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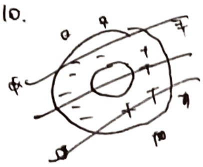
Q22.10.



The sphere has zero net charge.

For the enclosed sphere, The $Q_{enclosed}$ is 0.

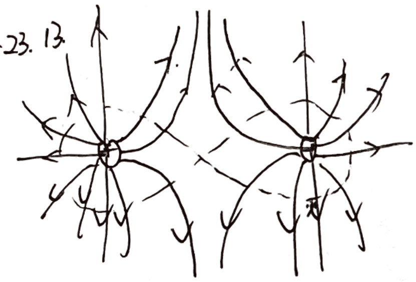
So $\oint \vec{E}\, d\vec{A} = \frac{Q_{enclose}}{\varepsilon_0} = 0. \Rightarrow E = 0.$

Q.22.13.

I think it's not valid.

For a conductor. if the electric field has component parallel to the surface, the free electrons will move. But for an insulator, there's no free electron, so the field's component does not matter.

Q23.13.

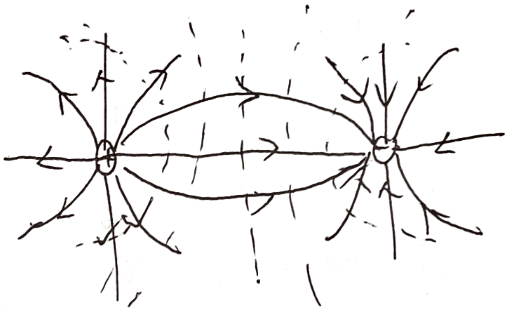


At that point $E=0$.

So it has no direction

So it's not ambiguous.

Q23.22. This is true. The electric field line is symmetry about $U=0$.

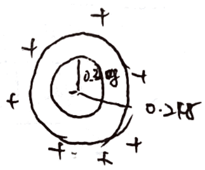


and it's perpendicular to the line.

The field is perpendicular to surface,

So ~~the~~ replacing one of the charges by a conducting surface.

22.19. (a)



$Q_1 = 6.44\times10^{-6}\ C/m^2 \cdot 4\pi r^2 = 4.98\ \mu C.$

new: $4.98\ \mu C - 0.56\ \mu C = 4.42\ \mu C.$

$\sigma_{new} = \frac{Q}{4\pi r^2} = 5.72\times10^{-6}\ C/m^2$

(b). sphere: $E_1 = \frac{\sigma}{\varepsilon_0} = \frac{6.44\times10^{-6}}{8.85\times10^{-12}} = 7.28\times10^{5}\ N/C$

point charge: $E_2 = \frac{kQ}{r^2} = -\frac{k|Q|}{r^2} = -\frac{9\times10^{9}\times0.56\times10^{-6}}{(0.248)^2} = -8.19\times10^{4}\ N/C$

$E = E_1 + E_2 = 7.28\times10^{5}\ N/C - 8.19\times10^{4}\ N/C = 6.46\times10^{5}\ N/C.$

(c). $Q_{total} = Q_1 + Q_2 = 6\times4\pi r^2 + (-0.56\times10^{-6}\ C) =$

$= 6.44\times10^{-6}\times 4\pi\times(0.248^2 - 0.208^2) = -6.33\times10^{4}\ N^2\cdot m/C.$

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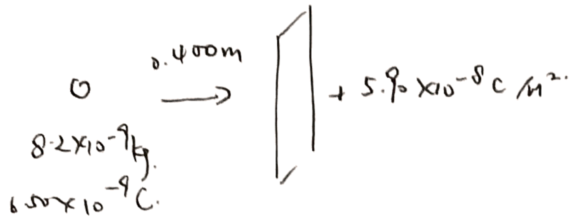
22.32



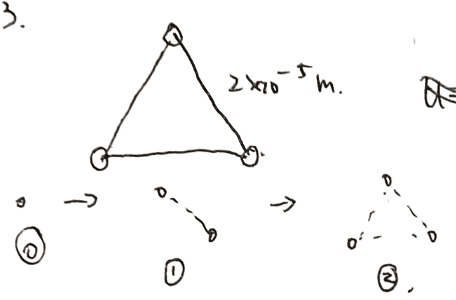
$$E=\frac{\sigma}{2\varepsilon_0}=\frac{5.9\times10^{-8}}{2\times8.85\times10^{-12}}=3333.3\ N/C$$

$$U=E\cdot d=3333.3N/C\times(0.400-0.100)\,m=1000V.$$

According to Energy theorem $\frac{1}{2}mv_0^2=qU$ $\Rightarrow v_0=\sqrt{\frac{2qU}{m}}=\sqrt{\frac{2\times6.50\times10^{-9}\times1000}{8.2\times10^{-9}}}$

$=39.82\,m/s.$

23.3.



