

# ОТВЕТЫ

## 1. ОСНОВЫ КИНЕМАТИКИ

27.  $d = vt \sin \alpha = 35$  м. 28.  $v = 5$  м/с,  $y = -0,5 + 0,8x$ .

29.  $v_2 = v_1 + 2v = 19$  км/ч,  $v_2' = v_1 + v = 17$  км/ч.

30.  $v_1 = \frac{L}{t} + \sqrt{\left(\frac{L}{t}\right)^2 + v^2} = 14$  м/с.

31.  $v_1 = \frac{s}{\sqrt{t_1 t_2}} = 5,0$  м/с,  $v_2 = \frac{s}{t_2} = 2,5$  м/с.

32.  $t = \frac{L+l}{v} = 1,2 \cdot 10^2$  с.

33. На расстоянии 200 м от местонахождения автомобиля в начальный момент времени (см. рис. 288);  $t = \frac{l}{v_1 + v_2} = 20$  с; не изменится.

34.  $t_3 = \frac{2t_1 t_2}{t_2 - t_1} = 30$  мин.

35.  $\tau = \frac{s}{v_1 - v_2} = 4$  ч,  $s_1 = \frac{sv_1}{v_1 - v_2} = 2,0 \cdot 10^2$  км.

36.  $v_1 = \frac{v}{\operatorname{tg} \alpha} = 8,7$  м/с. 37.  $l = l_0 - \frac{v_0^2}{2a} = 1 \cdot 10^2$  м. 38.  $t = \frac{t_1^2 + t_2^2}{2t_2}$ .

39.  $t_2 = (2 + \sqrt{2})t_1 = 102$  мин.

40.  $a = \frac{l_2 - l_1}{\tau^2} = 0,63$  м/с<sup>2</sup>,  $v_0 = \frac{3l_1 - l_2}{2\tau} = 3,8$  м/с.

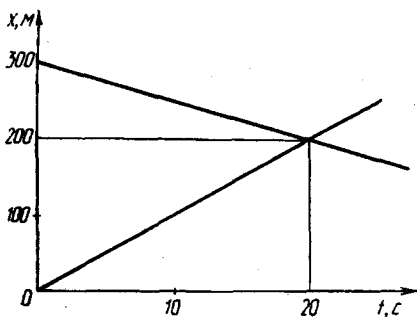
41.  $H = \frac{g}{2} \left( \frac{l}{g\tau} + \frac{\tau}{2} \right)^2 = 2,3 \cdot 10^2$  м. 42.  $h = 6gt^2 = 2,1 \cdot 10^2$  км.

43.  $v_0 = \frac{l_1 t_2^2 - l_2 t_1^2}{t_1 t_2^2 - t_2 t_1^2} = 10$  м/с. 44.  $v_1 = \frac{v}{\sqrt{2}} = 10$  м/с.

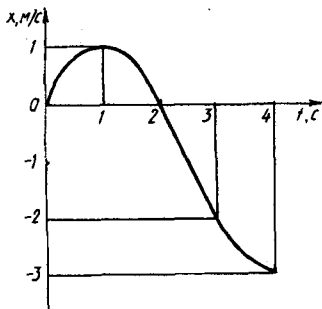
45.  $v_0 = \frac{4s - 18s_5}{t} = 0,6$  м/с. 46.  $\frac{l_2}{l_3} = 3$ .

47.  $l = \frac{8v_1^2 v_2^2}{a(v_1 + v_2)^2} = 3,8$  км. 48.  $t_2 = \frac{at_1}{g} \left( 1 + \sqrt{1 + \frac{g}{a}} \right) = 4$  с.

49.  $v_{\text{ср}} = \frac{2v_1(v_2 + v_3)}{2v_1 + v_2 + v_3} = 40$  км/ч.



Р и с. 288



Р и с. 289

50.  $v_{\max} = \frac{2s}{2s/v_{\text{ср}} - t_1 - t_2} = 58 \text{ км/ч.}$  51.  $v = \sqrt{2al} = 89 \text{ м/с.}$

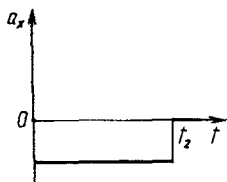
52.  $\Delta t = \tau - \sqrt{\frac{2h}{g}} = 0,37 \text{ с.}$

53. Решив уравнение  $\tau = \sqrt{\frac{2h}{g}} + \frac{h}{v}$ , получим  $h = 150 \text{ м.}$

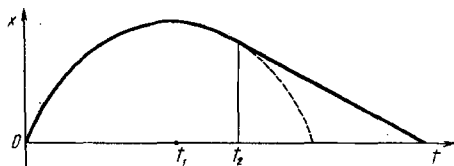
54.  $t = \sqrt{\frac{l}{a \cos \alpha}} = 2 \text{ с.}$  55.  $\tau = \sqrt{t^2 + \frac{2l}{g}} - t = 1 \text{ с.}$

56.  $h_1 = \frac{h}{9} = 30 \text{ м, } h_2 = \frac{3h}{9} = 90 \text{ м, } h_3 = \frac{5h}{9} = 150 \text{ м.}$

57. См. рис. 289. 58. См. рис. 290 и 291.



Р и с. 290



Р и с. 291

59.  $l = \frac{v_0^2}{g} - v_0 t_1 + \frac{g t_1^2}{2} = 41 \text{ м.}$  60. См. рис. 292.

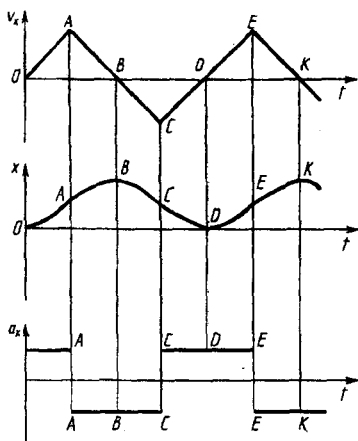
61.  $t_1 = \frac{v_0}{g} + \frac{\tau}{2} = 6 \text{ с, } h = \frac{v_0^2}{2g} - \frac{g \tau^2}{2} = 1,2 \cdot 10^2 \text{ м.}$  62.  $l = \sqrt{2} v_0 \tau.$

63.  $v_h = \sqrt{v_0^2 + 2g(H-h)} = 17 \text{ м/с, } v = \sqrt{v_0^2 + 2gH} = 22 \text{ м/с.}$

64.  $n_2 = 1 + (n_1 - 1) \frac{t_2}{t_1} = 11.$  65.  $l = \frac{1}{2} g (t_2^2 - t_1^2) = 15 \text{ м.}$

66.  $v_0 = \frac{1}{2} \sqrt{g(8h + g \tau^2)} = 40 \text{ м/с.}$

67.  $v_0 = \frac{g \tau}{2} = 50 \text{ м/с, } H = g \tau^2 / 8 = 1,3 \cdot 10^2 \text{ м.}$



Р и с. 292

$$68. t = \frac{v_0 + \sqrt{v_0^2 + 2gh_0}}{g}, \quad v = \sqrt{v_0^2 + 2gh_0}.$$

$$69. \alpha = \frac{(v_1 - v_2)t}{l} = 1 \text{ рад. } 70. v_0 = h \sqrt{\frac{g}{2H}} = 7 \text{ м/с.}$$

$$71. v_1 = v_2 = \sqrt{v_0^2 + 2gh} = 25 \text{ м/с. } 72. v = \sqrt{v_0^2 + 2g(H-h)} = 25 \text{ м/с.}$$

$$73. v_0 = s \sqrt{\frac{g}{2H}} = 10 \text{ м/с, } v_k = \sqrt{v_0^2 + 2gH} = 14 \text{ м/с.}$$

$$74. \frac{H_1}{H_2} = \text{tg}^2 \alpha. \quad 75. H = \frac{g\tau^2}{8} = 5 \text{ м.}$$

$$76. t_1 = \frac{v_0 \sin \alpha - \sqrt{v_0^2 \sin^2 \alpha - 2gh}}{g} = 0,3 \text{ с,}$$

$$t_2 = \frac{v_0 \sin \alpha + \sqrt{v_0^2 \sin^2 \alpha - 2gh}}{g} = 0,8 \text{ с.}$$

$$77. h = \frac{v_0^2}{2g} (\text{tg}^2 \alpha_0 - \text{tg}^2 \alpha) \cos^2 \alpha_0 = 6,7 \text{ м.}$$

$$78. v = \sqrt{v_0^2 + 2gh}. \quad 79. h_{\min} = l \text{tg} \alpha - \frac{gl^2}{2v^2 \cos^2 \alpha} = 0,3 \text{ м.}$$

$$80. s = 8h \sin \alpha = 8 \text{ м. } 81. s = t \sqrt{v_1^2 + v_2^2 - 2v_1v_2 \cos(\alpha_1 - \alpha_2)} = 46 \text{ м.}$$

82. Уравнение траектории  $x^2 + y^2 = R^2$ . Это уравнение окружности радиуса  $R$ . Модуль ускорения  $a = \omega^2 R$ , направлено оно по радиусу к центру окружности;  $\omega$  — угловая скорость.

$$83. \text{ В 2 раза. } 84. v_1 = 2v = 40 \text{ км/ч. } 85. R = \frac{lv_1}{v_1 - v_2} = 1,8 \text{ м.}$$

$$86. n = \frac{v}{\pi d} = 1 \cdot 10^2 \text{ с}^{-1}. \quad 87. v = 2\pi n l - \frac{a}{2\pi n} = 6 \text{ м/с}.$$

## 2. ОСНОВЫ ДИНАМИКИ

$$116. F = \frac{m(v_1 - v_2)}{\tau} = 2,8 \cdot 10^4 \text{ Н}.$$

$$117. v = \frac{F(\cos \alpha + \mu \sin \alpha) - \mu mg}{m} t = 39 \text{ м/с}, \quad s = \frac{vt}{2} = 2,0 \cdot 10^2 \text{ м}.$$

$$118. a = \frac{F}{m_1 + m_2} - \mu g = 4 \text{ м/с}^2, \quad T = \frac{m_1 F}{m_1 + m_2} = 3 \text{ Н}.$$

$$119. a = \frac{F}{m} \left( \cos \alpha_2 - \frac{mg - F \sin \alpha_2}{mg - F \sin \alpha_1} \cos \alpha_1 \right) = 0,82 \text{ м/с}^2.$$

$$120. s = \frac{F(F - \mu mg)t^2}{2\mu m^2 g}, \quad F > \mu mg. \quad 121. F = m\sqrt{a^2 - g^2} = 7 \text{ Н}.$$

$$122. a_1 = 2g \frac{m_2 - 2m_1}{4m_1 + m_2} = 2,8 \text{ м/с}^2, \quad a_2 = g \frac{m_2 - 2m_1}{4m_1 + m_2} = 1,4 \text{ м/с}^2,$$

$$T_1 = \frac{3m_1 m_2 g}{4m_1 + m_2} = 1,3 \text{ Н}, \quad T_2 = \frac{6m_1 m_2 g}{4m_1 + m_2} = 2,6 \text{ Н}.$$

$$123. t = \sqrt{\frac{h(m_1 + m_2)}{g(m_1 - m_2)}} = 1,4 \text{ с}.$$

$$124. a = \frac{gm_2}{m_1 + m_2} = 2,5 \text{ м/с}^2, \quad T = \frac{m_1 m_2 g}{m_1 + m_2} = 7,5 \text{ Н}.$$

$$125. T_1 = F - T = 70 \text{ Н}.$$

$$126. F = \frac{ES\Delta l}{l} = 2,16 \cdot 10^4 \text{ Н}, \quad F_{\min} = \sigma_{\text{пр}} S = 7,85 \cdot 10^4 \text{ Н}.$$

$$127. t = \frac{F\tau}{mg} \left( 1 + \sqrt{\frac{F}{F - mg}} \right).$$

$$128. F = m \left( \frac{v^2 - v_0^2}{2s} + g(\mu \cos \alpha + \sin \alpha) \right).$$

$$129. m = 2 \left( M - \frac{F_A}{g} \right) = 2 \cdot 10^2 \text{ кг}.$$

$$130. a = \frac{g(m_1(\sin \alpha - \mu \cos \alpha) - m_2)}{m_1 + m_2} = 1 \text{ м/с}^2.$$

$$131. m_1 = 3m_2. \quad 132. \mu = \frac{m_2}{m_1} - \frac{2s(m_1 + m_2)}{m_1 g t^2} = 0,2.$$

$$133. g = \frac{a(m_1 + m_2)}{m_2 - m_1} = 9,8 \text{ м/с}^2. \quad 134. m_1 = \frac{4ms}{gt^2 - 2s} = 10 \text{ г}.$$

$$135. F = \frac{4m_1 m_2 g}{m_1 + m_2} = 1 \cdot 10^1 \text{ Н}. \quad 136. \frac{F_1}{F_2} = \frac{1 + \mu \operatorname{tg} \alpha}{1 - \mu \operatorname{tg} \alpha} = 1,1.$$

$$137. T = \frac{m(g+a)}{2 \cos(\alpha/2)}. \quad 138. F = \rho S v^2 = 3 \cdot 10^1 \text{ Н.}$$

$$139. F = m \left( g + \frac{2\sqrt{2gh}}{t} \right) = 2,2 \text{ Н.} \quad 140. F_c = F - \frac{mv^2}{2l} = 2 \cdot 10^3 \text{ Н.}$$

$$141. l = \frac{v^2}{2\mu g} = 51 \text{ м.} \quad 142. v_2 = \frac{a_0 v_1}{a_0 - a_1} = 90 \text{ км/ч.}$$

$$143. F_{\min} = \frac{\mu mg}{\sqrt{\mu^2 + 1}} = 1,5 \cdot 10^2 \text{ Н.} \quad 144. F_{\text{тр}} = kt \cos \alpha = 6 \text{ Н.}$$

$$145. T = \frac{F_1 + 2F_2}{3} = 80 \text{ Н.}$$

$$146. F_{\text{тр}} = mg \sin \alpha \text{ при } \operatorname{tg} \alpha < \mu, \quad F_{\text{тр}} = \mu mg \cos \alpha \text{ при } \operatorname{tg} \alpha > \mu.$$

