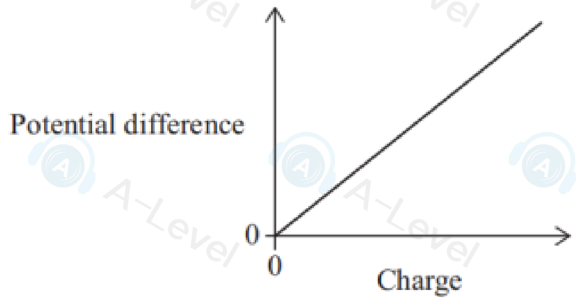
2: A capacitor is charging. A graph of potential difference against charge is shown.



Which of the following gives the capacitance of the capacitor?

☒ **A** The area between the line and the potential difference axis

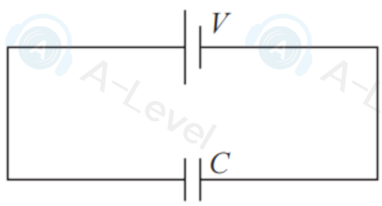
☒ **B** The area between the line and the charge axis

☒ **C** The gradient of the line

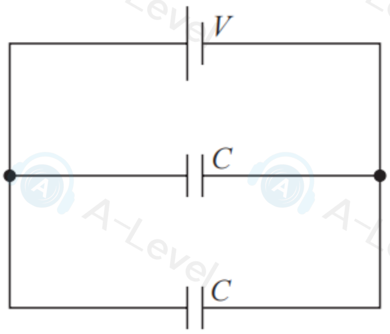
☒ **D** The inverse of the gradient of the line

(Total for Question 2 = 1 mark)

7 A potential difference V is connected across a capacitor of capacitance C. The charge stored on the capacitor is Q.



The capacitor is replaced with two capacitors, each of capacitance C, connected in parallel.



What is the total charge stored in the parallel circuit?

☒ **A** $\frac{Q}{4}$

☒ **B** $\frac{Q}{2}$

☒ **C** Q

☒ **D** $2Q$

6 A capacitor of capacitance C is charged to a potential difference of V_0. The capacitor then discharges through a resistor of resistance R.

After time t the potential difference across the capacitor is V.

Which of the following gives the time constant for this circuit?

☒ **A** $\dfrac{-t}{\ln(V - V_0)}$

☒ **B** $\dfrac{-t}{\ln V + \ln V_0}$

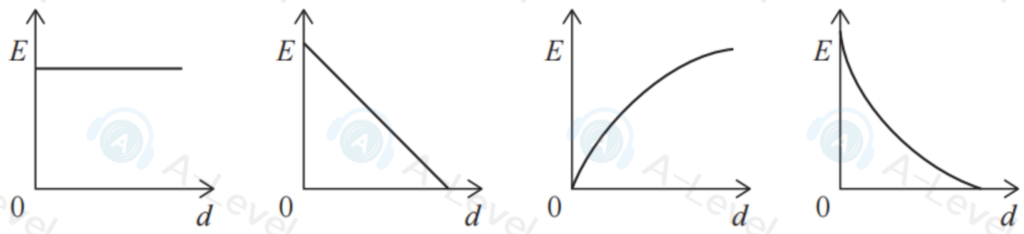
☒ **C** $\dfrac{-t}{\left(\dfrac{\ln V}{\ln V_0}\right)}$

☒ **D** $\dfrac{-t}{\ln\left(\dfrac{V}{V_0}\right)}$

(Total for Question 6 = 1 mark)

5 A potential difference is applied across two parallel metal plates.

Which of the following graphs shows how the electric field strength E varies with distance d from the positive plate?



A **B** **C** **D**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

3 Two identical charged particles were placed in a vacuum 0.020 m apart. The charge on each particle was $+8.0 \times 10^{-6}$ C.

Which of the following gives the magnitude of the force, in newtons, on each particle?

☒ **A** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})}{0.020}$

☒ **B** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})^2}{0.020^2}$

☒ **C** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})^2}{0.020}$

☒ **D** $\dfrac{8.99 \times 10^9 \times (8.0 \times 10^{-6})}{0.020^2}$

(Total for Question 3 = 1 mark)

9 A capacitor discharges through a resistor. The time constant of the circuit is 5 s.

What is the time taken, in s, for the charge on the plates of the capacitor to halve?

☒ **A** $0.5 \ln 2$

☒ **B** $0.5 \ln 5$

☒ **C** $2 \ln 5$

☒ **D** $5 \ln 2$

(Total for Question 9 = 1 mark)

3: A proton is in a vacuum. At a distance r from the proton, the electric field strength due to the proton is $0.77\,\mathrm{N\,C^{-1}}$.

