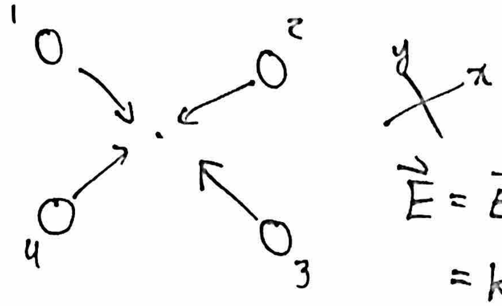
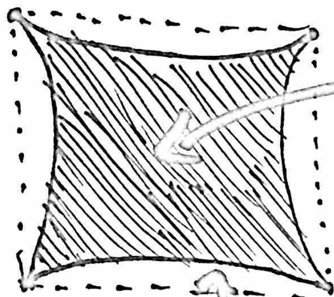
Worksheet 4 Solns

(1)



$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \vec{E}_4$$
$$= k(-\hat{y} - \hat{x} + \hat{y} + \hat{x})\frac{1}{\left(\frac{\sqrt{2}\,a}{2}\right)^2}$$
$$= 0$$

(2)

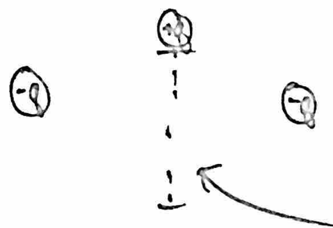


oscillates

diverges

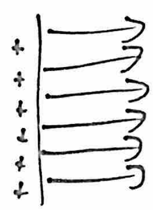
See electric field program

(3)



oscillates

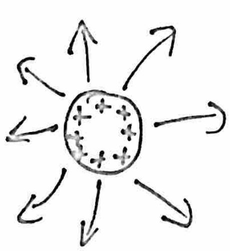
(4) E ||| ,



electric field is uniform

i.e. it does not spread out because it cannot

(5) $\frac{E}{(100)^2}$



electric field falls off as

$\frac{1}{r^2} \propto \frac{1}{\text{Area}} = \frac{1}{4\pi r^2}$

(6) Just about 0, or else nasty things like sparks would be observed. In particular, while there are positive ions, there are also negative electrons.

(7) Assume $1 m^3$:

$$n = \frac{1 \text{ kPa}}{8.314 \frac{L \cdot kPa}{K \cdot mol} \cdot 300K \cdot \frac{1 m^3}{10^3 L}} = 2.41 \times 10^{23} \left[\frac{atoms}{m^3}\right]$$

Now, the density of ions is 1% $\Rightarrow$

$$n = 2.41 \times 10^{21} \left[\frac{ions}{m^3}\right]$$

$\hookrightarrow$ Square arrangement

$$\frac{n}{length} = 1.34 \times 10^{7} \left(\frac{ions}{m}\right) \rightarrow 7.46 \times 10^{-8} [m] \text{ Spacing}$$

(8)

$$F = k\frac{q_1 q_2}{r^2} = \frac{8.988 \times 10^9 \cdot (1.602 \times 10^{-19})^2}{(7.46 \times 10^{-8})^2} = 4.14 \times 10^{-14} N$$

The mass of one charge is 3.33×10^{-25} kg, so:

$$\frac{F}{m} = \frac{4.14 \times 10^{-14}}{3.33 \times 10^{-25}} = 1.24 \times 10^{11} \left[\frac{N}{kg}\right]$$

yet, the net force is zero

(9)

$$F = \frac{k q_1 q_2}{r^2} = \frac{8.988 \times 10^9 (1.602 \times 10^{-19})^2}{(10^{-15})^2} = 231 N$$

$$\frac{F}{m} = \frac{231}{3 \cdot 1.67 \times 10^{-27}} = 4.61 \times 10^{28} \left[\frac{N}{kg}\right]$$

(10) $$\frac{F_g}{F_q} = \frac{k_g}{k_q}\,\frac{(g_1 g_2)}{(q_1 q_2)} = \frac{6.674\times10^{-11}}{8.988\times10^{9}}\cdot\frac{1.67\times10^{-27}\cdot 9.11\times10^{-31}}{(1.62\times10^{-19})^2} = 4.30\times10^{-40}$$

r^2 cancel out

(11) Consider ^{1}o $\quad o^{2}$ $\quad o_{3}$, all attract, so suppose BWOC 1 has positive charge, then both 2 and 3 should have negative charge, which means 2&3 repell, but they don't, so only magnitude is important for gravity.

(12) $$F = F_q + F_g = \frac{k_q\, q_1 q_2}{r^2} - \frac{k_g\,(g_1 g_2)}{r^2}$$
$$= -k_q\frac{e^2}{r^2} - k_g\frac{m^2}{r^2}$$

(13) $$F = -k_q\frac{e^2}{r^2} + k_g\frac{m^2}{r^2}$$

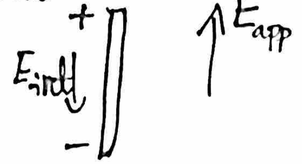
(14) If you apply a push in the $+x$ direction, the negative-mass object accelerates in the $-x$ direction!

(15) Polarization of the electron clouds. These effects become more prominent for larger atoms where clouds align to lower energy $+-+-+-+-$ arrangements.

(16) $$E = -\nabla V = -2k\begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

So, the electric field points radially towards the central point $(0,0,0)^T$.

(17) Schematic:



Charges in the needle align to produce an E_{int} to exactly oppose the applied electric field.

(18)
$$\phi_{3,-1} = \sin^{-1}\left(\frac{-1}{\sqrt{3(3+1)}}\right) = -16.8^{\circ}$$
$$\phi_{3,0} = \sin^{-1}(0) = 0$$
$$\phi_{3,1} = \sin^{-1}\left(\frac{1}{\sqrt{3(3+1)}}\right) = 16.8^{\circ}$$

(19)
$$\tau = p \times E = pE\sin\phi$$
$$= pE\sin\left(\sin^{-1}\frac{m}{\sqrt{\ell(\ell+1)}}\right) = pE\frac{m}{\sqrt{\ell(\ell+1)}}$$

(20)
$$\tau_{3,-1} = pE\frac{|-1|}{\sqrt{3(3+1)}} = 1.19\times10^{-28}\ [N\cdot m]$$
$$\tau_{3,0} = pE\frac{|0|}{\sqrt{3(3+1)}} = 0$$
$$\tau_{3,-1} = pE\frac{|1|}{\sqrt{3(3+1)}} = 1.19\times10^{-28}\ [N\cdot m]$$