147.  $\alpha = \arcsin \frac{a_1 + a_2}{2g} = 11^\circ$ ; здесь  $a_1 = 3 \text{ м/с}^2$ ,  $a_2 = 0,8 \text{ м/с}^2$  находим из графика.

$$148. \mu = \frac{n^2 - 1}{n^2 + 1} \operatorname{tg} \alpha = 0,2. \quad 149. h = \frac{v_0^2 \operatorname{tg} \alpha}{2g(\operatorname{tg} \alpha - \mu)}.$$

$$150. \alpha = \operatorname{arctg} \frac{v^2}{gR} = 45^\circ. \quad 151. v = \sqrt{\frac{(n-1)gR}{n}} = 20 \text{ м/с.}$$

$$152. v > \sqrt{(n-1)gR}. \quad 153. T = \sqrt{\frac{3\pi}{\rho G}} = 1 \cdot 10^2 \text{ мин.}$$

$$154. R = \frac{v^2}{\mu g} = 51 \text{ м.} \quad 155. F_B = 3mg = 1,2 \cdot 10^2 \text{ Н.}$$

$$156. \omega = \sqrt{\frac{g}{l \cos \alpha}} = 5 \text{ рад/с,} \quad T = \frac{mg}{\cos \alpha} = 2 \text{ Н.}$$

$$157. g_{\text{л}} = \frac{4\pi^2 l \cos \alpha}{T^2} = 9,8 \text{ м/с}^2. \quad 158. R = \frac{mv^2}{\sqrt{\rho^2 - m^2 g^2}} = 4 \cdot 10^2 \text{ м.}$$

$$159. v = \sqrt{R \left( \frac{F}{m} - g \right)} = 1,4 \cdot 10^2 \text{ м/с.}$$

$$160. g = g_3 \frac{n_1^2}{n_2} = 1,7 \text{ м/с}^2, \quad \frac{v_{03}}{v_{0\text{л}}} = \frac{\sqrt{n_2}}{n_1} = 2,4.$$

$$161. |\Delta \vec{p}| = \sqrt{2} mv = 14 \text{ кг} \cdot \text{м/с.} \quad 162. \alpha = \arccos 0,5 = 60^\circ.$$

$$163. T = mg \left( 1 + \frac{L^2}{2l(H-l)} \right) = 9 \text{ Н.} \quad 164. T = 3mg.$$

$$165. T = 3mg \sin \alpha = 1,5 \text{ Н,} \quad T_{\max} = 3mg = 2,9 \text{ Н.}$$

$$166. \alpha = \operatorname{arctg} \frac{v^2}{gR}. \quad 167. \mu = \frac{4\pi^2 n^2 r}{g} = 2,5 \cdot 10^{-2}.$$

$$168. \omega = \sqrt{\frac{g}{R \cos \alpha}} = 5 \text{ рад/с (здесь } \alpha = 60^\circ).$$

$$169. T = \sqrt{\frac{6\pi}{\rho G}} = 9,7 \cdot 10^3 \text{ с.} \quad 170. M = \frac{Rv^2}{G} = 2,0 \cdot 10^{30} \text{ кг.}$$

$$171. \rho = \frac{3rv^2}{4\pi GR^3} = 5 \cdot 10^2 \text{ кг/м}^3. \quad 172. r = g_0 R^2 \left( \frac{1}{v_1^2} - \frac{1}{v_2^2} \right).$$

$$173. F = \frac{(n^2 - 1)GmM}{R^2}. \quad 174. T = 2\pi \sqrt{\frac{R}{g}} = 84 \text{ мин.}$$

$$175. v_2 = v_1 \sqrt{\frac{n_1}{n_2}} = 1 \cdot 10^1 \text{ км/с.}$$

### 3. ЗАКОНЫ СОХРАНЕНИЯ В МЕХАНИКЕ

$$205. F_c = \frac{m}{2d}(v_1^2 - v_2^2) = 6,3 \cdot 10^4 \text{ Н.} \quad 206. A = 1,5mgl = 1,5 \cdot 10^2 \text{ Дж.}$$

$$207. A = \left( \frac{m_1}{2} + m_2 \right) gl = 1,3 \cdot 10^4 \text{ Дж.} \quad 208. A = m(g+a)h = 3 \cdot 10^3 \text{ Дж.}$$

$$209. A = \mu mgv\tau = 1,8 \cdot 10^9 \text{ Дж.} \quad 210. A = 2mgh.$$

$$211. E = \mu m_2 g s \left( 1 + \frac{m_2}{m_1} \right) = 88 \text{ Дж.} \quad 212. E_k = \frac{m}{2}(20 - 8t)^2 = 8 \text{ Дж.}$$

$$213. A = \frac{(\mu mg)^2}{2k} = 0,1 \text{ Дж.} \quad 214. \mu = \frac{A}{mgs - Atg\alpha} = 0,2.$$

$$215. s = \frac{lm_1}{m_1 + m_2} = 1 \text{ м.} \quad 216. u = \frac{mv_0 \cos \alpha}{M} = 8 \cdot 10^{-2} \text{ м/с.}$$

$$217. v = \frac{v_0}{M} \sqrt{M(m+M)} = 5,6 \text{ м/с.}$$

$$218. v_2 = \frac{m_1 v_1 - mv}{m_2} = 3 \cdot 10^2 \text{ м/с, } \bar{v}_2 \uparrow \downarrow \bar{v}_1.$$

$$219. \text{ а) } v = \frac{2mu}{M+2m} = 2 \text{ м/с; б) } v = 0;$$

$$\text{ в) } v = u \left( \frac{m}{M+m} + \frac{m}{M+2m} \right) = 2 \text{ м/с;}$$

$$\text{ г) } v = \frac{2m^2 u}{M(M+2m)} = 0,5 \text{ м/с.}$$

$$220. v = \frac{\sqrt{(m_1 v_1)^2 + (m_2 v_2)^2}}{m_1 + m_2}. \quad 221. \alpha = 120^\circ.$$

$$222. v_1 = v \sqrt{1 - \frac{m}{M}}, \quad v_2 = \frac{mv}{M}. \quad 223. l_1 = 4l = 40 \text{ см.}$$

$$224. x = \frac{mg}{k} \left( 1 + \sqrt{1 + \frac{2hk}{mg}} \right) = 0,1 \text{ м.}$$

$$225. E_k = \frac{m}{2}(v_0^2 - 2v_0 g \tau \sin \alpha + g^2 \tau^2) = 2 \cdot 10^2 \text{ Дж.}$$

$$226. v = 2\sqrt{0,6gl} = 4,2 \text{ м/с.} \quad 227. v = \sqrt{4gl}.$$

$$228. Q = \frac{m_1 m_2 (v_1 + v_2)^2}{2(m_1 + m_2)} = 2 \cdot 10^1 \text{ Дж.} \quad 229. Q = \frac{m_1 m_2 (v_1^2 + v_2^2)}{2(m_1 + m_2)}.$$

$$230. a) F = m_1 g \left( 1 + \frac{4Hm_2^2}{h(m_1 + m_2)^2} \right) = 8,9 \cdot 10^4 \text{ Н,}$$

$$b) F = (m_1 + m_2) g \left( 1 + \frac{Hm_2^2}{h(m_1 + m_2)^2} \right) = 9,2 \cdot 10^4 \text{ Н.}$$

$$231. u_1 = \frac{m_1 - m_2}{m_1 + m_2} v_1, \quad u_2 = \frac{2m_1}{m_1 + m_2} v_1.$$

$$232. F = m \left( \frac{v_1^2 - v_2^2}{2(h_1 - h_2)} + g \right) = 7,5 \cdot 10^3 \text{ Н.}$$

$$233. v = \sqrt{v_0^2 + 2gH}. \quad 234. \text{ В третьей.}$$

$$235. \alpha = \arccos \left( 1 - \frac{1}{2gl} \left( \frac{mv}{m+M} \right)^2 \right) \text{ при } \frac{m^2 v^2}{gl(m+M)^2} \leq 4.$$

$$236. Q = m \left( gl \sin \alpha - \frac{v^2}{2} \right) = 1,4 \cdot 10^2 \text{ Дж.}$$

$$237. k = \frac{2mgh}{(\Delta l)^2} = 4 \cdot 10^2 \text{ Н/м. } 238. E_k = \frac{1}{2} m(v_0^2 + g^2 t^2) = 6 \cdot 10^2 \text{ Дж.}$$

$$239. l = \frac{m^2 v^2}{2\mu g M^2} = 0,5 \text{ м. } 240. N = \mu F \pi d n = 5 \cdot 10^2 \text{ Вт.}$$

$$241. A_{\text{тр}} = mg \left( \frac{5}{2} R - H \right) = -2 \cdot 10^{-2} \text{ Дж. } 242. h_{\min} = \frac{5}{2} R = 10 \text{ м.}$$

$$243. F = \frac{mg(h+l)}{l} = 2 \cdot 10^3 \text{ Н. } 244. h = \frac{k(L-l)^2}{2g(M+m)}.$$

$$245. v_0 = \sqrt{\frac{2E_k}{m}} - gt = 40 \text{ м/с. } 246. v = \sqrt{\frac{2(n-1)gh}{n}} = 14 \text{ м/с.}$$

$$247. Q = \frac{m_1 m_2 v^2}{2(m_1 + m_2)} + m_2 gh = 1,5 \cdot 10^2 \text{ Дж.}$$

$$248. Q = \frac{m_1 v_1^2}{2} \left( 1 - \frac{m_1}{m_2} \right) = 25 \text{ Дж.}$$

$$249. \frac{Q}{E_0} = 1 - \frac{v^2}{v_0^2} - \frac{m(v_0 - v)^2}{Mv_0^2} = 0,6. \quad 250. h = \frac{v_0^2(n-1)}{2ng} = 7,7 \text{ м.}$$

$$251. s = \frac{(M-m)^3 v^3}{2NM^2} = 30 \text{ м.}$$

$$252. \Delta E_p = m_1 gl(1 - \cos \alpha) = 98 \text{ Дж, } h = \frac{lm_1^2(1 - \cos \alpha)}{(m_1 + m_2)^2} = 0,16 \text{ м.}$$

$$253. v = v_0 \sqrt{\frac{\sin \alpha - \mu \cos \alpha}{\sin \alpha + \mu \cos \alpha}} = 0,8 \text{ м/с.}$$

$$254. N = \rho g(\sin \alpha + \mu \cos \alpha) = 2 \cdot 10^4 \text{ Вт.}$$

$$255. N = \frac{\eta \rho g V h}{t} = 2,3 \cdot 10^8 \text{ Вт (здесь } \eta = 0,9). \quad 256. N = \frac{mgv}{2}.$$

$$257. v_1 = v_2 = \sqrt{v_0^2 + 2gh} = 25 \text{ м/с. } 258. Q = mg \left( h - \frac{g\tau^2}{8} \right) = 0.2 \text{ Дж.}$$

$$259. v = \sqrt{\left( \frac{mv_0}{m+M} \right)^2 + 2gH}. \quad 260. l = 2\sqrt{h(n-1)(H-h)} = 1,6 \text{ м.}$$

$$261. \alpha = \arccos \left( 1 - \frac{2m^2v^2}{(M+m)^2 gl} \right) = 30^\circ.$$

$$262. E_{k1} = \frac{1}{4} E_0, \quad E_{k2} = \frac{3}{4} E_0. \quad 263. m_2 = \frac{13}{5} m_1.$$

