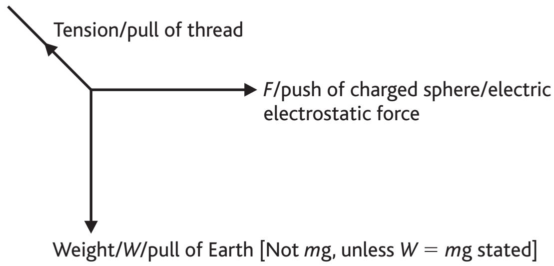
Unit 4 Topic 2 Electric and magnetic fields

1 **Free-body force diagram:**
Tension/pull of thread **(1)**
F/push of charged sphere/electric force/electrostatic force **(1)**
Weight/*W*/pull of Earth [Not *mg*, unless $W = mg$ stated] **(1)**



Force equation:
$W = T\cos\theta$ and $F = T\sin\theta$ **(1)**
Processing mark, e.g. $F = \dfrac{W}{\cos\theta}\sin\theta$ OR $\tan\theta = \dfrac{\sin\theta}{\cos\theta}$ **(1)**
OR
F, T, W labelled **(1)**
both angles labelled **(1)**

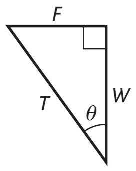


Table:
Using any pair of values **(1)**
Seeing correct constant for their pair of values **(1)**
Distance $r = 36 \times 10^{-3}$ m
$F = 35.5/36$ [no u.e.] **(1)**
Distance $r = 27 \times 10^{-3}$ m
$F = 63.1$ [no u.e.] **(1)**
OR
Valid simple ratio calculation using a pair of values **(1)**
stating product Q_1Q or kQQ_2 constant **(1)**
$F = 63.1$ [no u.e.] **(1)**

Measurements taken quickly because:
Leakage/discharge of charge [Allow dissipation or description of process] **(1)**

(Total 10 marks)

2 **Alpha particle: diagram**
Curving path between plates **(1)**
Towards 0 V plate **(1)**
Emerging from plates and carrying on straight **(1)**

Calculation:
Electric field = 2000 V/10 × (10^{-3}) m [correct substitutions] **(1)**
Force = *EQ*

$= \left(\dfrac{2000}{10 \times 10^{-3}}\right)$ V m^{-1} × (2) × 1.6 × 10^{-19} [correct substitution e.c.f. their *E*] **(1)**

$= 6.4 \times 10^{-14}$ N **(1)**

(Total 6 marks)

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3 **Electric pattern (diagram):**
Straight, parallel, reasonably perpendicular to plates and equispaced [minimum 3 lines] **(1)**
Correct direction labelled on one line [downwards arrow] **(1)**

Equipotential lines:
Any two correct equipotentials with any labelling to identify potentials (rather than field lines) **(1)** [Arrows on electric field lines – none on equipotential being sufficient labelling]

Force:
$E = \dfrac{3000\,\text{V}}{25 \times (10^{-3})\,\text{m}}$ [correct substitution] **(1)**
Use of $F = Ee$ even if value of E is incorrect **(1)**
$F = 120 \times (10^3)\,\text{V m}^{-1} \times 1.6 \times 10^{-19}\,\text{C} = 1.9(2) \times 10^{-14}$ (N) **(1)**

Graph:
Straight horizontal line [even if extending beyond 25 mm] **(1)**
Value of F marked [e.c.f. their value] provided graph begins on force axis and is marked at this point **(1)**

Speed:
Use **(1)**

$eV = \frac{1}{2}mv^2$ $v^2 = 2\,eV/m$	$v^2 = 2\left(\frac{F}{m}\right)s$	$Fd = \frac{1}{2}mv^2$ $v^2 = 2Fd/m$

Substitution **(1)**

$$v^2 = \frac{2 \times 1.6 \times 10^{-19}\,\text{C} \times 3000\,\text{V}}{9.11 \times 10^{-31}\,\text{kg}}$$

$$= 2\left(\frac{1.92 \times 10^{-14}\,\text{N}}{9.11 \times 10^{-31}\,\text{kg}}\right) \times 25 \times 10^{-3}\,\text{m}$$

