

$$q_1 = -\frac{a}{d}q_0, \text{ 位置为 } (0, \frac{a^2}{d})$$

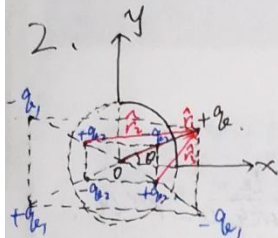
$$q_2 = \frac{a}{d}q_0, \text{ 位置为 } (0, -\frac{a^2}{d})$$

$$q_3 = -q_0, \text{ 位置为 } (0, -d)$$

$$\vec{F} = \frac{q_0}{4\pi\epsilon_0} \left[\frac{-\frac{a}{d}q_0}{(\frac{a^2}{d})^2} + \frac{-q_0}{(2d)^2} + \frac{\frac{a}{d}q_0}{(d+\frac{a^2}{d})^2} \right] \vec{e}_y$$

$$= \frac{-q_0^2}{4\pi\epsilon_0} \left[\frac{1}{4d^2} + \frac{4a^3d^3}{(d^4 - a^4)^2} \right] \vec{e}_y$$

(注: 课本P353例8.3解答中图(b)的 q_2, q_3 标反了)



$$q_1 = q_0, \text{ 距离原点为 } d, \quad q_2 = \frac{a}{d}q_0, \text{ 距离原点为 } \frac{a^2}{d}$$

$$\vec{F} = \frac{a q_0^2}{4\pi\epsilon_0} \left(\frac{\hat{r}_2}{r_2^2} + \frac{\hat{r}_3}{r_3^2} \right)$$

$$+ \frac{q_0^2}{4\pi\epsilon_0} \left[\frac{-\frac{a}{d}}{(d-\frac{a^2}{d})^2} \hat{r}_1 + \frac{1}{4d^2} \hat{r}_1 + \frac{-\frac{a}{d}}{(d+\frac{a^2}{d})^2} \hat{r}_1 \right]$$

$$+ \frac{-q_0^2}{4\pi\epsilon_0} \frac{1}{4d^2 \sin^2 \theta} \vec{e}_y$$

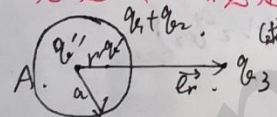
$$+ \frac{-q_0^2}{4\pi\epsilon_0} \frac{1}{4d^2 \cos^2 \theta} \vec{e}_x$$

可继续把 $\hat{r}_1, \hat{r}_2, \hat{r}_3$ 分解成 $\{\vec{e}_x, \vec{e}_y\}$ 的线性组合(巨麻烦...),
也可一开始用极坐标表示(也很麻烦...).

3. (1) 静电屏蔽

$$q_0, q_2 \text{ 位于空腔正中心} \Rightarrow \vec{F}_{q_1} = \vec{F}_{q_2} = 0$$

(注: 光有静电屏蔽是不够的, q_0, q_2 只有在空腔中心才受力为0, 且该平衡状态是一个不稳定平衡状态)



(或 F_{q_1} 等效为A的外表面带电荷量为 $q_1 + q_2$)

引入第一个像电荷 $q'_0 = -\frac{a}{r}q_3, r' = \frac{a^2}{r}$ (相当于外表面接地时的情况, 此时外表面电势为0)

为保证外表面电荷量为 $q_1 + q_2$, 引入第二个像电荷 $q''_0 = q_1 + q_2 - q'_0 = q_1 + q_2 + \frac{a}{r}q_3$

为保证A的外表面仍然等势, 应将 q''_0 置于A的球心处.

$$\vec{F}_{q_3} = \frac{q_3}{4\pi\epsilon_0} \left[\frac{-\frac{a}{r}q_3}{(r-\frac{a^2}{r})^2} + \frac{q_1 + q_2 + \frac{a}{r}q_3}{r^2} \right] \vec{e}_r, \quad \vec{F}_A = -\vec{F}_3$$

$$(2) r \gg a \text{ 时}, \vec{F}_{q_1} = \vec{F}_{q_2} = 0, \quad \vec{F}_A = -\frac{q_0 q_3}{4\pi\epsilon_0} \frac{q_1 + q_2}{r^2} \vec{e}_r$$