#### 4. ОСНОВЫ СТАТИКИ

$$284. l = \frac{m_1 l_1 + m_2 l_2}{m_1 + m_2} = 6 \text{ см.}$$

$$285. F = \left( m_2 + \frac{ml/2 - (m+m_1)l_1}{l-l_1} \right) g = 4 \text{ Н.}$$

$$286. m = \frac{2m_1 - 8m_2}{3} = 1 \text{ кг.}$$

$$287. x = \frac{l(m_1 + m/2)}{m_1 + m_2 + m} = 0,3 \text{ м. } 288. r = \frac{lk_2}{k_1 + k_2} = 0,8 \text{ м.}$$

$$289. m = \sqrt{m_1 m_2} = 4 \text{ кг. } 290. F = \frac{\mu mg}{\cos \alpha + \mu \sin \alpha} = 20 \text{ Н.}$$

$$291. F = \frac{mg(\mu\sqrt{l^2 - h^2} + h)}{l} = 2,2 \cdot 10^3 \text{ Н.}$$

$$292. h_{\max} = \frac{l}{\sqrt{n^2 + 1}} = 20 \text{ см. } 293. F = \frac{mg}{\mu l} (h - \mu\sqrt{l^2 - h^2}) = 14 \text{ Н.}$$

$$294. F = mg(\sin \alpha - \mu \cos \alpha) = 16 \text{ Н.}$$

$$295. F = \frac{g}{2h} (ML + m(2L - l)) \cos \alpha. \quad 296. l_1 = \frac{\mu l}{\mu + 1}.$$

$$297. F_{\min} = \frac{mg}{\mu} = 6 \cdot 10^2 \text{ Н.}$$

$$298. F_1 = \frac{mgl}{2(l-l_1)} = 3 \cdot 10^2 \text{ Н, } F_2 = mg - F_1 = 2 \cdot 10^2 \text{ Н.}$$

$$299. m \geq \frac{M}{2}, \quad m \geq 0,5 \text{ кг. } 300. F = \frac{mgl}{2(H-2a)} = 1 \cdot 10^2 \text{ Н.}$$

$$301. F_{\text{тр}} = \frac{mg}{2 \operatorname{tg} \alpha} = 49 \text{ Н. } 302. \mu = \frac{\sin 2\alpha}{1 + 2 \sin^2 \alpha} = 0,5.$$

$$303. \alpha \geq \operatorname{arctg} \frac{3}{\mu}, \quad \alpha \geq 84^\circ.$$

$$304. T = \frac{mgl \sin \alpha \cos^2 \alpha}{2h} = 1,5 \cdot 10^2 \text{ Н,}$$



$$F_c = mg \left( 1 - \frac{l \sin^2 \alpha \cos \alpha}{2h} \right) = 5,1 \cdot 10^2 \text{ Н,}$$

$$F_B = \frac{mgl \sin \alpha \cos \alpha}{2h} = 1,7 \cdot 10^2 \text{ Н.}$$

$$305. h = \frac{R}{\sqrt{1 + \mu^2}} = 1,5 \text{ м. } 306. T = \frac{mgl_1}{\sqrt{l_2^2 - l_1^2}} = 3 \cdot 10^3 \text{ Н.}$$

$$307. T = \frac{mg}{2 \operatorname{tg} \alpha}, N = \frac{mg}{2 \operatorname{tg} \alpha} \sqrt{4 \operatorname{tg}^2 \alpha + 1}, \bar{N} \text{ составляет с горизон-}$$

том угол  $\beta = \operatorname{arctg}(2 \operatorname{tg} \alpha)$ .

$$308. h = \frac{F_{\text{тр}} l}{mg} \operatorname{tg} \alpha \sin \alpha = 3 \text{ м. } 309. F = mg \frac{\sqrt{h(2R - h)}}{R - h}.$$

$$310. r = \frac{2\rho_1 R}{\rho_1 + \rho_2} = 5,5 \text{ см.}$$

311. На расстоянии 0,3 м от шара массой  $m_4$ .

312. На расстоянии  $r = R/6 = 5,0$  см от центра пластинки.

$$313. x = \frac{R_1^4 - R_2^4}{R_1^3 + R_2^3} = 2 \text{ см.}$$

314. На биссектрисе угла, в вершине которого находится шарик массой  $2m$ , на расстоянии  $a\sqrt{3}/4$  от этого шарика.

$$315. \cos \alpha = \frac{1}{2} \left( 3 - \frac{m_1 l_1}{m_2 l_2} \right) = 0,5, \alpha = 60^\circ.$$

$$316. F = mg(\cos \alpha - \sin \alpha \operatorname{tg} \beta) = 36 \text{ Н. } 317. \alpha = \operatorname{arctg} \frac{1}{3} = 18^\circ.$$

## 5. ЖИДКОСТИ И ГАЗЫ

$$340. \Delta h = \frac{4m}{\pi \rho d^2} = 1,8 \text{ см. } 341. F_{\min} = \rho g h S = 15 \text{ Н.}$$

$$342. h = \frac{(n-1)p_0}{\rho g} = 20 \text{ м. } 343. p = \frac{2gh\rho_1\rho_2}{\rho_1 + \rho_2} = 5,33 \cdot 10^3 \text{ Па.}$$

$$344. p_{\text{атм}} = \frac{2\rho gh(l-h)}{l-2h} = 9,4 \cdot 10^4 \text{ Па. } 345. l = h + \frac{\rho gh^2}{p_{\text{атм}}}.$$

$$346. F_{\text{ср}} = \frac{\rho g l h^2}{2} = 2,2 \cdot 10^2 \text{ Н.}$$

$$347. p = \frac{4(mv^2/2 + F_c l)}{\pi d^2} = 4,3 \cdot 10^5 \text{ кПа. } 348. F = P \left( 1 - \frac{\rho_2}{2\rho_1} \right) = 2 \text{ Н.}$$

$$349. P_0 = \frac{P}{1 - \rho_2/\rho_1} = 1521 \text{ Н. } 350. V = m \left( \frac{2}{\rho_2} - \frac{1}{\rho_1} \right) = 9 \cdot 10^{-3} \text{ м}^3.$$

$$351. \rho_1 = \frac{P_1 \rho_2 \rho_3}{(P_1 + P_2 - P_3)\rho_2 - P_2 \rho_3} = 0,2 \cdot 10^3 \text{ кг/м}^3.$$

$$352. H = \frac{\rho_2 h}{\rho_2 - \rho_1} = 16 \text{ м. } 353. m = Sd(\rho_2 - \rho_1) = 20 \text{ кг.}$$

$$354. V_n = \left(1 - \frac{\rho_2}{\rho_1}\right)V. \quad 355. x = \frac{l\rho_3(\rho_1 - \rho_2)}{2\rho_2(\rho_1 - \rho_3)} = 3 \text{ см.}$$

$$356. m_r = m \frac{\rho_2}{\rho_1}, \text{ на другую чашку.}$$

$$357. m_m = \frac{m(1/\rho_1 - 1/\rho_2)}{1/\rho_4 - 1/\rho_3} = 0,3m. \quad 358. \alpha = \frac{\rho_1}{\rho_2} = \frac{5}{4}.$$

$$359. \rho_3 = \alpha_1\rho_1 + \alpha_2\rho_2 = 4 \cdot 10^3 \text{ кг/м}^3.$$

$$360. n_2 = \frac{n_1\rho_1 - \rho_2}{\rho_1 - \rho_2} = 0,19.$$

$$361. \Delta h_1 = \frac{\rho_1 h}{\rho_2(1 + n^2)} = 6 \text{ см, } \Delta h_2 = n^2 \Delta h_1 = 0,4 \text{ см.}$$

$$362. h = \frac{\rho_1 \Delta h}{\rho_2} = 27 \text{ см. } 363. h = \frac{m_1 + m_2}{2\rho S} = 0,1 \text{ м.}$$

$$364. \Delta h = \frac{m}{2\rho S} = 1 \cdot 10^{-2} \text{ м. } 365. h = \frac{S_1 h_1 + S_2 h_2}{S_1 + S_2} = 25 \text{ см.}$$

$$366. \frac{V_1}{V} = \frac{\rho_2 - \rho_3 P_1 / (P_1 - P_2)}{\rho_2 - \rho_1} = 0,35, \text{ т. е. } 35\%;$$

$$\frac{V_2}{V} = 1 - 0,35 = 0,65, \text{ т. е. } 65\%, \quad V = \frac{P_1 - P_2}{\rho g} = 400 \text{ см}^3.$$

$$367. m = \frac{\rho_1(M - \rho_2 S h)}{\rho_1 - \rho_2} = 60 \text{ г.}$$

$$368. m = \frac{\rho_1(P_1 \rho_3 - (P_1 - P_2)\rho_2)}{\rho_3(\rho_1 - \rho_2)g} = 965 \text{ г.}$$

$$369. \Delta h = \frac{m}{\rho S} = 8 \cdot 10^{-3} \text{ м. } 370. m = \rho S h = 3 \cdot 10^6 \text{ кг.}$$

$$371. S_{\min} = \frac{m}{d(\rho_2 - \rho_1)} = 2 \text{ м}^2. \quad 372. \rho_2 = \rho_1 - \frac{m}{nV} = 7 \cdot 10^2 \text{ кг/м}^3.$$

$$373. h = \frac{\sigma_{\text{нр}}}{g(\rho_1 - \rho_2)} = 7,2 \cdot 10^3 \text{ м.}$$

$$374. T_1 = g(\rho V - m) = 9,1 \cdot 10^2 \text{ Н, } T_2 = \frac{T_1}{\cos \alpha} = 1,0 \cdot 10^3 \text{ Н.}$$

$$375. \rho_2 = \frac{3}{4}\rho_1 = 7,5 \cdot 10^2 \text{ кг/м}^3.$$

$$376. A = mg(H + h) - \rho Vgh = 1,5 \cdot 10^2 \text{ Дж.}$$

$$377. A = mg \left(1 - \frac{\rho_2}{\rho_1}\right) \left(h - \sqrt{\frac{m}{\rho_1}}\right) = 1,2 \cdot 10^5 \text{ Дж.}$$

$$378. A_{\min} = \frac{\rho g S h^2}{8} = 2 \cdot 10^2 \text{ Дж.}$$

$$379. h = \frac{\rho_1 H}{\rho_1 - \rho_2}, t = \frac{\rho_2}{\rho_1 - \rho_2} \sqrt{\frac{2H}{g}}. \quad 380. H = \frac{h(\rho_2 - \rho_1)}{\rho_1} = 0,2 \text{ м.}$$

$$381. Q = (\rho_1 - \rho_2)Vgh = 4 \cdot 10^{-2} \text{ Дж.}$$

$$382. P = \frac{m\rho_2 g V}{M + m + \rho_1 V} = 21 \text{ Н.} \quad 383. H = h \left( \frac{4\pi R^3 \rho}{3m} - 1 \right).$$