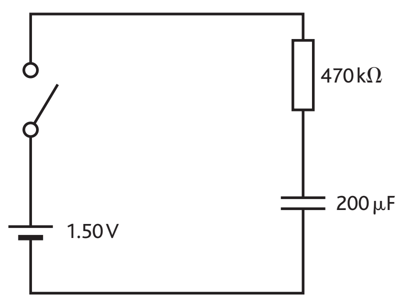
$$= \frac{2 \times 1.92 \times 10^{-14}\,\text{N} \times 25 \times 10^{-3}\,\text{m}}{9.11 \times 10^{-31}\,\text{kg}}$$

Answer: $v = 3.2 \times 10^7\,\text{m s}^{-1}$ **(1)**
[If $F = 2 \times 10^{-14}$ N, then $v = 3.3 \times 10^7\,\text{m s}^{-1}$]

(Total 11 marks)

4 **Define capacitance:**
Capacitance = charge/potential difference **(2)**

Circuit diagram: (1)



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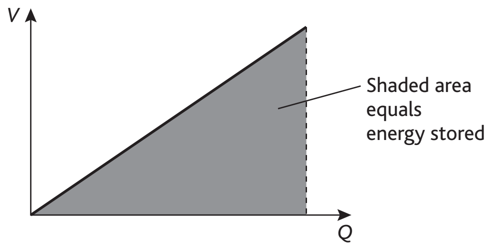
Maximum current:

Current = 1.5 V/470 kΩ **(1)**

Current = 3.2 μA **(1)**

Sketch graph: (4)



Energy stored:

$\frac{1}{2}CV^2 = \frac{1}{2} \times (200\ \mu\text{F}) \times (1.5\ \text{V})^2$ **(1)**

Energy = 2.25×10^{-4} J **(1)**

(Total 11 marks)

5 **Slope of graph:**

Capacitance **(2)**

Shaded area of graph:

Energy/work done **(2)**

Energy stored is 3.1 J:

Energy stored = $\frac{1}{2}CV^2$

= $\frac{1}{2} \times 100 \times 10^{-6} \times 250^2$ [formula + correct substitution] **(1)**

(= 3.125) = 3.1 J [must have previous mark] **(1)**

Power from cell and minimum time for cell to recharge capacitor:

Cell power = 1.5 V × 0.20 A **(1)**

= 0.30 W [allow 3/10 W here] **(1)**

Time = 3.1 J/0.30 W (e.c.f.)

= 10 s **(1)**

(Total 9 marks)

6 **Demonstration:**

A diagram with a wire perpendicular to a magnetic field with the means to measure the force on the wire. **(1)**

And max 3 marks from:

Method of providing and measuring d.c. **(1)**

Method of varying and measuring force with details. **(1)**

For various values of current, measure F. **(1)**

Plot F against I – straight line through origin. **(1)**

Direction of the current in the wire: To the east **(1)**

Calculate the current: $F = BIl$

$(1.5 \times 10^{-3}\ \text{kg}) \times (9.81\ \text{N kg}^{-1}) = (1.8 \times 10^{-5}\ \text{T}) \times I \times (2.0\ \text{m})$ **(1)**

Current = 410 A **(1)**

Other effect: Wire melts **(1)**

(Total 8 marks)

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7 **Explanation:**

The wire, when carrying a current, feels a force when in a magnetic field **(1)**
The current is at 90° to the magnetic field **(1)**
hence PQ feels an upward force; RS a downward force; they produce a couple which causes rotation **(1)**

Addition to diagram of an upward arrow (1)

Three factors:

(1) Strength/magnitude of magnetic field **(1)**
(2) Size of current **(1)**
(3) Number of turns of coil/length of PQ **(1)**

Explanation of observation:

Flux cut results in emf induced **(1)**
emf opposite to applied pd results in V_{total} less, hence I less **(1)**

(Total 9 marks)