2.3. 解: 2块板的情况. 取如图所示高斯面, 由于静电屏蔽,

$\oint \vec{E} \cdot d\vec{S} = 0$, 故有 $\Sigma q_i = \sigma_1 \cdot S + \sigma_3 \cdot S = 0 \Rightarrow \sigma_1 = -\sigma_3$.
 取右金属板内一点, $E = \frac{1}{2\epsilon_0}(\sigma_1 + \sigma_2 + \sigma_3 + \sigma_4) = 0$.
 由于 $\sigma_1 + \sigma_3 = 0$, 故 $\sigma_2 = \sigma_4$.

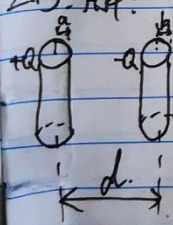
推广到本题有 $\begin{cases} Q_B + Q_C = 0, Q_D + Q_E = 0, Q_F + Q_G = 0, Q_A = Q_H, \\ Q_A + Q_B = 5, Q_C + Q_D = 1, Q_E + Q_F = 1, Q_G + Q_H = 2 \end{cases}$

解得 $\begin{cases} Q_A = 4.5C, Q_B = 0.5C, Q_C = -0.5C, Q_D = 1.5C, \\ Q_E = -1.5C, Q_F = 2.5C, Q_G = -2.5C, Q_H = 4.5C \end{cases}$

若用一根导线连接, 则有 $\begin{cases} Q_B + Q_C = 0, Q_F + Q_G = 0, Q_A = Q_H, \\ Q_A + Q_B = 5, Q_C + Q_F = 2, Q_G + Q_H = 2 \end{cases}$

解得 $Q_A = 4.5C, Q_B = 0.5C, Q_C = -0.5C, Q_F = 2.5C, Q_G = -2.5C, Q_H = 4.5C$

2.5. 解:



$\epsilon_0 E \cdot 2\pi r = Q \Rightarrow E = \frac{Q}{2\pi\epsilon_0 r}$

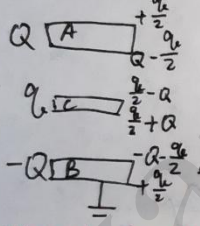
$U_1 = \frac{Q}{2\pi\epsilon_0} \int_a^b \frac{1}{r} dr = \frac{Q}{2\pi\epsilon_0} \ln \frac{b}{a}$

$U_2 = \frac{-Q}{2\pi\epsilon_0} \int_b^c \frac{1}{r} dr = \frac{-Q}{2\pi\epsilon_0} \ln \frac{c}{b}$

$\Delta U = U_1 - U_2 = \frac{Q}{2\pi\epsilon_0} \ln \frac{(b-a)(d-a)}{ab}$

$C = \frac{Q}{\Delta U} = \frac{2\pi\epsilon_0}{\ln \frac{(b-a)(d-a)}{ab}} \approx \frac{2\pi\epsilon_0}{\ln \frac{d^2}{ab}}$

2.10. 法一:



$C_0 = \frac{Q}{U} = \frac{\epsilon_0 S}{d}$

$C_{AC} = C_{CB} = \frac{\epsilon_0 S}{\frac{d}{2}} = \frac{2\epsilon_0 S}{d}$

$U_C = \frac{Q + \frac{Q}{2}}{\frac{2\epsilon_0 S}{d}} = \frac{1}{2} \left[\frac{Q}{C_0} + \frac{Q_0 d}{2\epsilon_0 S} \right] = \frac{1}{2} \left(U + \frac{Q_0 d}{2\epsilon_0 S} \right)$

法二 (叠加原理): $\frac{\int E}{\int E} \sigma = \frac{q_0}{S}, E = \frac{\sigma}{2\epsilon_0} = \frac{q_0}{2\epsilon_0 S}$

$U_C = \frac{U}{2} + E \cdot \frac{d}{2} = \frac{U}{2} + \frac{Q_0 d}{4\epsilon_0 S} = \frac{1}{2} \left(U + \frac{Q_0 d}{2\epsilon_0 S} \right)$