## 6. ОСНОВЫ МОЛЕКУЛЯРНО-КИНЕТИЧЕСКОЙ ТЕОРИИ. ИДЕАЛЬНЫЙ ГАЗ

$$401. \text{Одинаковое число } N = \frac{mN_A}{M} = 3 \cdot 10^{25}.$$

$$402. \langle u_{\text{кв}} \rangle = \sqrt{\frac{3pV}{m}} = 2 \cdot 10^3 \text{ м/с, } \langle E \rangle = \frac{3pVM}{2mN_A} = 7 \cdot 10^{-21} \text{ Дж.}$$

$$403. n = \frac{p_0}{kT_0} = 2,7 \cdot 10^{25} \text{ м}^{-3}. \quad 404. p = \frac{2E}{3V} = 8 \cdot 10^5 \text{ Па.}$$

$$405. m = \frac{pVM}{RT} = 4 \cdot 10^{-3} \text{ кг, } N = \frac{pVN_A}{RT} = 1,2 \cdot 10^{24}.$$

$$406. \langle u_{\text{кв}} \rangle = \sqrt{\frac{3pV}{m}} = 1,2 \cdot 10^3 \text{ м/с.} \quad 407. T = \frac{pVM}{mR} = 4,8 \cdot 10^2 \text{ К.}$$

$$408. M_2 = \frac{hM_1}{l-h} = 4 \cdot 10^{-3} \text{ кг/моль.} \quad 409. h_2 = \frac{7p_0}{\rho g} + 8h_1 = 8 \cdot 10^1 \text{ м.}$$

$$410. m = m_0 / \left( \frac{\rho RT}{M(\rho_0 + \rho gh)} - 1 \right) = 6 \cdot 10^{-4} \text{ кг.}$$

$$411. \delta = \left( \frac{T_2}{T_1} - 1 \right) 100\% = 4\%. \quad 412. m_2 = \frac{m_1}{2}. \quad 413. \alpha = 1 - \frac{n}{k}.$$

$$414. T_2 = \frac{\rho_2 V_1 T_0 T_1}{\rho_1 V_1 T_0 - \rho_0 V_2 T_1} = 255 \text{ К} \quad (\rho_0 = 1 \cdot 10^5 \text{ Па, } T_0 = 273 \text{ К}).$$

$$415. \rho = \frac{pM}{RT} = 1 \text{ кг/м}^3, \quad m_0 = \frac{M}{N_A} = 5,3 \cdot 10^{-26} \text{ кг.}$$

$$416. \rho = \frac{p(m_1 + m_2)}{(m_1/M_1 + m_2/M_2)RT} = 0,5 \text{ кг/м}^3.$$

$$417. p = \frac{Np_0 V_0}{V} = 2 \cdot 10^5 \text{ Па.} \quad 418. \frac{V_c}{V_u} = \frac{1}{\sqrt[3]{\rho_0/p} - 1} = 0,4.$$

$$419. m = \rho V \left( 1 - \frac{p}{\rho_{\text{атм}} + \rho gh} \right) = 6 \text{ кг.}$$

$$420. F_{\text{max}} = \frac{\pi \rho_{\text{атм}} d^2 (T_1 - T_2)}{4T_1} = 21 \text{ Н.}$$

$$421. T_1 = \frac{T_2}{\left( 1 - \frac{mg}{\rho_{\text{атм}} S} \right) \left( 1 - \frac{m}{\rho Sh} \right)}. \quad 422. p = \frac{\rho_1 V_1 + \rho_2 V_2}{V_1 + V_2}.$$

$$423. T_2 = \frac{T_1(\rho_{\text{атм}} + \rho gh(l + S_2/S_1))(V_1 + S_2h)}{\rho_{\text{атм}}V_1}$$

$$424. p_{\text{атм}} = \frac{m}{S} \left( \frac{\alpha}{1-\alpha} a - g \right) = 1,0 \cdot 10^5 \text{ Па.}$$

$$425. v = \frac{mRT}{\rho MS\tau} = 20 \text{ м/с. } 426. t_2 = 10,5 \text{ }^\circ\text{C.}$$

$$427. \varphi_2 = \varphi_1 \frac{\rho_{01}T_2}{\rho_{02}T_1} = 62 \text{ } \%$$

$$428. m = (\varphi\rho_{01} - \rho_{02})Sh = 1,6 \cdot 10^7 \text{ кг } (\varphi = 0,73).$$

$$429. m = \frac{(\varphi_1\rho_{01} - \varphi_2\rho_{02})V}{100\%} = 86 \text{ кг.}$$

$$430. p_0 = \frac{mRT \cdot 100\%}{MV\varphi} = 1,9 \cdot 10^3 \text{ Па. } 431. \varphi = \frac{\varphi_1V_1 + \varphi_2V_2}{V_1 + V_2} = 27\%.$$

$$432. A = 2\sigma l_1 l_2 = 1,3 \cdot 10^{-3} \text{ Дж. } 433. N = \frac{mg}{\sigma\pi d} = 1,1 \cdot 10^3.$$

$$434. m = \frac{\pi d \sigma t}{g\tau} = 20 \text{ кг. } 435. \sigma = \frac{\rho g d_1 d_2 \Delta h}{4(d_2 - d_1)} = 5 \cdot 10^2 \text{ мН/м.}$$

$$436. m = \sigma\pi d/g = 2,3 \cdot 10^{-5} \text{ кг.}$$

## 7. ТЕПЛОВЫЕ ЯВЛЕНИЯ. ОСНОВЫ ТЕРМОДИНАМИКИ

$$451. m = \frac{\rho Vc(T_1 - T_2)}{\lambda + c(T_2 - T_3)} = 1 \text{ кг. } 452. m_2 = \frac{m_1 c_1 \Delta T}{c_2(T_2 - T_1 - \Delta T)} = 3,0 \text{ кг.}$$

$$453. t_2 = t_1 + \frac{m_1 \lambda}{cm_2} = 100 \text{ }^\circ\text{C. } 454. n = 1 + \frac{c(t_1 - t_2)}{r} = 1,15.$$

$$455. m_1' = m_1 - \frac{c_2 m_2 (t_{\text{пл}} - t_2) - c_1 m_1 (t_1 - t_{\text{пл}})}{\lambda} = 1,9 \text{ кг, } m_2' = 2,1 \text{ кг, где } t_{\text{пл}} = 0 \text{ }^\circ\text{C.}$$

$$456. t = 0 \text{ }^\circ\text{C, } m_4 = \frac{m_3(r + c(t_2 - t_1))}{\lambda} = 4 \text{ кг.}$$

$$457. m_3 = \frac{m_2(\lambda + c_2(T_{\text{пл}} - T_2)) - c_1 m_1(T_2 - T_1)}{c_1(T_{\text{к}} - T_1) + r - c_1(T_2 - T_1)}$$

$$458. v = \sqrt{\frac{2(c(T_{\text{пл}} - T) + \lambda)}{\eta}} = 4,5 \cdot 10^2 \text{ м/с.}$$

$$459. l = \sqrt{\frac{2h(v_0^2 - 2c\Delta T)}{g}} = 284 \text{ м. } 460. Q = \frac{m\alpha\tau^2}{2} = 2 \cdot 10^8 \text{ Дж.}$$

$$461. \Delta T = \frac{np^2}{2cmM} = 8 \text{ К. } 462. V = \left( \frac{1}{\eta} - 1 \right) \frac{Wv\tau}{\rho c\Delta T} = 9 \text{ л.}$$

$$463. m = \frac{\eta U l \tau}{c(t_{\text{пл}} - t) + \lambda} = 1 \text{ кг, где } t_{\text{пл}} = 0 \text{ }^\circ\text{C, } \eta = 0,8.$$

$$464. \tau_2 = \frac{\tau_1 r}{c(t_k - t_1)} = 30 \text{ мин, где } t_k = 100^\circ \text{ С.}$$

$$465. \eta = \frac{cm_2 \Delta T}{qm_1} \cdot 100\% = 34\%. \quad 466. \tau = \frac{m(c\Delta T + \lambda)}{P} = 2 \text{ ч } 50 \text{ мин.}$$

$$467. m_2 = \frac{1}{g} \left( \frac{m_1 R \Delta T}{Mh} - p_0 S \right) = 2,8 \cdot 10^3 \text{ кг.}$$

$$468. \Delta U = Q - \nu R(T_2 - T_1) = 2 \cdot 10^2 \text{ Дж.}$$

$$469. U = \frac{3}{2} pV = 6 \cdot 10^5 \text{ Дж.} \quad 470. \frac{V_2}{V_1} = 1 + \frac{Q}{\nu RT} = 3.$$

$$471. A = \left( p_0 + \frac{mg}{S} \right) \left( \frac{T_2}{T_1} - 1 \right) V = 2 \cdot 10^2 \text{ Дж.}$$

$$472. \Delta U = \left( C - \frac{(p_0 + mg/S)V}{T} \right) \Delta T = 4 \cdot 10^2 \text{ Дж.}$$

$$473. m = \frac{M(Q_1 - Q_2)}{R\Delta T} = 4,8 \cdot 10^{-4} \text{ кг.}$$

$$474. A = (n-1)\nu RT = 8 \cdot 10^3 \text{ Дж.} \quad 475. c_p = \frac{5}{2} \frac{R}{M}, \quad c_V = \frac{3}{2} \frac{R}{M}.$$

$$476. Q = A = 25 \text{ Дж.} \quad 477. \nu = \frac{2A}{3R\Delta T}.$$

$$478. Q = \frac{5}{2} (n-1)\nu RT = 1,9 \cdot 10^4 \text{ Дж.} \quad 479. \frac{V_2}{V_1} = 1 + \frac{A}{\nu RT} = 2.$$

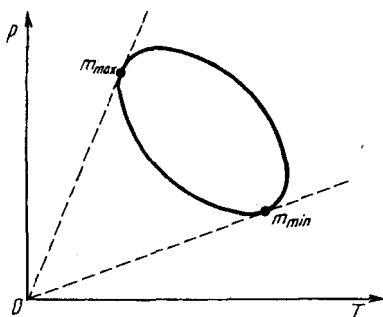
$$480. \Delta U = \frac{3}{2} \frac{m}{M} R\Delta T = 3 \cdot 10^3 \text{ Дж, } A = \frac{m}{M} R\Delta T = 2 \cdot 10^3 \text{ Дж,}$$

$$Q = \Delta U + A = 5 \cdot 10^3 \text{ Дж.}$$

$$481. m = \frac{(n-1)pV + \Delta U}{\eta q} = 6 \cdot 10^{-3} \text{ кг.}$$

$$482. T_1 - T_3 = \frac{T_2 T_4 - T_3^2}{T_3} = -117 \text{ К.} \quad 483. \text{ См. рис. 293.}$$

$$484. h_{\max} = \frac{Q(1 - T_0/T)}{mg} = 8,6 \text{ м, где } T_0 = 273 \text{ К.}$$



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$$485. c = \frac{mgHT_2}{\rho V(T_2 - T_1)^2} = 4,2 \cdot 10^3 \text{ Дж}/(\text{кг} \cdot \text{К}).$$

$$486. s = \frac{q\rho V(T_1 - T_2)}{FT_1} = 5 \cdot 10^2 \text{ км.}$$

$$487. \Delta U = Q_1 - \frac{(\rho_1 + \rho_2)(V_2 - V_1)}{2} = 5 \cdot 10^2 \text{ Дж, } \eta = \frac{Q_1 - Q_2}{Q_1} \cdot 100\% = 20\%.$$

## 8. ЭЛЕКТРОСТАТИКА

$$521. T = mg - \frac{q_1 q_2}{4\pi\epsilon_0 r^2} = 1,1 \cdot 10^{-2} \text{ Н. } 522. F = \frac{\sqrt{3} q_1 q_2}{4\pi\epsilon_0 r^2} = 8 \cdot 10^{-6} \text{ Н.}$$

$$523. q_1 = \frac{Q + \sqrt{Q^2 + 16\pi\epsilon_0 r^2 F}}{2} = 6 \cdot 10^{-6} \text{ Кл, } q_2 = Q - q_1 = -2 \cdot 10^{-6} \text{ Кл.}$$

$$524. |Q| = \frac{1 + 2\sqrt{2}}{4} q, \quad Q < 0.$$

$$525. Q = -\frac{q}{4d^3} \sqrt{(4h^2 + d^2)^3} = -3,8 \cdot 10^{-6} \text{ Кл.}$$

$$526. E = \frac{\sqrt{2}q}{4\pi\epsilon_0 a^2} = 3 \cdot 10^4 \text{ В/м. } 527. q = \frac{4\pi\epsilon_0 E d^3}{l} = 1 \cdot 10^{-10} \text{ Кл.}$$

$$528. E = \frac{\sqrt{2}\sigma}{2\epsilon_0} = 80 \text{ В/м, под углом } \alpha = 45^\circ \text{ к горизонту.}$$

$$529. E = \frac{|\sigma|}{9\epsilon_0}. \quad 530. \alpha = \text{arctg} \frac{qE}{mg} = 45^\circ.$$

$$531. q_3 = -\frac{3\sqrt{3}}{4} q = -5 \text{ мкКл. } 532. E = \frac{|q|}{4\pi\epsilon_0 \epsilon a^2} = 41 \text{ В/м, } \varphi = 0.$$

533.  $E = 0$ , если на концах диагонали находятся одноименные заряды, и  $E = \frac{q\sqrt{2}}{a^2 \pi \epsilon_0}$ , если разноименные.

$$534. A = \frac{q\sigma R^2}{\epsilon_0(R+r)} = 1 \cdot 10^{-4} \text{ Дж.}$$

$$535. E_1 = \frac{R_1 \varphi}{(R_1 + r)^2} = 3,3 \cdot 10^2 \text{ В/м, } E_2 = \frac{R_1^2 \varphi}{(R_1 + R_2)(R_1 + r)^2} = 1,1 \cdot 10^2 \text{ В/м.}$$

$$536. A = \frac{q_1 q_2}{4\pi\epsilon_0 \epsilon} \left( \frac{1}{r_2} - \frac{1}{r_1} \right) = 9 \cdot 10^{-2} \text{ Дж.}$$

$$537. q = \left( \frac{C_1 C_2}{C_1 + C_2} + C_3 \right) U = 1,3 \cdot 10^{-3} \text{ Кл. } 538. C = \frac{2\epsilon_0 \epsilon (\epsilon + 1) S}{d(4\epsilon + (\epsilon + 1)^2)}.$$

$$539. \Delta q = \frac{\epsilon_0 (\epsilon - 1) S \mathcal{E}}{d} = 2,5 \cdot 10^{-10} \text{ Кл.}$$

$$540. C_2 = \frac{C_1(U_1 - U_2)}{U_2} = 3 \text{ мкФ. } 541. U_2 = \frac{d_2 U_1}{d_1} = 2 \cdot 10^2 \text{ В.}$$

