

1. Der Dipol

$$k = \frac{1}{4\pi\epsilon_0}; \quad x_1 = -\frac{d}{2}; \quad x_2 = \frac{d}{2}$$

(a)

$$V_{ges} = V_+ + V_- = kq \left(\frac{1}{r_+} - \frac{1}{r_-} \right)$$

(b) $d \ll r; \quad \vec{p} := q\vec{d}$

$$kq \left(\frac{1}{r_+} - \frac{1}{r_-} \right) = kq \left(\frac{r_- - r_+}{r_+ r_-} \right) \\ \approx kq \frac{d \cos(\theta)}{r^2}$$

$$\begin{aligned} r_- - r_+ &\approx d \cos(\theta) \\ r_+ r_- \pm l &\approx r^2 \end{aligned}$$

$$(c) |\vec{M}| = |\vec{p} \times \vec{E}| = \vec{p} \vec{E} \sin(\theta); \quad E_{pot} = \int_{\theta}^{\pi/2} |\vec{M}| d\tilde{\theta}$$

$$0 = \cos\left(\frac{1}{2} \delta \omega t\right)$$

$$t = \frac{2 \arccos(0)}{\delta \omega} = \underline{\underline{50.29 \text{ s}}}$$

2. Kondensator mit Dielektrikum

$$k = \frac{1}{4\pi\epsilon_0}; \quad C = \frac{\epsilon A}{d}; \quad \epsilon_{rel} = \frac{\epsilon}{\epsilon_0}$$

(a)

$$C_1 = \frac{\epsilon_0 a(a-h)}{d}$$

$$C_2 = \frac{\epsilon_r a h}{d}$$

$$C_{ges} = C_1 + C_2 = \underline{\underline{\frac{\epsilon_0 a}{d} (\epsilon_{rel} h + a - h)}}$$

(b)

$$E = \frac{CU^2}{2} = \frac{U^2 \epsilon_0 a (\epsilon_{rel} h + a - h)}{2d}$$

(c)

$$E' = \frac{C'U^2}{2} = \frac{U^2 \epsilon_0 a (\epsilon_{rel} (h + \Delta h) + a - (h + \Delta h))}{2d}$$

$$\Delta E = \frac{U^2 \epsilon_0 a}{2d} (\epsilon_{rel} \Delta h - \Delta h)$$

$$\Delta E_{pot} = \frac{mg \Delta h}{2} = \frac{\rho a^2 dg \Delta h}{2}$$

(d)

$$\Delta q = 2 \frac{\Delta E}{U} = \frac{U \epsilon_0 a}{d} (\epsilon_{rel} \Delta h - \Delta h)$$

3. Kapazität eines Koaxialkabels

$$k = \frac{1}{4\pi\epsilon_0}; \quad C = \frac{\epsilon A}{d}; \quad \epsilon_{rel} = \frac{\epsilon}{\epsilon_0}$$

(a) For $r \leq d \leq R$:

$$\frac{q_{in}}{\epsilon_0} = \oint \vec{E}(\vec{d}) \cdot d\vec{A} = E(d) \oint dA = E(d) 2\pi dl$$

$$E(d) = kq \frac{2}{dl}$$

For $R < d$:

$$q_{in} = 0$$

$$E(d) = 0$$

$$E(d) = \begin{cases} kQ \frac{2}{lr} & \text{for } r \leq d \leq R, \\ 0 & \text{for } R < d. \end{cases}$$

(b) For $r \leq d \leq R$:

$$E(d) = kq \frac{2}{dl}$$

$$V(d) = \int_d^{\infty} \vec{E}(r) \, d\vec{r} = \int_d^R kq \frac{2}{rl} \, dr + \underbrace{\int_R^{\infty} 0 \, dr}_{=0}$$

$$V(d) = \frac{2kq}{l} \ln\left(\frac{R}{d}\right)$$

$$V(d) = \begin{cases} \frac{2kq}{l} \ln\left(\frac{R}{d}\right) & \text{for } r \leq d \leq R, \\ 0 & \text{for } R < d. \end{cases}$$

(c) $r = 7.0 \cdot 10^{-4} \text{ m}; \quad R = 2.5 \cdot 10^{-3} \text{ m}; \quad C = 500 \text{ pF}$

$$C = \frac{q}{V(r)} = \frac{l}{2k \ln\left(\frac{R}{r}\right)}$$

$$l = \frac{C}{2k \ln\left(\frac{R}{r}\right)} \\ = \underline{\underline{11.44 \text{ m}}}$$

(d) $I = 0.1 \text{ A}; \quad U = 10 \text{ V}$

$$\Delta q = 2 \frac{\Delta E}{U} = \underline{\underline{\frac{U \epsilon_0 a}{d} (\epsilon_{rel} \Delta h - \Delta h)}}$$