Electric Fields - ②

A Physics

STOKE

DATA: $g = 10$ N/kg
$\varepsilon_0 = 8.9 \times 10^{-12}$ Farad/m
$e = -1.6 \times 10^{-19}$ Coulombs
$1\,\mu g = 1 \times 10^{-6}$ g
Volume sphere $= \frac{4}{3}\pi r^3$ m

1 (a) The diagram shows how smoke is precipitated using an electrostatic field between plates A & B.

(a) Sketch the field and equipotential lines around the plates A & B (4)

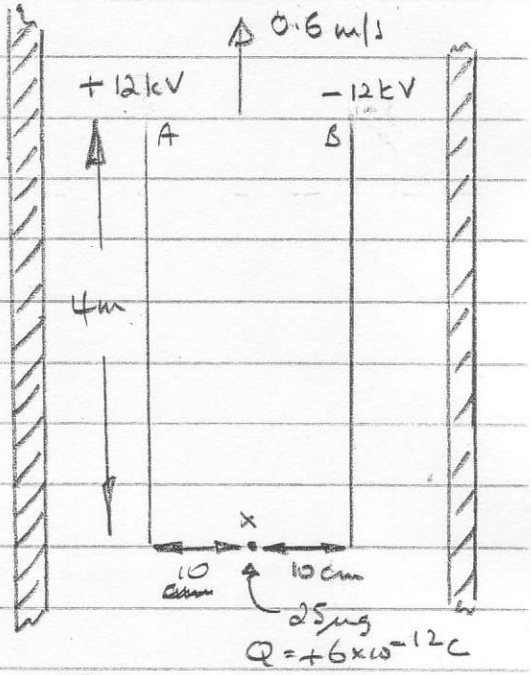
(b) Calculate the electric field at point X. (2)

(c) Calculate the force on the smoke particle at X (2)

(d) Calculate the initial lateral (sideways) acceleration of the particle (2)

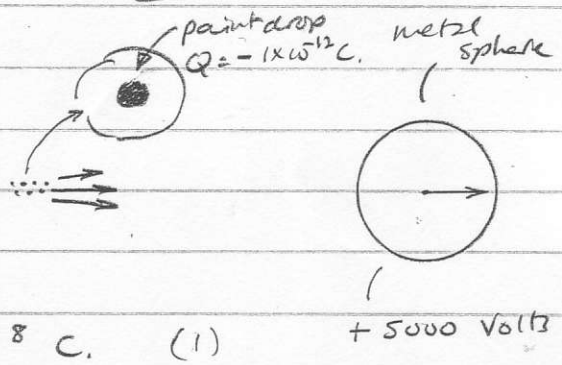
(e) The particle quickly reaches a terminal sideways velocity - why? (2)

(f) What must be the minimum sideways velocity for the smoke to be just captured by plate B? (2)



(14)

2 The diagram shows electrostatic paint spraying. The sphere behaves as a capacitor with $C = 4\pi\varepsilon_0 r$ Farads (where r = radius)



(a) Show that the stored charge is 5.6×10^{-8} C. (1)

(b) For a point 10 cm from the surface of the sphere, Calculate...
(i) the electric field strength (2) (ii) the electric potential (2)

(c) Sketch graphs to show how these quantities vary up to 3 times the radius from the sphere's centre. (2 × 3)

(d) Sketch field lines and equipotentials round the sphere, and sketch possible paths of paint drops to show how the sphere gets coated all over. (2 + 2 + 2)

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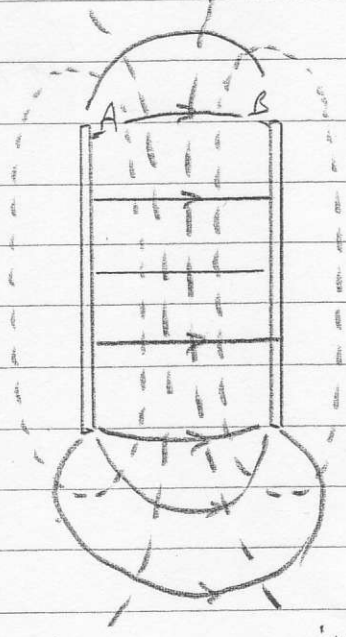
(e) Assume each paint drop has a radius of 0.1 mm, and the paint has a density of 1500 kg/m³, what is the mass? (3)

(f) What is the maximum distance a drop can be below the sphere, and still be drawn up to it by the electric field? (3) (23)

Electric Fields – Answers – 2

A – Physics

1. (a) field – shape ① + direction ① equipotential – 2 /4



(b) $E = V/d$ ① $= 24000 / 20\times10^{-2} = \underline{120,000\ V/m}$ ①

(c) $F_{elec} = QE$ ① $= 6\times10^{-12} \times 120\times10^{3}$

$= \underline{0.72\times10^{-6}\ N}$ ①

(d) $a = F_{elec}/m = \dfrac{0.72\times10^{-6}}{25\times10^{-6}} = \underline{0.029\ m/s^2}$