Which of the following gives the distance r, in m?

☒ **A** $\sqrt{\dfrac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times 0.77}}$

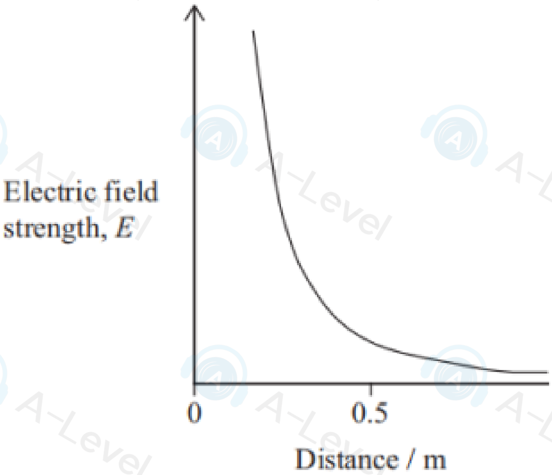
☒ **B** $\sqrt{\dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 0.77}}$

☒ **C** $\dfrac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} \times 0.77}$

☒ **D** $\dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 0.77}$

(Total for Question 3 = 1 mark)

9 The graph shows how electric field strength varies with distance from a charged conducting sphere.



Which of the following gives the electric potential at a distance of 0.5 m from the sphere?

☒ **A** The area under the graph from 0 to 0.5 m.

☒ **B** The area under the graph from 0.5 m to infinity.

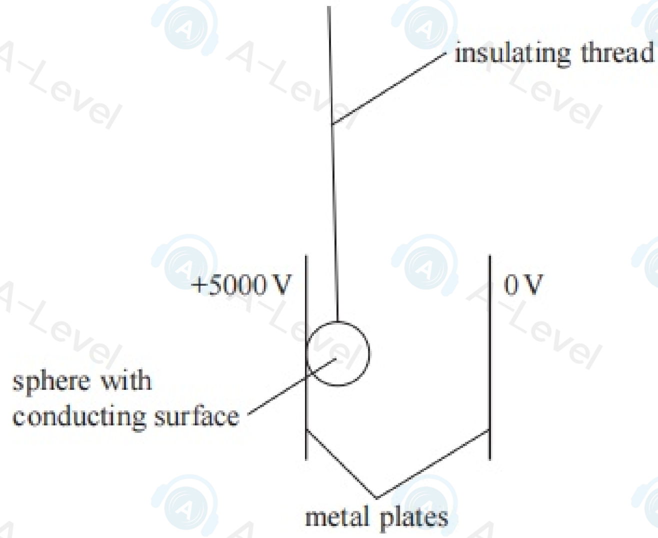
☒ **C** The gradient of the tangent to the graph at 0.5 m.

☒ **D** The value of E at 0.5 m divided by 0.5 m.

(Total for Question 9 = 1 mark)

17 A potential difference of 5000 V is applied across two vertical metal plates.

A sphere with a conducting surface is suspended by an insulating thread and touches the positively charged plate as shown.



The sphere becomes positively charged.

(a) Complete the diagram to show the electric field around a positively charged sphere.

(3)

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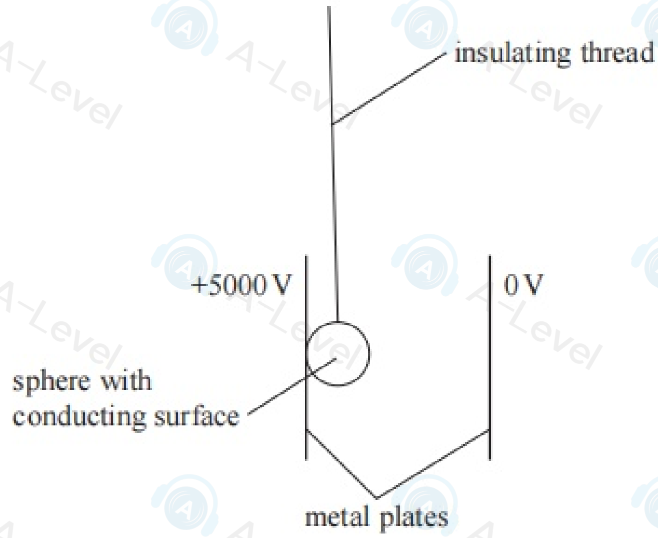

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(3)

(b) (i) Show that the charge on the sphere is about 10 nC.

