/2 - R_1} = \frac{R_1(R/2 - R_1)}{R/2}$$



$R_2 = R/2 - R_1$

$$I_1 = I_{02} \cdot \frac{R/2 - R_1}{R/2} \qquad I_2 = I_{02} \frac{R_1}{R/2} \qquad I_1 - I_2 = I = \frac{UR(R - 4R_1)}{2R_1(R/2 - R_1)R} = \frac{UR - 4R_1U}{R_1R - 2R_1^2}$$

$$IR_1R - 2IR_1^2 = UR - 4R_1U \qquad R_1^2 \cdot 2 \cdot 0,5 - R_1(4\cdot 24 + 0,5\cdot 72) + 24\cdot 72 = 0$$

$$D = 17424 - 6912 = 10512$$

$$R_1 = \frac{132 \pm \sqrt{10512}}{2} \qquad R_1 = R\frac{\beta}{360°} \qquad \beta = \frac{R_1 \cdot 360}{R} = 73,68°$$

(два ответа потому, что β может быть меньше и больше 90°, то есть R_1 и R_2 могут поменяться местами, тогда ток I пойдет „вверх".)

$$P_2 = \frac{U^2}{R_{02}} = \frac{24^2 \cdot 36}{14,736(36 - 14,736)} = 66,17 \text{ Вт.}$$

Ответ: $P = 32$ Вт; $\beta = 73,68°$ (106,32°); $P_2 = 66,17$ Вт.

лист 2 из 2

Чистовик

4. Дано:

$m = 10$ г

$t_0 = 20°C$

$P_0 = 1{,}0 \cdot 10^5$ Па

$Q = 33$ кДж

$Q_1 - ?$

$V - ?$

Решение:

$Q_1 = cm(t_{100} - t_0)$ $\quad t_{100} = 100°C$

$Q_1 = 4180 \cdot 0{,}01 \cdot 80 = \underline{3344 \text{ Дж}}$

Проверим, испарится ли вся вода

$Q = Q_1 + rm_1$ $\quad m_1 = \dfrac{Q - Q_1}{r} = \dfrac{33 \cdot 10^3 - 3344}{2{,}26 \cdot 10^6} = 0{,}013$ кг

$m_1 > m \Rightarrow$ вся вода испарится, и пар начнет нагреваться.

$Q = Q_1 + rm + c_p m(t_к - t_{100})$ $\quad t_к$ - температура пара в конце

$$t_к = \frac{Q - Q_1 - rm}{c_p m} + t_{100} = \frac{33 \cdot 10^3 - 3344 - 2{,}26 \cdot 10^6 \cdot 0{,}01}{2200 \cdot 0{,}01} + 100 = 420{,}73°C$$

$P_0 V = \nu R T_к$ $\quad T_к = t_к + 273$ $\quad \nu = \dfrac{m}{\mu_в}$ $\quad \mu_в = 0{,}018$ кг/моль

$$V = \frac{\nu R T_к}{P_0} = \frac{mR(t_к + 273)}{\mu_в P_0} = \frac{0{,}01 \cdot 8{,}31 \cdot 693{,}73}{0{,}018 \cdot 10^5} = 3{,}203 \cdot 10^{-3} \text{ м}^3$$

<u>Ответ</u>: $Q_1 = 3344$ Дж; $V = 3{,}203 \cdot 10^{-3}$ м^3

лист 1 из 2