(e) terminal velocity – due to collisions with air ① molecules

'drag (friction) force

= force due to electric field ①

(resultant force and acceleration = 0)

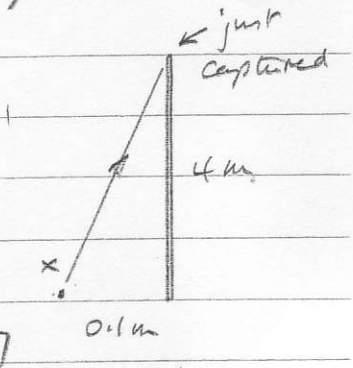
(f) Rising hot air carries smoke up at 0.6 m/s

It will get to the top of plate B in

time $t = \dfrac{D}{V} = \dfrac{4\ m}{0.6} = \underline{6.67\ sec}$ ①

So smoke has this time to travel 10 cm sideways

So $V_{sideways} = D/t = 0.1/6.67 = \underline{0.015}$ ① m/s



[14]

2. (a) $C_{sphere} = 4\pi\varepsilon_0 r = 4\pi \times 8.9\times10^{-12} \times 10\times10^{-2} = \underline{1.1\times10^{-11}\ F}$ ← given

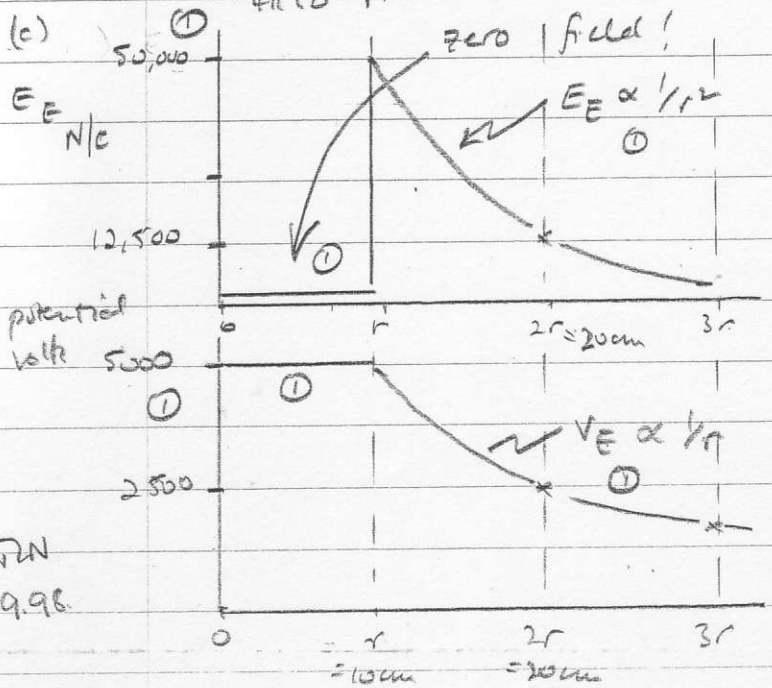
Radius r = 10 cm.

$Q = CV = 1.1\times10^{-11} \times 5\times10^{3} = \underline{5.6\times10^{-8}\ Coulombs}$ (1)

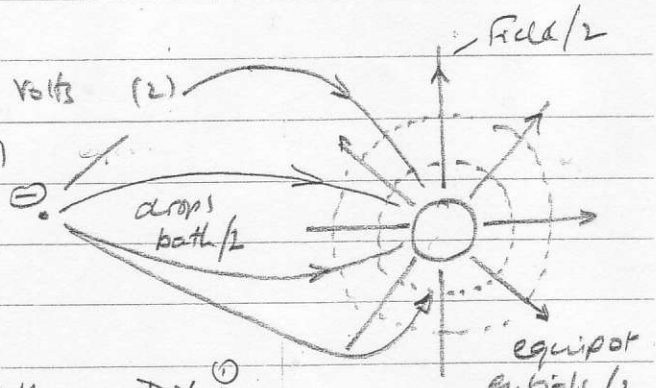
(b) $E_E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_{sphere}}{r^2}$ (r from centre = (10 + 10 cm)) $= \underline{12,500\ V/m \text{ or } N/C}$ (2)

$V_E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_{sphere}}{r} = E_E \times r = \underline{2500\ Volts}$ (2)

(c) ①



(d)



(e) Mass = DV ①

$= 1500 \times \frac{4}{3}\pi r^3 = 1500 \times 4.2\times10^{-12} = \underline{6.3\times10^{-9}\ kg}$ ①

(f) $F_{elec} = QE = Q\dfrac{1}{4\pi\varepsilon_0}\dfrac{Q_{sphere}}{r^2} = mg$ ↑ F_{elec}

So... $\dfrac{8.9\times10^{9} \times 5.6\times10^{-8} \times 3\times10^{-12}}{r^2} = \dfrac{6.3\times10^{-8}}{mg}$ ↓ mg

$r^2 = 0.024 \rightarrow r = 0.15\ m = \underline{15\ cm}$ from centre.

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