542.  $l = \frac{C_1 C_2 (U_1 + U_2)}{\tau (C_1 + C_2)} = 6 \cdot 10^{-4}$  А. 543.  $h = H \frac{\rho_2}{\rho_1} + \frac{q^2}{2 \epsilon_0 \epsilon S^2 \rho_1 g}$ .
544.  $U_2 = \frac{2U_1}{\epsilon + 1}$ . 545.  $\Delta q = \frac{CU}{2} = 50$  мкКл,  $q_1 = 0$ .
546.  $q = \frac{\epsilon_0 S mg}{q_0} \operatorname{tg} \alpha = 3,6 \cdot 10^{-6}$  Кл. 547.  $r = \sqrt[3]{\frac{3eU}{4\pi d \rho g}} = 4 \cdot 10^{-6}$  м.
548.  $T = mg \frac{\cos 2\alpha}{\cos \alpha} = 8,7 \cdot 10^{-3}$  Н.
549.  $T = \frac{mg \sin^2 \alpha \operatorname{tg} \alpha}{\epsilon} = 3,5 \cdot 10^{-4}$  Н, равновесие безразличное.
550.  $E = \frac{\pi d^3 g (\rho_2 - \rho_1)}{6q} = 4 \cdot 10^4$  В/м.
551. Увеличится на  $\Delta g = \frac{qE}{m} = 9,6 \cdot 10^{-4}$  м/с<sup>2</sup>.
552.  $t = \sqrt{\frac{2lU_1}{g(U_1 - U_2)}} = 9 \cdot 10^{-2}$  с. 553.  $a = \frac{g}{11} = 0,89$  м/с<sup>2</sup>.
554.  $l = \frac{d}{2} \left( 1 + \frac{W_k}{qU} \right) = 1,6$  см. 555.  $v = \sqrt{\frac{2eU}{m}} = 8,0 \cdot 10^6$  м/с.
556.  $U_{\min} = \frac{md^2 v^2}{el^2} = 6 \cdot 10^2$  В.
557.  $q = \pm \frac{r}{\sin \alpha} \sqrt{2\pi \epsilon_0 m \left( \frac{g}{\cos \alpha} - \frac{\omega^2 r}{\sin \alpha} \right)} = \pm 1,3 \cdot 10^{-7}$  Кл.
558.  $v = \sqrt{v_0^2 + \left( \frac{eEt}{m_e} \right)^2} = 9 \cdot 10^6$  м/с,  $\alpha = \operatorname{arctg} \frac{eEt}{m_e v_0} = 24^\circ$   
 ( $\alpha$  - угол между векторами  $\vec{v}$  и  $\vec{v}_0$ ).
559.  $T = \frac{q^2}{4\pi \epsilon_0 l^2} - \frac{2mg}{\operatorname{tg} 60^\circ} = 0,1$  Н. 560.  $v = \sqrt{\frac{2eU}{m}} = 1,2 \cdot 10^7$  м/с.
561.  $s = \frac{mv^2}{2qE} = 2 \cdot 10^3$  м. 562.  $v = \sqrt{\frac{b(mg + qE)}{m(\operatorname{tg} \alpha + \operatorname{tg} \beta) \cos^2 \alpha}} = 3$  м/с.
563.  $h = \frac{Ul^2}{2dv^2} \frac{e}{m_e} = 6 \cdot 10^{-3}$  м.
564.  $\beta = \operatorname{arctg} \frac{v \sin \alpha}{v \cos \alpha + eE\Delta t / m_e} = 45^\circ$ .
565.  $W_B = W_A + 0,5R(3mg - F) = -4 \cdot 10^{-3}$  Дж.
566.  $A = (\epsilon^2 - 1) \frac{CU^2}{4}$ . 567.  $U \geq \frac{Wd}{el} = 2 \cdot 10^2$  В.
568.  $A_{\text{мех}} = \frac{C_0 U^2 (\epsilon - 1)}{2}$ ,  $A_{\text{ист}} = -C_0 U^2 (\epsilon - 1)$ .
569.  $W = \frac{CE^2 d^2}{2} = 2 \cdot 10^{-6}$  Дж,  $w = \frac{\epsilon \epsilon_0 E^2}{2} = 4 \cdot 10^{-6}$  Дж/м<sup>3</sup>.

$$570. Q = \frac{C_1 C_2 (U_1 - U_2)^2}{2(C_1 + C_2)} = 5 \cdot 10^{-4} \text{ Дж.}$$

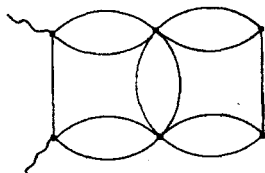
$$571. A = \frac{\epsilon_0 S U^2}{2d_1} \left( \frac{d_2}{d_1} - 1 \right) = 1,7 \cdot 10^{-3} \text{ Дж.} \quad 572. \Delta W = -\frac{C U^2}{4}.$$

$$573. t = 2RC \approx 20,0 \text{ с.}$$

### 9. ЗАКОНЫ ПОСТОЯННОГО ТОКА

$$608. v = \frac{IM}{\epsilon \rho S N_A} = 1,8 \cdot 10^{-5} \text{ м/с.} \quad 609. \delta = \frac{U_B}{I_a R_B} \cdot 100\% = 0,3\%.$$

$$610. R_2 = \frac{9}{8} R_1 = 90 \text{ Ом.} \quad 611. n = \sqrt{R_1/R_2} = 4.$$



Р и с. 294

612. Соединив точки с одинаковыми потенциалами, получим эквивалентную схему (рис. 294). По ней найдем сопротивление:  $R_x = 7R/12 = 3,5 \text{ Ом.}$

$$613. U = 22 \text{ В.}$$

$$614. R_d = R_B \left( \frac{U}{U_B} - 1 \right) = 3,6 \cdot 10^3 \text{ Ом.}$$

$$615. I = I_a \left( 1 + \frac{\pi d^2 R_a}{4\rho l} \right) = 13 \text{ А.}$$

$$616. l = \frac{I_a R_a S}{\rho(I - I_a)} = 2 \text{ м.}$$

$$617. U_1 = \frac{U R_1}{R_1 + R_2} = 140 \text{ В,} \quad U_2 = \frac{U R_2}{R_1 + R_2} = 160 \text{ В.}$$

$$618. t = \frac{q^2 R}{A} = 2 \text{ с.} \quad 619. R = \frac{U_1(U_2 - U_1)}{P} = 24,2 \text{ Ом.}$$

$$620. P_1' = \frac{P_1 P_2^2}{(P_1 + P_2)^2} = 96,0 \text{ Вт,} \quad P_2' = \frac{P_1^2 P_2}{(P_1 + P_2)^2} = 144 \text{ Вт.}$$

$$621. R = \frac{k U^2}{(1+k)^2 P} = 0,2 \text{ Ом.}$$

$$622. P_1 = \frac{I_1^2 (I_1 R_1 - I_2 R_2)}{I_2 - I_1} = 8 \text{ Вт,} \quad P_2 = \frac{I_2^2 (I_1 R_1 - I_2 R_2)}{I_2 - I_1} = 12 \text{ Вт,}$$

$$\eta_1 = \frac{R_1 (I_2 - I_1)}{I_2 (R_1 - R_2)} = 0,4, \quad \eta_2 = \frac{R_2 (I_2 - I_1)}{I_1 (R_1 - R_2)} = 0,3.$$

623. Если  $R > r$ , то большая мощность выделяется при параллельном соединении резисторов, если  $R < r$ , — при последовательном.

$$624. U = U_1 + \frac{4\rho l P}{\pi d^2 U_1} = 2,2 \cdot 10^2 \text{ В.} \quad 625. m = \frac{4D\rho l^2 (1+k)^2 P}{k U^2} = 78 \text{ кг.}$$

$$626. \epsilon = (\sqrt{2} + 1) \sqrt{\frac{PR}{2}}, \quad r = \frac{\sqrt{2}}{2} R. \quad 627. P_2' = \frac{P_1^2}{P_2} = 10 \text{ Вт.}$$



$$628. \eta = 1 - \frac{IR}{\mathcal{E} - Ir} = 0,9. \quad 629. \eta = \frac{mgh}{IUt} \cdot 100\% = 49\%.$$

$$630. P_{\max} = \frac{\mathcal{E}I_{\max}}{4} = 3 \text{ Вт.} \quad 631. P_{\max} = \frac{k\mathcal{E}^2}{4R(1-k)} = 5 \text{ Вт.}$$

$$632. P'_1 = \frac{U_2^2 P_1 (P_2 + P_3)^2}{U_1^2 (P_1 + P_2 + P_3)^2} = 72 \text{ Вт,} \quad P'_2 = \frac{U_2^2 P_1^2 P_2}{U_1^2 (P_1 + P_2 + P_3)^2} = 16 \text{ Вт,}$$

$$P'_3 = \frac{U_2^2 P_1^2 P_3}{U_1^2 (P_1 + P_2 + P_3)^2} = 32 \text{ Вт.}$$

$$633. \frac{Q_1}{Q_2} = \frac{4(r + R/2)^2}{(r + R)^2} = 1,4. \quad 634. \frac{P_2}{P_1} = 1,1.$$

$$635. l = \frac{\eta U^2 S \tau}{\rho m (c(t_2 - t_1) + r)} = 1,2 \text{ м} \quad (t_2 = 100 \text{ }^\circ\text{C}).$$

$$636. \Delta T = \frac{j^2 \rho t}{cD} = 0,2 \text{ К.}$$

$$637. \mathcal{E} = \frac{P_2 I_1^2 - P_1 I_2^2}{I_1 I_2 (I_1 - I_2)} = 12 \text{ В,} \quad r = \frac{\mathcal{E} I_1 - P_1}{I_1^2} = 2,0 \text{ Ом.}$$

$$638. \Delta Q = IU\tau - cm(t_2 - t_1) = 1,9 \cdot 10^5 \text{ Дж,} \quad \eta = \frac{cm(t_2 - t_1)}{IU\tau} = 0,7.$$

$$639. \tau_3 = \frac{\tau_1 \tau_2}{\tau_1 + \tau_2} = 5,7 \text{ мин,} \quad \tau_4 = \tau_1 + \tau_2 = 28 \text{ мин.}$$

$$640. t_2 = 4t_1 = 12 \text{ мин.} \quad 641. r = \sqrt{R_1 R_2} = 6 \text{ Ом.} \quad 642. \frac{P_2}{P_1} = \frac{1}{9}.$$

$$643. \alpha = 1 - \frac{\rho V c \Delta T}{P\tau} = 0,4. \quad 644. I_3 = \frac{I_1 I_2}{I_1 + I_2} = 2 \text{ А.}$$

$$645. q_1 = \frac{(\mathcal{E}_1 - \mathcal{E}_2)(R_1 + R_3)C_1}{R_1 + R_3 + R_4}, \quad q_2 = \frac{(\mathcal{E}_1 - \mathcal{E}_2)R_3 C_2}{R_1 + R_3 + R_4}.$$

$$646. U'_1 = \frac{\mathcal{E}}{1 + U_2/U_1} = 7 \text{ В,} \quad U'_2 = \mathcal{E} - U'_1 = 5 \text{ В.}$$

$$647. R = \frac{Edr}{\mathcal{E} - Ed} = 5 \text{ Ом.} \quad 648. U_1 = U_2 = \frac{4}{9}\mathcal{E}.$$

$$649. q = \left(1 - \frac{1}{n}\right)\mathcal{E}C. \quad 650. \mathcal{E} = \frac{q(R_1 + 2R_2)}{CR_1} = 110 \text{ В.}$$

$$651. \mathcal{E} = \frac{U_2 I_1 - U_1 I_2}{I_1 - I_2} = 1 \cdot 10^1 \text{ В,} \quad r = \frac{U_2 - U_1}{I_1 - I_2} = 3 \text{ Ом.}$$

$$652. \mathcal{E} = \frac{U_1 U_2}{3U_1 - 2U_2} = 40 \text{ В.} \quad 653. q = \frac{\mathcal{E}CR}{2R + 3r} = 1,2 \cdot 10^{-4} \text{ Кл.}$$

$$654. \mathcal{E} = U - Ir = 23 \text{ В.} \quad 655. I_{к.з.} = \frac{U_1 I_2 + U_2 I_1}{U_1 - U_2} = 80 \text{ А.}$$

$$656. R = \frac{\mathcal{E}_1 r_2 - \mathcal{E}_2 r_1}{\mathcal{E}_2} = 0,2 \text{ Ом.}$$

$$657. R = \frac{r(2\sqrt{k} - 1)}{2 - \sqrt{k}} = 0,8 \text{ Ом. } 658. r = R.$$