(接地处没有电荷)

2.6 设地球带电 $+q$ ，以无穷远为电势零点，
月球 $-q'$

则 $\Delta U = \frac{q}{4\pi\epsilon_0} \left(\frac{1}{a} + \frac{1}{b} \right)$ 显然

$$C = \frac{q}{\Delta U} = 4\pi\epsilon_0 \frac{ab}{b+a}$$

\Rightarrow 若用细导线连通 \Rightarrow 二者等势 \Rightarrow 并联

$$C = 4\pi\epsilon_0(a+b)$$

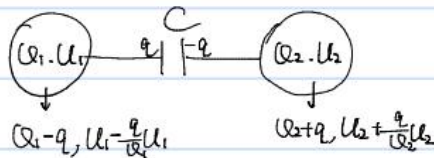
[若详细推导，

则由等势 $\Rightarrow \frac{q_1}{4\pi\epsilon_0 a} = \frac{q_2}{4\pi\epsilon_0 b} = U$

$$q_1 + q_2 = Q$$

解得 $q_1 = \frac{a}{a+b} Q \Rightarrow U = \frac{Q}{4\pi\epsilon_0(a+b)}$
 $q_2 = \frac{b}{a+b} Q \Rightarrow C = \frac{Q}{U} = \dots$

2.14



$$\frac{Q}{C} = (U_1 - \frac{Q}{Q_1} U_1) - (U_2 + \frac{Q}{Q_2} U_2)$$

即 $Q = C(U_1 - U_2) - Q \left(\frac{U_1}{Q_1} + \frac{U_2}{Q_2} \right) \Rightarrow Q = \frac{C(U_1 - U_2)}{1 + C \left(\frac{U_1}{Q_1} + \frac{U_2}{Q_2} \right)}$

此时 $U_C = \frac{Q}{C} = \frac{Q_1 Q_2}{Q_1 Q_2 + C(U_1 Q_2 + U_2 Q_1)} (U_1 - U_2)$

2.21

由于介质和极化电荷的存在，考虑电位移量 \vec{D} 。

Gauss: $Q_{\text{tot}} = \oint_S \vec{D} \cdot d\vec{s}$ (x) ("o"代表自由电荷)

取半径为 r 的球形 Gauss 面 ($a < r < b$),

(x) 式化为 $+Q = \epsilon_1 E_1 \cdot 2\pi r^2 + \epsilon_2 E_2 \cdot 2\pi r^2$ ①

由于介质分界面平行于电场方向，由静电场环路定理： $E_1(r) = E_2(r)$ ②

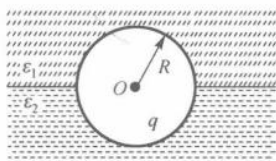
联立 ①② 解得 $E_1 = E_2 \triangleq E = \frac{Q}{2\pi(\epsilon_1 + \epsilon_2)r^2}$

故 $\Delta U = \int_a^b E(r) dr = \frac{Q}{2\pi(\epsilon_1 + \epsilon_2)} \left(\frac{1}{a} - \frac{1}{b} \right)$

$$C = \frac{Q}{\Delta U} = 2\pi(\epsilon_1 + \epsilon_2) \frac{ab}{b-a}$$

(别忘了写 E 的方向!)

2.19 如习题 2.19 图所示,一导体球外充满两半无限电介质,介电常量分别为 ε_1 和 ε_2 , 介质界面为通过球心的无限平面. 设导体球半径为 a , 总电荷为 q , 求空间电场分布和导体球表面的自由面电荷分布.



