试卷参考答案

一、填空题：（12题，共48分）

1. $l^2 = h^2 + x^2$　　$2l\dfrac{\mathrm{d}l}{\mathrm{d}t} = 2x\dfrac{\mathrm{d}x}{\mathrm{d}t}$　　$v = \dfrac{\mathrm{d}x}{\mathrm{d}t} = \dfrac{\sqrt{h^2+x^2}}{x}\cdot\dfrac{\mathrm{d}l}{\mathrm{d}t} = 10\sqrt{2}\,(\mathrm{m/s})$

2. $\Delta E_{\mathrm{k}} = -GMm(\dfrac{1}{R_1} - \dfrac{1}{R_2}) = GMm\dfrac{R_1 - R_2}{R_1R_2}$

3. $mR(v_0 - V) = mRV$　　$V = \dfrac{v_0}{2}$

4. $-Mgr\sin\theta = J\beta$　　$-Mgr\cdot\theta = 2Mr^2\dfrac{\mathrm{d}^2\theta}{\mathrm{d}t^2}$　　$\omega = \sqrt{\dfrac{g}{2r}} = \dfrac{2\pi}{T} = 4$　　$r = \dfrac{g}{32}$

5. $\Delta t = \dfrac{\Delta x}{u} = \dfrac{20}{0.6c}$　　$\Delta t' = \Delta t\sqrt{1-u^2/c^2} = \dfrac{20}{0.6c}0.8 = \dfrac{80}{3c} = 8.89\times10^{-8}\,(\mathrm{s})$

6. $v' = \dfrac{0.4c-(-0.5c)}{1-0.4c\cdot(-0.5c)/c^2} = \dfrac{3}{4}c$　　$p = \dfrac{m_0v'}{\sqrt{1-v'^2/c^2}} = \dfrac{3m_0c}{\sqrt{7}} = 1.13m_0c$

$E_{\mathrm{k}} = mc^2 - m_0c^2 = m_0c^2(\dfrac{4}{\sqrt{7}} - 1) = 0.51m_0c^2$

7. $A = 0.02\,(\mathrm{m})$　　$v_m = A\omega$　　$\omega = \dfrac{5}{2}\,(\mathrm{rad/s})$　　$\varphi = -\dfrac{\pi}{2}$

$x = 0.02\cos(\dfrac{5}{2}t - \dfrac{\pi}{2})\,(\mathrm{m})$

8. $\varphi_2 - \varphi_1 - \dfrac{2\pi}{\lambda}(r_2 - r_1) = 2k\pi$

9. $E = \nu\dfrac{i}{2}RT$　　$\dfrac{V_{O_2}}{V_{He}} = \dfrac{1}{2} = \dfrac{\nu_{O_2}}{\nu_{He}}$　　$\dfrac{E_{O_2}}{E_{He}} = \dfrac{\nu_{O_2}}{\nu_{He}}\cdot\dfrac{i_{O_2}}{i_{He}} = \dfrac{1}{2}\cdot\dfrac{5}{3} = \dfrac{5}{6}$

10. $\dfrac{\Delta N}{N} = \int_{v_p}^{\infty} f(v)\mathrm{d}v$

11. $\bar{\lambda} = \dfrac{kT}{\sqrt{2}\pi d^2 p} = \dfrac{1.38\times10^{-23}\times273}{\sqrt{2}\pi\times(3.5\times10^{-10})^2\times1.013\times10^5} = 6.8\times10^{-8}\,(\mathrm{m})$

$\bar{v} = \sqrt{\dfrac{8RT}{\pi M}} = \sqrt{\dfrac{8\times8.31\times273}{\pi\times29\times10^{-3}}} = 446\,(\mathrm{m/s})$　　$\bar{Z} = \dfrac{\bar{v}}{\bar{\lambda}} = 6.5\times10^9\,(\mathrm{s}^{-1})$

12. 当 $r << L$ 时，为无限长：$E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$　　当 $r >> L$ 时，为点电荷：$E = \dfrac{\lambda L}{4\pi\varepsilon_0 r^2}$

二、计算题：（6题，共52分）

1.（1）$T - mg = ma$　　$mg - T' = ma'$　　$T'\cdot 2r - T\cdot r = \dfrac{9}{2}mr^2\beta$