$$659. r = \frac{R(nI_2 - I_1)}{nI_1 - I_2} = 0,3 \text{ Ом, } \mathcal{E} = I_2 \left( R + \frac{r}{n} \right) = 2 \text{ В, где } n = 3.$$

$$660. R = \frac{2\mathcal{E}_2 r}{\mathcal{E}_1 - \mathcal{E}_2} = 1 \text{ Ом.}$$

$$661. P_1 = \frac{\mathcal{E}^2 U^2}{P(U^2/P + r)^2} = 42 \text{ Вт. Не будет.}$$

$$662. P = \frac{m^2 R}{k^2 \tau^2} = 40 \text{ Вт. } 663. \Delta I = I - \frac{m}{kt} = 0,1 \text{ А.}$$

$$664. q = \frac{It}{2} = 20 \text{ Кл, } m = \frac{kIt}{2} = 6,6 \cdot 10^{-6} \text{ кг.}$$

$$665. m = kjStN = 3,6 \cdot 10^4 \text{ кг, } W = UjStN = 1,1 \cdot 10^{13} \text{ Дж.}$$

$$666. t = \frac{\rho h}{kj} = 29 \text{ ч. } 667. W = \frac{UFmn}{\eta M} = 1,3 \cdot 10^8 \text{ Дж.}$$

$$668. q = 2ewdSC_2R = 6 \cdot 10^{-13} \text{ Кл.}$$

$$669. F = I \sqrt{\frac{2Um_e}{e}} = 2,0 \cdot 10^{-7} \text{ Н.}$$

## 10. МАГНИТНОЕ ПОЛЕ. ЭЛЕКТРОМАГНИТНАЯ ИНДУКЦИЯ

$$692. M = \frac{USBa}{4\rho} = 0,5 \text{ Н} \cdot \text{м.}$$

693. Прямая, проходящая параллельно проводнику на расстоянии

$$r = \frac{\mu_0 I}{2\pi B} = 5 \cdot 10^{-2} \text{ м от него, } F = IBl = 5 \cdot 10^{-3} \text{ Н.}$$

$$694. \alpha = \arcsin \frac{F}{IBl} = 30^\circ. \quad 695. l = \frac{m(g + v/t)}{IB \sin \alpha} = 6 \text{ м.}$$

$$696. I = \frac{mg}{2aB} = 5 \text{ А. } 697. A_{\max} = IBls = 1,5 \cdot 10^{-1} \text{ Дж.}$$

$$698. E_k = \frac{e^2 B^2 R^2}{2m_e} = 5,6 \cdot 10^{-16} \text{ Дж. } 699. R = \frac{El}{v_0 B} = 5 \cdot 10^{-3} \text{ м.}$$

$$700. \frac{q}{m} = \frac{8U}{B^2 l^2} = 1 \cdot 10^8 \text{ Кл/кг. } 701. v \leq \frac{eBd}{m_e}.$$

$$702. p = \frac{hqB}{2\pi \cos \alpha} = 7,3 \cdot 10^{-24} \text{ кг} \cdot \text{м/с.}$$

$$703. B = \frac{2\pi v \cos \alpha}{(e/m_e)L} = 2 \cdot 10^{-4} \text{ Тл.}$$

$$704. W_k = \frac{q^2 B^2 R^2}{2m \sin^2 \alpha} = 1,2 \cdot 10^{-16} \text{ Дж. } 705. N = \frac{rB(e/m_e)}{2\pi v \cos \alpha} = 3 \cdot 10^2.$$

$$706. \frac{e}{m_e} = \frac{2U}{B^2 R^2} = 1,76 \cdot 10^{11} \text{ Кл/кг.}$$

$$707. B = E \sqrt{\frac{m_e}{2W}}, \quad \vec{B} \perp \vec{E} \text{ и } \vec{B} \perp \vec{v}. \quad 708. t = \frac{RB}{E} \sqrt{n-1} = 2 \cdot 10^{-3} \text{ с.}$$

$$709. v_{\min} = \left( 5gl + \frac{q^2 B^2 l^2}{2m^2} \left( 1 - \sqrt{1 + \frac{4m^2 g}{q^2 B^2 l}} \right) \right)^{1/2}.$$

$$710. v = \frac{1}{2m} \left( qB + \sqrt{(qB)^2 + \frac{4m^2}{l \cos \alpha}} \right) l \sin \alpha.$$

$$711. \Delta t = \frac{N\Phi}{\mathcal{E}_i} = 4,8 \cdot 10^{-1} \text{ с.} \quad 712. a = 2 \sqrt{\frac{\mathcal{E}_i \tau}{B \sin 2\alpha}} = 3 \cdot 10^{-2} \text{ м.}$$

$$713. q = \frac{BdS}{2\rho}. \quad 714. \mathcal{E} = Blv = 4 \cdot 10^{-4} \text{ В.}$$

$$715. Q = \frac{B^2 l^2 v^2 t}{R} = 2 \cdot 10^{-2} \text{ Дж.} \quad 716. \omega = \frac{2\mathcal{E}}{Bl^2} = 75 \text{ рад/с.}$$

$$717. F = \frac{B^2 l^2 v}{R}. \quad 718. q = CS \frac{\Delta B}{\Delta t} = 5 \cdot 10^{-10} \text{ Кл.}$$

$$719. I = \frac{l^2}{12\pi R} \frac{\Delta B}{\Delta t} = 4 \cdot 10^{-4} \text{ А.} \quad 720. U = \frac{\omega Bl^2}{2} = 1,5 \text{ В.}$$

$$721. I_m = \frac{\omega Bl^2}{R} = 6,0 \cdot 10^{-3} \text{ А.} \quad 722. I = \frac{B(S_1 - S_2)}{\tau R} = 4 \cdot 10^{-6} \text{ А.}$$

$$723. B = \frac{\mathcal{E} \tau}{a^2} = 2,0 \cdot 10^{-3} \text{ Тл.} \quad 724. q = \frac{2\pi r^2 B}{R} = 3 \cdot 10^{-6} \text{ Кл.}$$

$$725. \alpha = \arccos \left( 1 - \frac{qR}{BSN} \right) = 60^\circ.$$

$$726. Q = \frac{NSa^3 (\Delta B)^2}{4\rho \Delta t} = 1 \cdot 10^{-2} \text{ Дж.} \quad 727. Q = \frac{2B^2 l_1^2 l_2 v}{R} = 1 \cdot 10^{-3} \text{ Дж.}$$

$$728. \langle \mathcal{E}_s \rangle = \frac{LI}{\Delta t} = 0,6 \text{ В,} \quad Q = \frac{LI^2}{2} = 4,3 \cdot 10^{-5} \text{ Дж.}$$

$$729. W = \frac{LU^2}{2R_1^2} = 1,3 \text{ Дж,} \quad \langle \mathcal{E}_s \rangle = \frac{LU}{R\Delta t} = 25 \text{ В.}$$

$$730. |\mathcal{E}_i| = \frac{\Delta I / \Delta t}{4\pi^2 v^2 C} = 0,25 \text{ В.}$$

## 11. МЕХАНИЧЕСКИЕ КОЛЕБАНИЯ И ВОЛНЫ

$$742. x_m = 50 \text{ м, } v_m = 52 \text{ м/с, } a_m = 54 \text{ м/с}^2, F_m = 108 \text{ Н, } E = 2,7 \cdot 10^3 \text{ Дж.}$$

$$743. T = 6 \text{ с, } x_m = 2 \text{ м, } \varphi_0 = \pi/4. \quad 744. \frac{T_1}{T_2} = \sqrt{\frac{\rho_1}{\rho_2}} = 1,8.$$

$$745. \frac{E_k}{E_p} = \operatorname{tg}^2 \left( \frac{2\pi}{T} t \right). \quad 746. T = 2\pi \sqrt{\frac{x}{g}} = 4,5 \cdot 10^{-2} \text{ с.}$$

$$747. l = 4tva = 0,4 \text{ м. } 748. v_m = x_m \sqrt{\frac{k}{m}} = 3,8 \text{ м/с.}$$

$$749. h_{\max} = \frac{2mg}{k}. \quad 750. \omega_1 = \sqrt{\frac{k_1 + k_2}{m}}, \quad \omega_2 = \sqrt{\frac{k_1 k_2}{m(k_1 + k_2)}}.$$

$$751. \frac{l_2}{l_1} = \left(\frac{N_1}{N_2}\right)^2 = 4. \quad 752. T_1 = T \sqrt{\frac{mg - F}{mg + F}} = 1,6 \text{ с.}$$

$$753. l = \frac{n^2 \Delta l}{n^2 - 1} = 9 \cdot 10^{-2} \text{ м. } 754. \Delta l = l \left(1 - \frac{t^2}{(t + \Delta t)^2}\right) = 8 \cdot 10^{-2} \text{ м.}$$

$$755. \Delta t = \frac{T_1 T_2}{T_1 - T_2} = 0,3 \cdot 10^2 \text{ с. } 756. T = 2\pi \sqrt{\frac{l}{g(1 - \rho_2/\rho_1)}}.$$

$$757. T_1 = 2\pi \sqrt{\frac{l}{g + qU/(md)}} = 7 \cdot 10^{-1} \text{ с, если вектор напряженности поля направлен вниз; } T_2 = 2\pi \sqrt{\frac{l}{g - qU/(md)}} = 2 \text{ с, если вектор напряженности поля направлен вверх.}$$

$$758. F = mg \left(1 - \frac{v^2}{2gl}\right) = 4 \cdot 10^{-1} \text{ Н. } 759. v = \frac{L}{2\pi} \sqrt{\frac{g}{l}} = 19 \text{ м/с.}$$

$$760. l = \frac{gT^2}{4\pi^2} = 2 \cdot 10^{-1} \text{ м (} T = 1 \text{ с следует из данного уравнения).}$$

$$761. a = g \left(\frac{T_0^2}{T^2} - 1\right) = 2 \text{ м/с}^2, \text{ ускорение направлено вверх.}$$

$$762. \Delta T = T_0 \frac{h}{R} = 3 \cdot 10^{-3} \text{ с. } 763. N = \frac{1}{\pi} \sqrt{\frac{h}{2l} \left(1 + \frac{g}{a}\right)} = 10.$$

$$764. T = 2\pi \sqrt{\frac{l}{g - a}} = 2 \text{ с, лифт движется либо вниз с возрастающей скоростью, либо вверх с убывающей скоростью.}$$

$$765. E_{\text{км}} = E_{\text{рм}} = E = 2\pi^2 v^2 m x_m^2 = 2 \cdot 10^{-4} \text{ Дж.}$$

$$766. v_m = x_m \sqrt{\frac{g}{l}} = 2 \cdot 10^{-1} \text{ м/с, } F_m = \frac{\pi r d^3 g x_m}{6l} = 0,1 \text{ Н.}$$

$$767. l_1 = \frac{\Delta l}{(N_1/N_2)^2 - 1} = 24,9 \text{ см, } l_2 = l_1 + \Delta l = 99,6 \text{ см,}$$

$$g = \frac{4\pi^2 N_1^2 \Delta l}{t^2 ((N_1/N_2)^2 - 1)} = 9,82 \text{ м/с}^2.$$

$$768. \text{ а) } T = 2\pi \sqrt{\frac{l}{g}} = 1,42 \text{ с; б) } T = 2\pi \sqrt{\frac{l}{\sqrt{g^2 + a^2}}} = 1,38 \text{ с;}$$

$$\text{ в) } T = 2\pi \sqrt{\frac{l}{g \cos \alpha}} = 1,44 \text{ с.}$$

$$769. T = 2\pi \sqrt{\frac{l}{g + a}} = 2 \text{ с. } 770. T = 2\pi \sqrt{\frac{m}{\rho g S}}.$$

$$771. x_m = \frac{2mv_0}{m + M} \sqrt{\frac{M}{k}} = 0,40 \text{ м. } 772. v = \frac{1}{2\pi} \sqrt{\frac{2\rho S g}{m}} = 2 \text{ Гц.}$$

$$773. h = \frac{\rho_1 g T^2}{4\pi^2 \rho_2} = 0,3 \text{ м. } 774. \Delta\varphi = \frac{2\pi l v}{v} = \pi.$$

$$775. l_1 = \frac{\lambda}{2} = 30 \text{ см, } l_2 = \frac{\lambda \Delta\varphi}{2\pi} = 7,5 \text{ см. } 776. \lambda = \frac{l}{N} = 8,00 \cdot 10^{-1} \text{ м.}$$

$$777. \lambda_2 = \frac{\lambda_1 v_2}{v_1} = 4 \text{ м. } 778. v = 2v(l_2 - l_1) = 3,6 \cdot 10^2 \text{ м/с.}$$

$$779. l = \frac{v_1 v_2 t}{v_2 - v_1} = 7 \cdot 10^2 \text{ м. } 780. l = \frac{2v_1 v_2}{v(v_2 - v_1)} = 4,5 \cdot 10^2 \text{ м.}$$