习题 2.19 图

解 本题属于介质界面与电场线重合的情况, 具有对称性的是电场. 取球坐标 (r, θ, ϕ) , 原点位于球心, 电场沿径向方向, 且只与 r 有关. 由高斯定理得

$$2\pi r^2 \varepsilon_1 E + 2\pi r^2 \varepsilon_2 E = q \Rightarrow E = \frac{q}{2\pi(\varepsilon_1 + \varepsilon_2)r^2} e_r$$

据此求得两介质区的电位移矢量如下:

$$D_1 = \varepsilon_1 E = \frac{\varepsilon_1 q}{2\pi(\varepsilon_1 + \varepsilon_2)r^2} e_r, \quad D_2 = \varepsilon_2 E = \frac{\varepsilon_2 q}{2\pi(\varepsilon_1 + \varepsilon_2)r^2} e_r$$

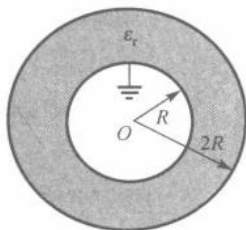
导体球表面的自由面电荷密度为

$$\sigma_1 = D_1(a) = \frac{\varepsilon_1 q}{2\pi(\varepsilon_1 + \varepsilon_2)a^2}, \quad \sigma_2 = D_2(a) = \frac{\varepsilon_2 q}{2\pi(\varepsilon_1 + \varepsilon_2)a^2}$$

2.15 有一半径为 R 的金属球, 外面包有一层相对介电常量为 $\varepsilon_r = 2$ 的均匀电介质, 壳内外半径分别为 R 和 $2R$, 介质内均匀分布着电量为 q_0 的自由电荷, 金属球接地. 求介质球壳外表面的电势.

解 金属球接地, 如习题 2.15 图所示, 其电势 $U = 0$. 介质中自由电荷密度为 $3q_0 / \{4\pi[(2R)^3 - R^3]\}$. 设接地金属球表面的感应电荷总量为 q , 由对称性可判断电荷沿金属球表面均匀分布. 运用高斯定理, 可求得介质内电场强度

$$4\pi r^2 \varepsilon_r \varepsilon_0 E_1 = q + \frac{r^3 - R^3}{(2R)^3 - R^3} q_0 \Rightarrow E_1 = \frac{1}{8\pi \varepsilon_0} \left(\frac{q}{r^2} + \frac{q_0 r}{7R^3} - \frac{q_0}{7r^2} \right)$$



习题 2.15 图

在介质外的电场强度 $E_2 = (q + q_0) / (4\pi \varepsilon_0 r^2)$. 由金属球和无穷远电势均等于零的条件

$$\int_{2R}^R E_1 dr = \int_{2R}^{\infty} E_2 dr \Rightarrow \frac{1}{8\pi \varepsilon_0} \int_{2R}^R \left(\frac{q}{r^2} + \frac{q_0 r}{7R^3} - \frac{q_0}{7r^2} \right) dr = \frac{q + q_0}{4\pi \varepsilon_0} \int_{2R}^{\infty} \frac{dr}{r^2}$$

可求得 $q = -16q_0 / 21$. 介质球壳外表面电势为

$$U = \int_{2R}^{\infty} E_2 dr = \int_{2R}^{\infty} \frac{q + q_0}{4\pi \varepsilon_0 r^2} dr = \frac{q + q_0}{8\pi \varepsilon_0 R} = \frac{5q_0}{168\pi \varepsilon_0 R}$$

$$2.28: r < a: D \cdot 4\pi r^2 = q_e \cdot \frac{r^3}{a^3} \Rightarrow \vec{D} = \frac{q_e r}{4\pi a^3} \vec{e}_r$$

$$r > a: D \cdot 4\pi r^2 = q_e \Rightarrow \vec{D} = \frac{q_e}{4\pi r^2} \vec{e}_r$$

$$\vec{E} = \frac{\vec{D}}{\epsilon_0} = \begin{cases} \frac{q_e r}{4\pi \epsilon_0 a^3} \vec{e}_r, & r < a \\ \frac{q_e}{4\pi \epsilon_0 r^2} \vec{e}_r, & r > a \end{cases}$$

$$\text{法一: } U(\vec{r}) = \int_r^{+\infty} \vec{E}(\vec{r}) \cdot d\vec{r} = \frac{q_e}{8\pi \epsilon_0 a} \left(\frac{1}{a} - \frac{r^2}{a^3} \right) + \frac{q_e}{4\pi \epsilon_0 a}, \quad r < a$$

$$\rho = \frac{q_e}{\frac{4}{3}\pi a^3}$$

$$W = \frac{1}{2} \iiint_V \rho U dV$$

(积分区间 V_0 为球, $r < a$ 部分)