$a = r\beta$　　$a' = 2r\beta$　　$\beta = \dfrac{2g}{19r} = 10.3\,(\mathrm{rad/s^2})$

（2）　$\omega = \sqrt{2\beta\theta} = \sqrt{2\cdot\dfrac{2g}{19r}\cdot\dfrac{h}{r}} = 9.08\,(\mathrm{rad/s})$

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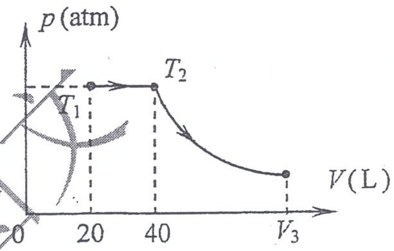
2.（1） 摩擦力的力矩为零，故角动量守恒。

（2） $[\frac{1}{12}Ml^2+2mr^2]\frac{2\pi n_0}{60}=[\frac{1}{12}Ml^2+2m(\frac{l}{2})^2]\omega$　　　$\omega=\frac{\pi}{5}=0.628\,(\text{rad/s})$

（3） 小物体离开棒端的瞬间，棒的角速度仍为ω。因为两者间无冲力矩作用。

3. 氦气自由度为：$i=3$



（1） 如图所示。$T_2=\frac{V_2}{V_1}T_1=600\,(\text{K})$

（2） $Q=\nu C_p(T_2-T_1)=2\cdot\frac{3+2}{2}R(600-300)$

$=1.25\times10^4\,(\text{J})$

（3） $\Delta E=0$

（4） $A=\Delta E-Q=-1.25\times10^4\,(\text{J})$

（5） $\Delta S=\int_{T_1}^{T_2}\frac{\nu C_p\,\mathrm{d}T}{T}=\nu C_p\ln\frac{T_2}{T_1}=5R\ln2\,(\text{J/K})$

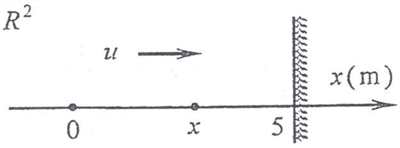
（6） $\gamma=\frac{C_p}{C_V}=\frac{5}{3}$　　$V_3=(\frac{T_2}{T_1})^{\frac{1}{\gamma-1}}V_2=2^{\frac{3}{2}}V_2=80\sqrt{2}=113\,(\text{L})$

4. 场强叠加原理

$E_1=\frac{\sigma}{2\varepsilon_0}$　方向向上　　　$E_2=\frac{-\sigma}{2\varepsilon_0}(1-\frac{z}{\sqrt{z^2+R^2}})$　方向向下

$\boldsymbol{E}=\boldsymbol{E}_1+\boldsymbol{E}_2=\frac{\sigma z}{2\varepsilon_0\sqrt{z^2+R^2}}\boldsymbol{k}$

或：　$E=\int_R^\infty\frac{\sigma}{4\pi\varepsilon_0}\cdot\frac{2\pi x\mathrm{d}x}{z^2+x^2}\cdot\frac{z}{\sqrt{z^2+x^2}}=\frac{\sigma z}{2\varepsilon_0}\cdot\frac{1}{\sqrt{z^2+R^2}}$



5.　$y_1(x)=0.25\cos(4t-\pi x-\frac{\pi}{2})$

$y_2(x)=0.25\cos(4t+\pi x+\varphi)$

$x=5$：$(4t+5\pi+\varphi)-(4t-5\pi-\frac{\pi}{2})=\pi$　　　$\varphi=\frac{\pi}{2}-10\pi$

$y_2(x)=0.25\cos(4t+\pi x+\frac{\pi}{2})$ (SI)

6.　$\overline{AP}=50\,(\text{cm})$

$\varphi_2-\varphi_1-\frac{2\pi}{\lambda}(\overline{BP}-\overline{AP})=\pm(2k+1)\pi$　　　$(k=0,1,2,\cdots)$

$\pi+\frac{2\pi}{\lambda}\times10=(2k+1)\pi$

$\lambda=\frac{10}{k}$　　$(k=1,2,3,\cdots)$　　　$k=1$　　　$\lambda_{\max}=10\,(\text{cm})$