## 12. ЭЛЕКТРОМАГНИТНЫЕ КОЛЕБАНИЯ И ВОЛНЫ

$$790. \varepsilon = \frac{\lambda^2 d}{4\pi^2 c^2 \varepsilon_0 L S} = 6. \quad 791. \lambda = 2\pi\sqrt{LC} = 3 \cdot 10^5 \text{ м}$$

$$792. \text{Увеличить в } (\lambda v/c)^2 = 2 \text{ раза. } 793. I_{m2} = I_{m1} \sqrt{\frac{L_1}{L_2}} = \frac{I_{m1}}{\sqrt{2}}.$$

$$794. \text{От } v_1 = \frac{1}{2\pi\sqrt{LC_1}} = 5 \cdot 10^7 \text{ Гц до } v_2 = \frac{1}{2\pi\sqrt{LC_2}} = 2 \cdot 10^7 \text{ Гц,}$$

от  $\lambda_1 = c/v_1 = 6 \text{ м}$  до  $\lambda_2 = c/v_2 = 15 \text{ м.}$

$$795. \frac{T_2}{T_1} = 2. \quad 796. I_m = U_m \sqrt{\frac{C}{L}}. \quad 797. T = \pi D \sqrt{\frac{\varepsilon \varepsilon_0 \pi L}{d}} = 2 \cdot 10^{-6} \text{ с.}$$

$$798. \lambda = \frac{2\pi c q_m}{I_m} = 2 \cdot 10^2 \text{ м. } 799. I_m = 2\pi v q = 6 \cdot 10^{-2} \text{ А.}$$

$$800. L = \frac{2W_m}{I_m^2} = 1 \text{ Гн. } 801. Q = \frac{PL}{2R} = 1,6 \text{ Дж.}$$

$$802. P = \frac{CU_m R}{2L} = 5 \cdot 10^{-3} \text{ Вт. } 803. Q = \frac{\pi \omega N B^2 S^2}{R} = 7 \cdot 10^{-1} \text{ Дж.}$$

804. Будет гореть.

$$805. X_L = 2\pi v L = 13 \text{ Ом, } X_C = \frac{1}{2\pi v C} = 40 \text{ Ом,}$$

$$Z = \sqrt{R^2 + \left(2\pi v L - \frac{1}{2\pi v C}\right)^2} = 2,0 \cdot 10^2 \text{ Ом, } I = \frac{U}{Z} = 1,1 \text{ А,}$$

$$I_m = I\sqrt{2} = 1,5 \text{ А.}$$

$$806. C = \frac{I_m}{2\pi v \sqrt{2U^2 - I_m^2 R^2}} = 2 \cdot 10^{-5} \text{ Ф.}$$

$$807. I = \frac{U}{\sqrt{R^2 + \left(2\pi v L - \frac{1}{2\pi v C}\right)^2}} = 0,99 \text{ А, } U_R = IR = 20 \text{ В,}$$

$$U_L = 2\pi v LI = 1,3 \cdot 10^2 \text{ В, } U_C = \frac{I}{2\pi v C} = 27 \text{ В.}$$

$$808. U = \sqrt{U_R^2 + (U_L - U_C)^2} = 13 \text{ В.}$$

$$809. C = \frac{l}{2\pi v} \sqrt{\frac{1}{U_2^2 - U_1^2}} = 4 \cdot 10^{-6} \text{ Ф. } 810. Q = \frac{I_m^2}{2} Rt = 7 \cdot 10^6 \text{ Дж.}$$

$$811. L = \frac{1}{2\pi v} \sqrt{nR_1^2 - (R_1 + R_2)^2} = 0,3 \text{ Гн. } 812. \cos \varphi = \frac{P\sqrt{2}}{180I} = 0,8.$$

$$813. U = \sqrt{\varepsilon_1 \varepsilon_2} = 8 \text{ В. } 814. n_2 = \frac{n_1(lr + U_2)}{U_1} = 40.$$

$$815. U_2 = U_1/k - lr = 2 \cdot 10^1 \text{ В. } 816. R_2 = \frac{\eta(R_1 + r)}{1 - \eta} = 9,5 \cdot 10^3 \text{ Ом.}$$

$$817. \frac{U_1}{U} = \sqrt{\frac{\Delta W}{tP\eta/100\%}} = 3.$$

### 13. ЗАКОНЫ ОТРАЖЕНИЯ И ПРЕЛОМЛЕНИЯ СВЕТА

$$822. l_2 = \frac{l_1 d_2}{d_1} = 1 \cdot 10^2 \text{ м, } \omega = \frac{\pi d_1^2}{4l_1^2} = 8 \cdot 10^{-9} \text{ ср, } \varphi = \frac{d_1}{l_1} = 1 \cdot 10^{-4} \text{ рад.}$$

$$823. v = 4\pi nR = 6 \cdot 10^1 \text{ м/с. } 824. \beta = \frac{\pi}{4} + \frac{\alpha}{2} = 60^\circ. 825. \gamma = \alpha.$$

$$826. \text{Вертикально вверх со скоростью } v = 3 \text{ м/с.}$$

$$827. n_1 = \frac{n_2}{\operatorname{tg} \alpha} = 1,4. 828. H = nh = 8 \text{ см. } 829. n = \frac{d}{h} = 1,5.$$

$$830. H = nh = 4 \text{ м. } 831. \beta = \arcsin\left(\frac{\sin \alpha}{n}\right). 832. l = \frac{2h \sin \alpha}{\sqrt{n^2 - \sin^2 \alpha}} = 0,97 \text{ м.}$$

$$833. H = nh = 4 \text{ км. } 834. b' = b \frac{\sqrt{1 - n^2 \sin^2 \alpha}}{\cos \alpha} = 10 \text{ см.}$$

$$835. s = d \left(1 - \frac{\cos \alpha}{\sqrt{n^2 - \sin^2 \alpha}}\right) \sin \alpha. 836. v = c \frac{\sin \beta}{\sin \gamma} = 2 \cdot 10^8 \text{ м/с.}$$

$$837. s = d \left(\operatorname{tg} \alpha - \frac{\sin \alpha}{\sqrt{n^2 - \sin^2 \alpha}}\right) = 0,9 \text{ см. } 838. l = \frac{2h}{n} = 0,9 \text{ м.}$$

$$839. \gamma = \alpha, l = \frac{2dn}{\sqrt{n^2 - \sin^2 \alpha}}.$$

$$840. \theta = \alpha - \varphi + \arcsin\left(\frac{n_2}{n_1} (\sin \varphi) \sqrt{1 - \left(\frac{n_1}{n_2}\right)^2 \sin^2 \alpha - \cos \varphi \sin \alpha}\right) = 47^\circ.$$

$$841. \varphi = \operatorname{arctg}\left(\frac{\sin \alpha}{n - \cos \alpha}\right).$$

$$842. \beta = \arcsin\left(\sin \alpha \cos \varphi - (\sin \varphi) \sqrt{\left(\frac{n_B}{n_C}\right)^2 - \sin^2 \alpha}\right) = 17^\circ.$$

$$843. n = \frac{\sin \alpha}{\sin \varphi} = 1,4. 844. \varphi = 60^\circ. 845. h = \frac{a}{2} \sqrt{n^2 - 1} = 1,8 \text{ м.}$$

846.  $\varphi = \arcsin(n \sin \alpha) - \alpha = 22^\circ$ ; не выйдет при углах падения  $\alpha \geq \arcsin(1/n) = 40^\circ$ .

847.  $s = \frac{d}{n} \left( 1 - \frac{1}{\sqrt{n^2 + 1}} \right)$ .

## 14. СОБИРАЮЩИЕ И РАССЕИВАЮЩИЕ ЛИНЗЫ

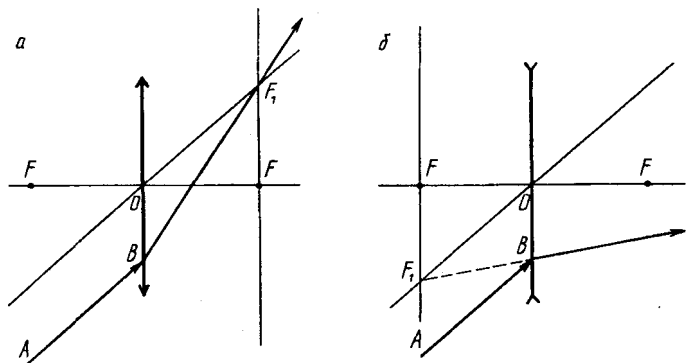
859. См. рис. 295. 860. См. рис. 296. 861. См. рис. 297.

862. См. рис. 298. 863. а) См. рис. 299; б) см. рис. 300.

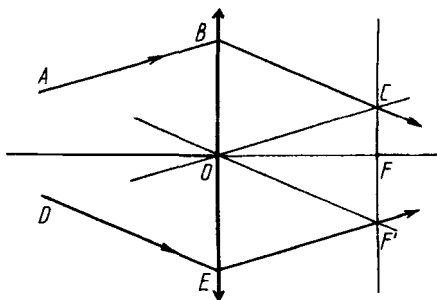
864.  $F = \pm(1 + \sqrt{2})l = \pm 9,6$  см.

865.  $H = \frac{hF}{l} = 4$  см,  $d_1 = F \left( 1 + \frac{1}{\Gamma} \right) = 11$  см,  $d_2 = F \left( 1 - \frac{1}{\Gamma} \right) = 9$  см.

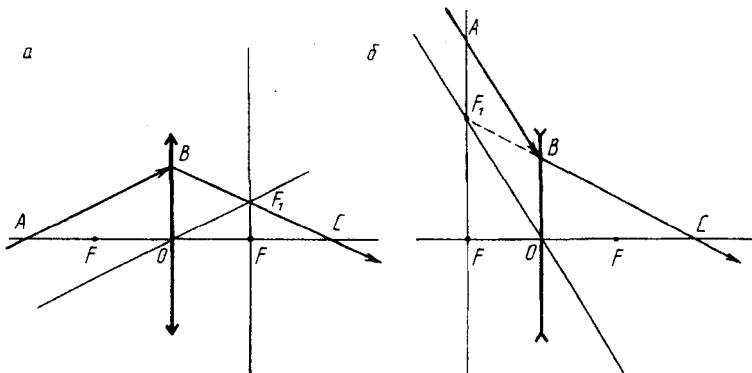
866.  $F = \frac{fd}{d-f} = 12$  см,  $D = -\frac{1}{F} = -8,3$  дптр.



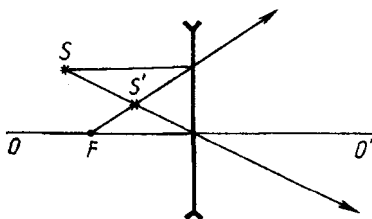
Р и с. 295



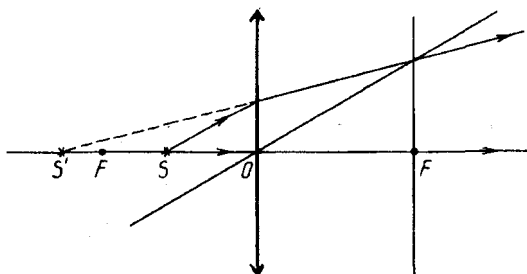
Р и с. 296



Р и с. 297



Р и с. 298



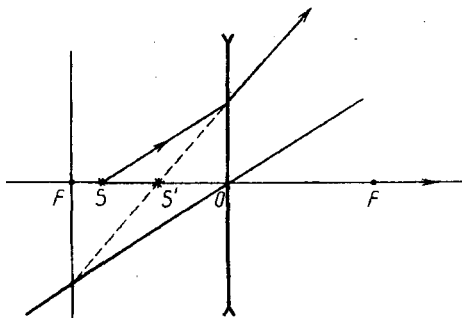
Р и с. 299

867.  $F = \frac{l^2 - l'^2}{4L} = 24$  см. 868.  $H_2 = \frac{h^2}{H_1} = 9$  см.

869. Если  $d > f$ , то  $\Gamma = \frac{2F - l + \sqrt{l^2 + 4F^2}}{2F + l + \sqrt{l^2 + 4F^2}} = \frac{1}{3}$ ,

если  $d < f$ , то  $\Gamma = \frac{2F + l + \sqrt{l^2 + 4F^2}}{2F - l + \sqrt{l^2 + 4F^2}} = 3$  ( $d$  – расстояние от предмета до линзы;  $f$  – расстояние от линзы до изображения).





Р и с. 300

870.  $D_1 = \frac{\Gamma + 1}{\Gamma d} = 3$  дптр,  $D_2 = \frac{\Gamma - 1}{\Gamma d} = 2$  дптр.