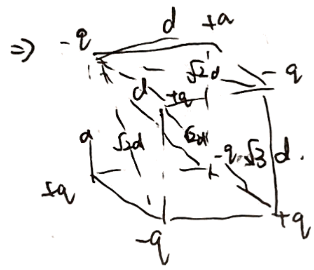
$$W=\frac{1}{4\pi\varepsilon_0}\left(\frac{q q_0}{r^2}\right)\cdot r=\frac{1}{4\pi\varepsilon_0}\cdot(q\cdot q_0)$$

$$=\frac{1}{4\pi\varepsilon_0}\cdot\frac{3\cdot e^2}{r}=9\times10^9N\cdot m^2/C\cdot\frac{3\cdot(1.6\times10^{-19}C)^2}{(2\times10^{-5}m)}$$

$$=3.46\times10^{-13}$$

23.? (a). $V=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}=\frac{U}{q}$ $\Rightarrow U=V\cdot q=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{r}$

(amount of work).



$\Rightarrow$.

for d: 12 edges. $U_1=\left(\frac{-q^2}{4\pi\varepsilon_0}\cdot\frac{1}{d}\right)\times12=\frac{-3q^2}{\pi\varepsilon_0 d}$.

and all have q & $(-q)$

for $\sqrt{2}d$: 6 square with 12 line.

~~both~~ all have $-q$ & $-q$ or q & q.

$$\Rightarrow U_2=\left(\frac{q^2}{4\pi\varepsilon_0}\cdot\frac{1}{\sqrt{2}d}\right)\cdot12=\frac{q}{\pi\varepsilon_0\cdot\sqrt{2}d}.$$

for $\sqrt{3}d$ 4 and all have. $-q$ & $+q$.

$$\Rightarrow U_3=\left(\frac{-q^2}{4\pi\varepsilon_0}\cdot\frac{1}{\sqrt{3}d}\right)\cdot4=-\frac{q^2}{\pi\varepsilon_0\sqrt{3}d}$$

$$\Rightarrow U=U_1+U_2+U_3=\frac{q^2}{\pi\varepsilon_0 d}\left(-3+\frac{3}{\sqrt{2}}-\frac{1}{\sqrt{3}}\right)=\frac{-1.46q^2}{\pi\varepsilon_0 d}.$$

$$=\frac{-1.46q^2}{\pi\cdot8.85\times10^{-12}d}=-5.23\times10^{10}\cdot\frac{q^2}{d}$$

(b). It shows that energy will be released while forming crystal. So it will be stable since it's harder to absorb energy rather than release it.

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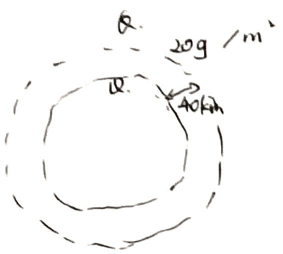
Essay question:



(A). $\oint_E d\vec{A} = \frac{Q}{\varepsilon_0}$

$\Rightarrow E \cdot 4\pi (R_0 + 40km)^2 = \frac{Q}{\varepsilon_0} \Rightarrow E = \frac{Q}{4\pi\varepsilon_0 \cdot (R_0+40km)^2}$

$F_e = EQ = \frac{Q^2}{4\pi\varepsilon_0 (R_0 + 40km)^2}$

$F_g = \frac{G M_e \cdot M_s}{(R_0 + 40km)^2}$ $\Rightarrow$ what we need to calculate

$\frac{Q}{4\pi (R_0+40km)^2} \rightarrow \sigma$

Since it's at equilibrium $\Rightarrow F_e = F_g$

$\Rightarrow Q^2 = G M_e \cdot M_s \cdot 4\pi\varepsilon_0 = 6.67\times10^{-11} \times 5.965\times10^{24} \times \frac{20}{1000} kg/m^2 \times 4\pi \times (400000 + R_0)^2 \times 8.85\times10^{-12} \times 4\pi$

$\Rightarrow Q^2 = 4.57\times10^{17} \Rightarrow Q = 6.76\times10^8 C$

$\sigma = \frac{Q}{A} = \frac{6.76\times10^8}{4\pi(R_0+40000)^2} = 1.37\times10^{-6} C/m^2$.

(B) $Q^2 = G M_e \cdot m_s \cdot A \cdot 4\pi\varepsilon_0$ $\quad Q = \sqrt{G M_e, m_s \cdot 4\pi R^2 \cdot 4\pi\varepsilon_0}$ $\quad d\downarrow R\downarrow Q\downarrow$

$\Rightarrow$ As R decrease, Q decrease

(C) $U = \int_{R_0+40}^{R_0} E \cdot dr = \int_{R_0+40}^{R_0} \frac{Q}{4\pi\varepsilon_0 r^2} dr = -\cancel{\int_{R_0+40}^{R_0}} \left(-\frac{1}{r}\right)\Big|_{R_0+40}^{R_0} \frac{Q}{4\pi\varepsilon_0}$

$= -\frac{6.76\times10^8 C}{\cancel{9.0}} \times 9\times10^9 \times \left(\frac{1}{R_0} - \frac{1}{R_0+40km}\right)$

$V_{earth} - V_{sheet} = 5.9\times10^9 V$