$$\text{法二: } w = \frac{1}{2} \vec{D} \cdot \vec{E}, \quad W = \iiint_V w dV = \frac{q_e^2}{8\pi \epsilon_0 a} \left(1 + \frac{1}{5} \right), \quad (\text{积分区间 } V \text{ 为全空间})$$

$$2.32: \text{法一: } V = \frac{q_1}{4\pi \epsilon_0 R_1} + \frac{q_2}{4\pi \epsilon_0 R_2} \Rightarrow q_1 = 4\pi \epsilon_0 V R_1 - \frac{R_1}{R_2} q_2$$

$$\text{法二: 由高斯定理, 可求得 } \vec{E} = \begin{cases} \frac{q_1}{4\pi \epsilon_0 r^2} \vec{e}_r, & R_1 < r < R_2 \\ \frac{q_1 + q_2}{4\pi \epsilon_0 r^2} \vec{e}_r, & r > R_2 \end{cases}$$

$$V = \int \vec{E} \cdot d\vec{r} = \frac{1}{4\pi \epsilon_0} \left[\int_{R_1}^{R_2} \frac{q_1}{r^2} dr + \int_{R_2}^{+\infty} \frac{q_1 + q_2}{r^2} dr \right]$$

$$\Rightarrow q_1 = 4\pi \epsilon_0 V R_1 - \frac{R_1}{R_2} q_2$$

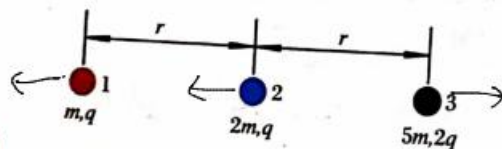
$$(2) \text{法一: } V_2 = \frac{1}{4\pi \epsilon_0} \left(\frac{q_1}{R_2} + \frac{q_2}{R_2} \right), \quad W = \frac{1}{2} (V q_1 + V_2 q_2)$$

$$\text{法二: } W = \iiint_V \frac{1}{2} \vec{D} \cdot \vec{E} dV = \iiint_V \frac{\epsilon_0}{2} E^2 dV$$

$$= \frac{\epsilon_0}{2} \left[\int_{R_1}^{R_2} \left(\frac{q_1}{4\pi \epsilon_0 r^2} \right)^2 \cdot 4\pi r^2 dr + \int_{R_2}^{+\infty} \left(\frac{q_1 + q_2}{4\pi \epsilon_0 r^2} \right)^2 \cdot 4\pi r^2 dr \right]$$

$$= \frac{1}{8\pi \epsilon_0} \left[(4\pi \epsilon_0 V)^2 R_1 + \left(\frac{1}{R_2} - \frac{R_1}{R_2^2} \right) q_2^2 \right]$$

2.30 3个带正电的粒子分别被固定在如图中相应位置。每个粒子的质量、带电量 and 相邻粒子间距 r 都已经给出。同时释放3个粒子。求3个粒子彼此离得非常远时它们的动能。假设粒子沿同一直线运动。粒子在图中分别标号为1,2,3。



习题 2.30 图

$$\begin{aligned} \text{总静电能 } W_0 &= W_{12} + W_{13} + W_{23} = \frac{1}{4\pi\epsilon_0} \left(\frac{q^2}{r} + \frac{2q^2}{r} + \frac{2q^2}{2r} \right) \\ &\quad (\text{点电荷近似}) = \frac{q^2}{\pi\epsilon_0 r} \end{aligned}$$

“离得很远” $\Rightarrow W_0$ 完全转化为 E_k 。

定性分析 \Rightarrow 1, 2 向左运动, 3 向右运动。

$$p \text{ Momentum: } \sqrt{2mE_{k1}} + \sqrt{4mE_{k2}} = \sqrt{10mE_{k3}} \Rightarrow \sqrt{E_{k1}} + \sqrt{2E_{k2}} = \sqrt{5E_{k3}} \quad (1)$$

