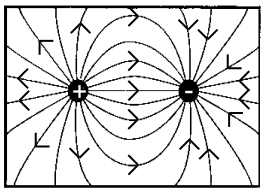
1. a) ①: negative, ②: negative, ③: positive, ④: positive

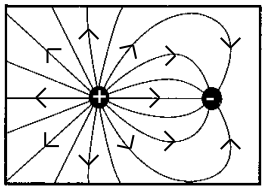
   b) ①: same, ②: smaller, ③: same, ④: smaller
   (a larger charge generates a stronger field which is represented by a bigger density of electric field lines)

   c)

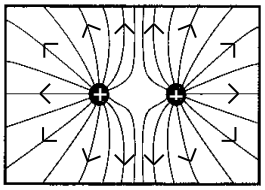
①



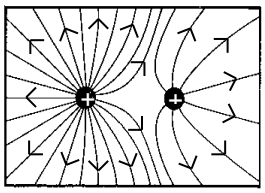
②



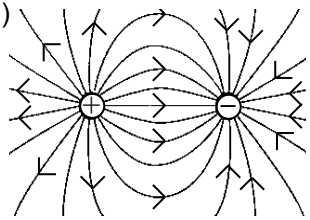
③



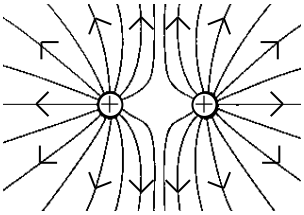
④



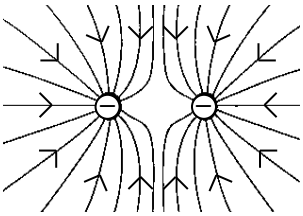
2. a)



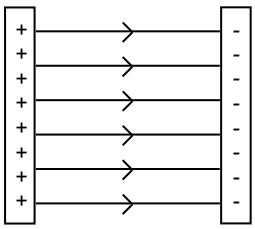
b)



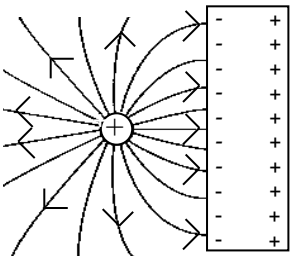
c)



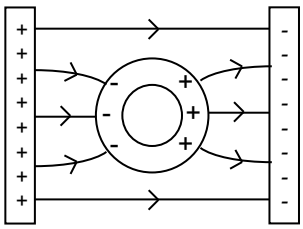
d)



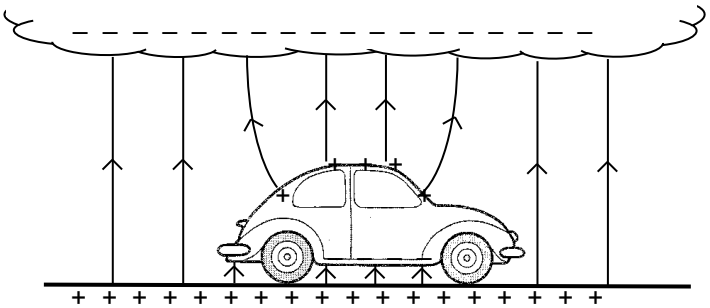
e)



f)



3. a) and b)



c) There is no electric field inside the car. The charges within the car body separate and move until the net force acting upon them is zero, which is the case when the electric field inside the car body is cancelled (electrostatic induction).

4. a) $E = \frac{F}{Q} = \frac{0.568 \cdot 10^{-3}\ \text{N}}{1.49 \cdot 10^{-9}\ \text{C}} = 381'208\ \frac{\text{N}}{\text{C}} = \underline{\underline{3.81 \cdot 10^{5}\ \frac{\text{N}}{\text{C}}}}$

b) $a = \frac{F}{m} = \frac{0.568 \cdot 10^{-3}\text{N}}{2.73 \cdot 10^{-3}\ \text{kg}} = \underline{\underline{0.208\ \frac{\text{m}}{\text{s}^2}}}$

5. First calculate the Coulomb force $F_C$ which acts on a small test charge $q$. The electric field strength is the force acting on the test charge divided by the quantity of the test charge: $E = \frac{F_C}{q}$.
The test charge is located between the two charges. $Q_2$ attracts $q$ and $Q_2$ repels $q$. Those two forces act in the same direction and must therefore be added. Furthermore $r_1 = r_2 = \frac{d}{2}$

$$F_C = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_1 \cdot q}{r_1^2} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_2 \cdot q}{r_2^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{\left(\frac{d}{2}\right)^2} \cdot \left(Q_1 + Q_2\right)$$

$$E = \frac{F_C}{q} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{\left(Q_1 + Q_2\right)}{\left(\frac{d}{2}\right)^2} = \frac{1}{4\pi \cdot 8.85 \cdot 10^{-12}\ \frac{\text{C}^2}{\text{N} \cdot \text{m}^2}} \cdot \frac{3.24 \cdot 10^{-8}\ \text{C} + 2.16 \cdot 10^{-8}\ \text{C}}{\left(0.40\ \text{m}\right)^2} = \underline{\underline{3.03 \cdot 10^{3}\ \frac{\text{N}}{\text{C}}}}$$

6. a) $F_{el} = q \cdot E = 3.00 \cdot 10^{-8}\,\text{C} \cdot 18 \cdot 10^{3}\ \frac{\text{N}}{\text{C}} = \underline{5.4 \cdot 10^{-4}\ \text{N}}$

b) The raindrop is hovering (no acceleration), therefore the net force on the rain drop is zero. The magnitude of the electric force equals the magnitude of the gravitational force:
$F_G = F_{el} = \underline{5.4 \cdot 10^{-4}\ \text{N}}$

c) $F_{el} = F_G \qquad q \cdot E = m \cdot g \qquad m = \frac{q \cdot E}{g} = \frac{3.00 \cdot 10^{-8}\ \text{C} \cdot 18 \cdot 10^{3}\ \frac{\text{N}}{\text{C}}}{9.81\ \frac{\text{m}}{\text{s}^2}} = \underline{\underline{5.5 \cdot 10^{-5}\ \text{kg}}} = \underline{55\ \text{mg}}$

d) $F_{res} = m \cdot a = F_{el} - F_G = q \cdot E - m \cdot g \qquad m \cdot a = q \cdot E - m \cdot g$

$m \cdot a + m \cdot g = q \cdot E \qquad m \cdot (a + g) = q \cdot E$

$$E = \frac{m \cdot (a + g)}{q} = \frac{5.5 \cdot 10^{-5}\ \text{kg}\ (1.07\ \frac{\text{m}}{\text{s}^2} + 9.81\ \frac{\text{m}}{\text{s}^2})}{3.00 \cdot 10^{-8}\ \text{C}} = \underline{\underline{2.0 \cdot 10^{4}\ \frac{\text{N}}{\text{C}}}} = \underline{\underline{20\ \frac{\text{kN}}{\text{C}}}}$$