871.  $F = \frac{L^2 - l^2}{4L} = 24$  см. 872.  $d = \frac{1}{|D|} = 0,5$  м.

873.  $h = 2H = 1,4$  см. 874.  $d = \frac{1 - k}{-|D|} = 0,6$  м.

875.  $n = 1 + \frac{R(k+1)}{d} = 1,6$ . 876.  $f = \left(1 + \frac{1}{k}\right)F = \frac{2}{3}F$ .

877.  $F = \frac{f}{\Gamma + 1} = 0,1$  м. 878.  $\varphi_{\max} = \arctg \frac{a}{2F} = 32^\circ$ .

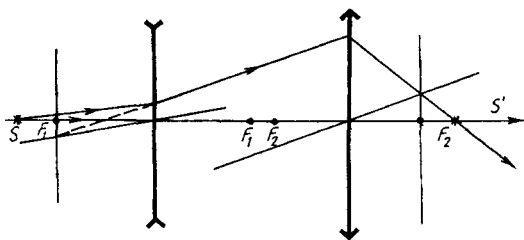
879. Линза собирающая,  $F = \frac{\Gamma d}{\Gamma - 1} = 10$  см.

880.  $d = 2F$ . 881.  $D = \frac{h}{f(h-f)} = 1,7$  дптр.

882.  $F = \frac{l_1 l_2}{l_2 - l_1} = 30$  см. 883.  $F = \frac{l d_1}{d_2 - d_1} = 7$  см.

884.  $l = \frac{dr}{d - F} = 3$  см. 885.  $g_C = \frac{16\pi^2 R f^2}{T^2 d^2} = 2,7 \cdot 10^2$  м/с<sup>2</sup>.

886.  $l = F_1$ . 887. См. рис. 301.



Р и с. 301

$$888. f_2 = \frac{F_2(ld_1 - lF_1 - d_1F_1)}{(d_1 - F_1)(l - F_2) - d_1F_1} = 60 \text{ см.}$$

$$889. f_2 = \frac{F_2(ld_1 - lF_1 - d_1F_1)}{(d_1 - F_1)(l + F_2) - d_1F_1} = 30 \text{ см. } 890. D = \frac{d - d_0}{dd_0} = 3 \text{ дптр.}$$

$$891. \Gamma = \frac{F}{h - F} = 1:4000. \quad 892. F = \frac{d_2h_2 - d_1h_1}{h_2 - h_1} = 0,4 \text{ м.}$$

$$893. \Gamma = d_0D = 4, \quad d_0 = 25 \text{ см, см. рис. 260.}$$

$$894. f = (1 + \Gamma)F = 4,2 \text{ м. } 895. v' = \frac{vF}{d - F} = 4 \text{ см/с.}$$

$$896. d = F \left( 1 + \frac{gt^2}{4\pi^2 N^2 l} \right) = 4 \text{ м.}$$

## 15. СВЕТОВЫЕ ВОЛНЫ

$$901. l_1 = nl_2 = 16 \text{ мм. } 902. N' = nN = 39.$$

$$903. \lambda_2 = \frac{\lambda_1}{n} = 405 \text{ нм, } v_2 = v_1 = \frac{c}{\lambda_1} = 5,6 \cdot 10^{14} \text{ Гц, зеленый.}$$

$$904. \alpha = \text{arctg} \frac{\lambda_1}{\lambda_2} = 55^\circ. \quad 905. \text{ Обеспечит.}$$

$$906. \Delta\lambda = (n - 1)\lambda = 198 \text{ нм. } 907. x_3 = \frac{(2k + 1)\lambda l}{2d} = 6 \text{ мм } (k = 3).$$

$$908. d = \frac{k\lambda}{2} = 1,3 \text{ мкм } (k = 4). \quad 909. R = \frac{2r_k^2}{(2k - 1)\lambda} = 0,64 \text{ м } (k = 3).$$

$$910. N = 9. \quad 911. \varphi_2 = \text{arcsin} \left( \frac{k_2 \sin \varphi_1}{k_1} \right) = 15^\circ \quad (k_1 = 2, k_2 = 3).$$

## 16. ЭЛЕМЕНТЫ ТЕОРИИ ОТНОСИТЕЛЬНОСТИ

$$915. l = l_0 \sqrt{1 - \frac{v^2}{c^2}} = 0,6 \text{ м. } 916. \tau = \frac{\tau_0}{\sqrt{1 - v^2/c^2}} = 125 \text{ ч.}$$

$$917. E = c\sqrt{p^2 + m^2c^2} = 2 \cdot 10^{-10} \text{ Дж,}$$

$$E_k = c\sqrt{p^2 + m^2c^2} - mc^2 = 5 \cdot 10^{-11} \text{ Дж.}$$

$$918. E_0 = mc^2 = 9 \cdot 10^{16} \text{ Дж.}$$

$$919. u = \frac{v_1 + v_2}{1 + v_1v_2/c^2} = 0,98c, \text{ где } c = 3 \cdot 10^8 \text{ м/с.}$$

$$920. v'_2 = \frac{|-v_2 - v_1|}{1 + v_1v_2/c^2} = 0,96c, \text{ где } c = 3 \cdot 10^8 \text{ м/с.}$$

## 17. СВЕТОВЫЕ КВАНТЫ

925.  $E = \frac{hc}{\lambda} = 3 \cdot 10^{-19}$  Дж,  $p = \frac{h}{\lambda} = 1 \cdot 10^{-27}$  кг · м/с.
926.  $n = \frac{hc}{\lambda E} = 1,5$ . 927.  $N = \frac{Pt\lambda}{hc} = 5 \cdot 10^1$ . 928.  $P = \frac{Nhc}{\eta\lambda t} = 4 \cdot 10^1$  Вт.
929.  $p_{\max} = \sqrt{\frac{2m_e hc(\lambda_{\max} - \lambda)}{\lambda_{\max} \lambda}} = 4 \cdot 10^{-25}$  кг · м/с.
930.  $N = \frac{W\lambda}{hc} = 3 \cdot 10^{13}$ .
931.  $\nu = \nu_{\min} + \frac{eU_3}{h} = 1 \cdot 10^{15}$  Гц,  $A = h\nu_{\min} = 4 \cdot 10^{-19}$  Дж.
932.  $\nu = \sqrt{\frac{2hc(\lambda_{\max} - \lambda)}{m\lambda_{\max} \lambda}} = 2 \cdot 10^5$  м/с.
933.  $\lambda_2 = \frac{k^2 \lambda_1 \lambda_{\max}}{\lambda_{\max} - (1 - k^2)\lambda_1} = 540$  нм.
934.  $h = \frac{E_{km}}{\nu - \nu_{\min}} = 6,6 \cdot 10^{-34}$  Дж · с,  $A = h\nu_{\min} = 4 \cdot 10^{-19}$  Дж.
935.  $I = \frac{\eta P \lambda e}{hc} = 8 \cdot 10^{-10}$  А.
936.  $A = \frac{hc}{\lambda_1} - eU = 3 \cdot 10^{-19}$  Дж,  $\lambda_{\max} = \frac{hc}{A} = 6 \cdot 10^{-7}$  м, не будет.
937.  $\Delta E_{k \max} = \Delta E = 3$  эВ. 938.  $\lambda_{\max} = \frac{(n_2 - 1)c}{(n_2 - n_1)\nu} = 5 \cdot 10^{-7}$  м.
939.  $A = \frac{hc}{\lambda} - e\varphi_{\max} = 4$  эВ. 940.  $A = \frac{hc}{\lambda} - \frac{(RBe)^2}{2m_e}$ .
941.  $\theta = \arccos\left(1 - \frac{E_0(E - E')}{EE'}\right) = 31^\circ$ ,  $E_k = E - E' = 0,05$  МэВ.
942.  $p_e = \sqrt{p^2 + (p')^2 - 2pp' \cos \theta} = 5 \cdot 10^{-23}$  кг · м/с, где  $p = \frac{h}{\lambda}$ ,  
 $p' = \frac{h}{\lambda + \lambda_C(1 - \cos \theta)}$ .
943.  $E' = \frac{2hc}{3\lambda_C(1 - \cos \theta)} = 1 \cdot 10^{-13}$  Дж,  
 $p' = \frac{2h}{3\lambda_C(1 - \cos \theta)} = 4 \cdot 10^{-22}$  кг · м/с.

## 18. АТОМ И АТОМНОЕ ЯДРО

955.  $\rho = \frac{3m_0}{4\pi R_0^3} = 1,8 \cdot 10^{17}$  кг/м<sup>3</sup>,  $m = \rho V = 1,8 \cdot 10^{11}$  кг.
956.  $r = \frac{qeN_A}{\pi \epsilon_0 M \nu^2} = 3 \cdot 10^{-14}$  м. 957.  $\frac{m_m}{m_\alpha} = \frac{\sqrt{E_0} + \sqrt{E}}{\sqrt{E_0} - \sqrt{E}} = 16$ .

$$958. v = \sqrt{\frac{2E_k}{m}} = 1,92 \cdot 10^7 \text{ м/с. } 959. R_1 = 0,96R_2.$$

$$960. n = \frac{e}{4\pi r \sqrt{\pi \epsilon_0 m_e r}} = 6,6 \cdot 10^{15} \text{ с}^{-1}. 961. \Delta E = hc \left( \frac{1}{\lambda_1} + \frac{1}{\lambda_2} \right) = 13 \text{ эВ.}$$

$$962. r = \frac{e^2}{4\pi \epsilon_0 m_e v^2} = 5,2 \cdot 10^{-11} \text{ м, } E = \frac{4\pi \epsilon_0 m_e^2 v^4}{e^3} = 5,3 \cdot 10^{11} \text{ В/м.}$$

$$963. E = \frac{e}{4\pi \epsilon_0 r_1^2} = 5,1 \cdot 10^{11} \text{ В/м, } E_k = \frac{e^2}{8\pi \epsilon_0 r_1} = 2,2 \cdot 10^{-18} \text{ Дж.}$$

$$964. \frac{v_3}{v} = \frac{e^2}{4\pi \epsilon_0 \hbar v} = 9,3 \cdot 10^3. 965. d = \frac{W_1 - W_2 - A}{eE} = 9,2 \cdot 10^{-3} \text{ м.}$$

$$966. E_p/E_k = -2.$$

$$967. \text{ а) } Z = 13, N = 14; \text{ б) } Z = 82, N = 125; \text{ в) } Z = 92, N = 143.$$

$$968. E_{\text{св}} = c^2(92m_p + (235 - 92)m_n - m_a) = 1784 \text{ МэВ.}$$

$$969. \Delta m_1 = 4(\Delta m_2 + m_2) - m_1 = 0,12 \text{ а. е. м., } E_{\text{св}} = c^2 \Delta m_1 = 1,1 \cdot 10^2 \text{ МэВ.}$$

$$970. \frac{E_{\text{св}}}{A} = \frac{(Z_{\text{I}} + (A - Z)m_n - m_a)931,5}{A} = 7,98 \text{ МэВ.}$$

$$971. E_0 = \frac{EM}{mN_A} = 3,2 \cdot 10^{-11} \text{ Дж } (M = 235 \cdot 10^{-3} \text{ кг/моль}).$$

$$972. P = \frac{\eta E_0 m N_A}{Mt \cdot 100\%} = 5,2 \cdot 10^7 \text{ Вт.}$$

$$973. t = \frac{\alpha m N_A E_0}{PM} = 1,9 \cdot 10^2 \text{ сут } (M = 235 \cdot 10^{-3} \text{ кг/моль}).$$

974. Первый и второй переходы обусловлены  $\beta$ -распадом, а третий -  $\alpha$ -распадом.

$$975. t = \frac{T \lg n}{\lg 2} = 54 \text{ сут. } 976. T = \frac{t \lg 2}{\lg(N_0/(N_0 - \Delta N))} = 4 \text{ сут.}$$

$$977. N = \frac{I\tau}{2en} = 2,3 \cdot 10^{13}. 978. N = 17.$$

$$979. \alpha\text{-Частица } \left( {}^4_2\text{He} \right), E = \frac{E_0 m N_A}{M} = 2,4 \cdot 10^{11} \text{ Дж}$$

$$(M = 7 \cdot 10^{-3} \text{ кг/моль}).$$

980. Нейтрон, протон и  $\alpha$ -частица.

$$981. \text{ а) } {}^1_1\text{H} + {}^1_0\text{n} \rightarrow {}^2_1\text{H} + \gamma; \text{ б) } {}^9_4\text{Be} + \gamma \rightarrow {}^4_2\text{He} + {}^4_2\text{He} + {}^1_0\text{n}.$$

$$982. Q_1 = 2,4 \text{ МэВ, } Q_2 = -1,03 \text{ МэВ.}$$