$$Energy: E_{k1} + E_{k2} + E_{k3} = W_0 \quad (2)$$

还差一个方程。此时可以分析一下3者的运动过程。

$$m\ddot{x}_1 = \frac{1}{4\pi\epsilon_0} \left(-\frac{q^2}{r_{12}^2} - \frac{2q^2}{r_{13}^2} \right) \quad (1) \quad t=0 \text{ 时, } r_{12}=r_{21}=r$$

$$2m\ddot{x}_2 = \frac{1}{4\pi\epsilon_0} \left(-\frac{q^2}{r_{21}^2} - \frac{2q^2}{r_{23}^2} \right) \quad (2) \quad r_{23}=r_{32}=r$$

$$5m\ddot{x}_3 = \frac{1}{4\pi\epsilon_0} \left(\frac{2q^2}{r_{31}^2} + \frac{2q^2}{r_{32}^2} \right) \quad (3) \quad r_{13}=r_{31}=2r$$

$$\text{可知 } m\ddot{x}_1(0) = -\frac{q^2}{4\pi\epsilon_0} \frac{3}{r^2} \quad (*)$$

$$2m\ddot{x}_2(0) = -\frac{q^2}{4\pi\epsilon_0} \frac{1}{r^2} \Rightarrow \ddot{x}_2(0) = \frac{1}{2} (\ddot{x}_1(0) + \ddot{x}_3(0))$$

$$5m\ddot{x}_3(0) = \frac{q^2}{4\pi\epsilon_0} \frac{5}{r^2}$$

$$\text{两端对时间积分 } \dot{x}_2(t) - \dot{x}_2(0) = \frac{1}{2} [(\dot{x}_1(t) - \dot{x}_1(0)) + (\dot{x}_3(t) - \dot{x}_3(0))]$$

$$\text{两端对时间积分 } x_2(dt) - x_2(0) = \frac{1}{2}[(x_1(dt) - x_1(0)) + (x_3(dt) - x_3(0))]$$

$$(dt \rightarrow 0) \int_0^t x_2(dt) - x_2(0) = \frac{1}{2}[(x_1(dt) - x_1(0)) + (x_3(dt) - x_3(0))]$$

$$\text{即在 } dt \text{ 时刻} \left\{ \begin{aligned} r_{12}(dt) &= x_2(dt) - x_1(dt) = \frac{1}{2}[x_3(dt) - x_1(dt)] \\ r_{23}(dt) &= x_3(dt) - x_2(dt) = \frac{1}{2}[-x_1(dt)] \\ r_{13}(dt) &= x_3(dt) - x_1(dt) = 2r(dt) \end{aligned} \right\} \triangleq r(dt)$$

这说明 (x) 式所示关系在 dt 时也成立, 进而在任意 t 时成立.

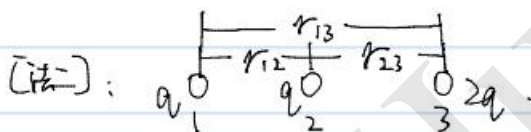
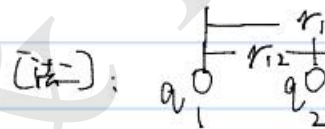
$$\text{于是恒有关系: } v_2 = \frac{1}{2}(v_1 + v_3) \Rightarrow -2\sqrt{\frac{2E_k}{2m}} = -\sqrt{\frac{2E_k}{m}} + \sqrt{\frac{2E_k}{5m}} \quad (\text{方向表现在符号上})$$

(v_i 带方向)

$$\text{即 } -\sqrt{2E_k} + 2\sqrt{E_k} + \sqrt{\frac{2}{5}E_k} = 0$$

$$\sqrt{E_k} = \sqrt{2E_k} + \sqrt{\frac{2}{5}E_k} \quad (3)$$

$$\Rightarrow \text{联立 } ① \sim ③ \text{ 解得 } \begin{cases} E_{k1} = \frac{9q^2}{16\pi\epsilon_0 r} \\ E_{k2} = \frac{q^2}{8\pi\epsilon_0 r} \\ E_{k3} = \frac{5q^2}{16\pi\epsilon_0 r} \end{cases}$$



从初态 \rightarrow 末态, 三个电荷力做的功转化成了动能.

$$\text{① 考虑 } 1 \& 2: E_1 = \int_r^\infty \frac{q^2}{4\pi\epsilon_0 r^2} dr_{12} = \frac{q^2}{4\pi\epsilon_0 r} \quad (\text{为简便起见, 不妨记 } E_0 \triangleq \frac{q^2}{\pi\epsilon_0 r})$$

重点在于分解 E_1 , 理清 E_1 中有多少转化到了 1 上, 又有多少转化到了 2 上.

$$\begin{aligned} \xleftarrow{3m} & \quad \xleftarrow{2m} & \quad \xrightarrow{5m} \\ dm & \quad dm & \quad dm \end{aligned}$$

$$E_{k1} = \frac{3}{3+(-1)} E_1 = \frac{3}{8} E_0$$

$$E_{k2} = \frac{-1}{3+(-1)} E_1 = -\frac{1}{8} E_0$$

② 同理考虑 2 & 3:

$$E_2 = \int_r^\infty \frac{2q^2}{4\pi\epsilon_0 r_{23}^2} dr_{23} = \frac{q^2}{2\pi\epsilon_0 r} \Rightarrow \begin{cases} E_{k2} = \frac{1}{1+1} E_2 = \frac{1}{4} E_0 \\ E_{k3} = \frac{1}{1+1} E_2 = \frac{1}{4} E_0 \end{cases}$$

③ 1 & 3:

$$E_3 = \int_{2r}^\infty \frac{2q^2}{4\pi\epsilon_0 r_{13}^2} dr_{13} = \frac{q^2}{4\pi\epsilon_0 r} \Rightarrow \begin{cases} E_{k1} = \frac{3}{3+1} E_3 = \frac{3}{16} E_0 \\ E_{k3} = \frac{1}{3+1} E_3 = \frac{1}{16} E_0 \end{cases}$$

$$\text{综上, } \begin{cases} E_{k1} = E_{k1} + E_{k3} = \frac{9}{16} E_0 \\ E_{k2} = E_{k2} + E_{k2} = \frac{1}{8} E_0 \\ E_{k3} = E_{k3} + E_{k3} = \frac{5}{16} E_0 \end{cases}$$

$$3.2. \text{解. } R = \int \frac{dr}{\sigma S} = \frac{1}{\sigma} \int_a^b \frac{1}{4\pi r^2} dr = \frac{1}{4\pi\sigma} \left(\frac{1}{a} - \frac{1}{b} \right) = \frac{b-a}{4\pi\sigma ab}$$

$$3.3. \text{解. (1)} R = \int \frac{\rho dr}{S} = \rho \int_a^b \frac{1}{2\pi r l} dr = \frac{\rho}{2\pi l} \ln \frac{b}{a}$$

$$(2) \oint \vec{E} \cdot 2\pi r l \vec{e}_r = Q \Rightarrow \vec{E} = \frac{Q}{2\pi \epsilon r l} \vec{e}_r$$

$$U_{ab} = \int \vec{E} \cdot d\vec{r} = \int_a^b \frac{Q}{2\pi \epsilon r l} dr = \frac{Q}{2\pi \epsilon l} \ln \frac{b}{a}$$

$$C = \frac{Q}{U_{ab}} = \frac{2\pi \epsilon l}{\ln \frac{b}{a}}$$

$$(3) R \cdot C = \frac{\rho}{2\pi l \ln \frac{b}{a}} \cdot \frac{2\pi \epsilon l}{\ln \frac{b}{a}} = \rho \epsilon$$

$$3.5. \text{解. } \vec{j} = \frac{I}{2\pi r^2} \vec{e}_r = \sigma \vec{E} = \frac{1}{\rho} \vec{E} \Rightarrow \vec{E} = \frac{\rho I}{2\pi r^2} \vec{e}_r$$

$$U = \int_r^{\infty} \vec{E} \cdot d\vec{r} = \int_r^{\infty} \frac{\rho I}{2\pi} \cdot \frac{1}{r^2} dr = \frac{\rho I}{2\pi} \left(\frac{1}{r} - \frac{1}{r+b} \right)$$

$$r = \frac{1}{2}b, U \approx 1193.66V. \quad r = 10\text{mm}, U \approx 18.02V.$$