potential at surface of sphere = 5000 V
radius of sphere = 20 mm

(2)

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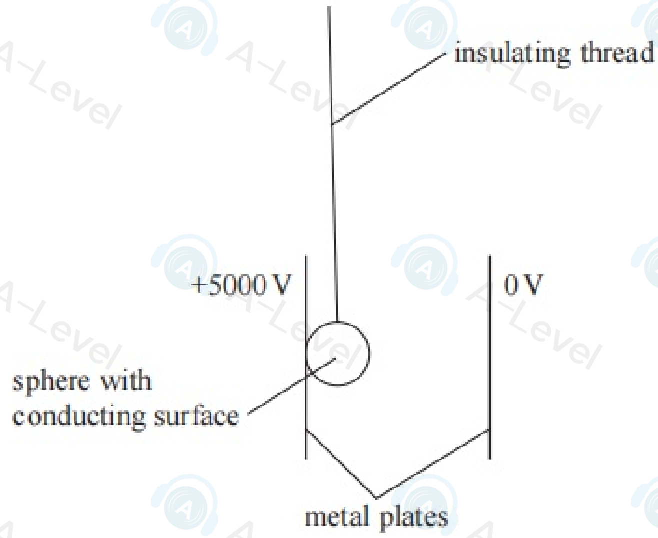

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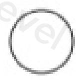

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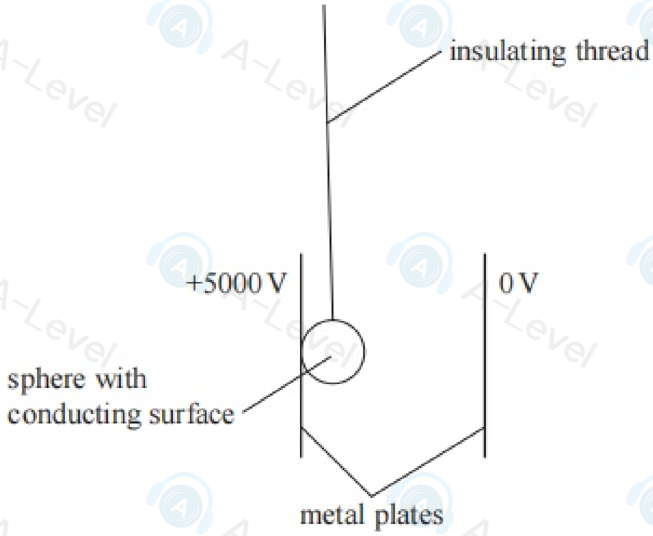

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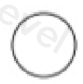

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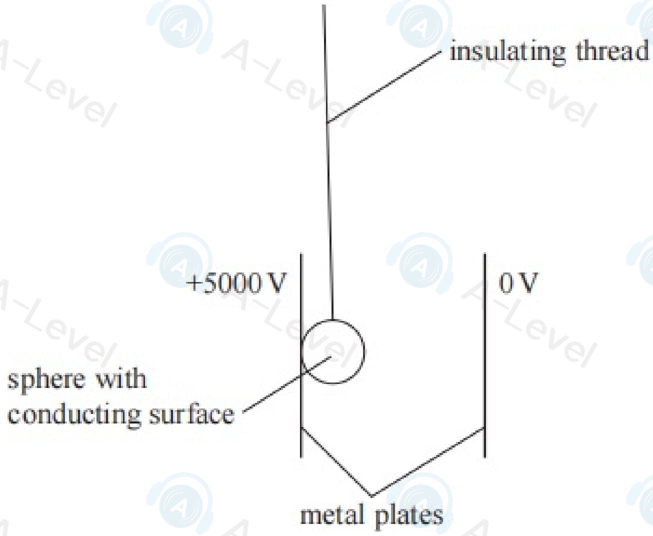

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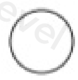

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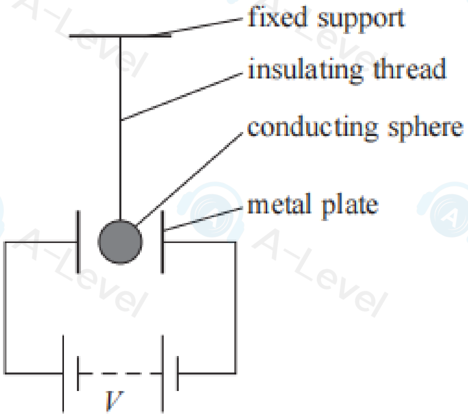
20 In the 18th century, a scientist called Gordon made the first device that used electrostatic forces to produce continuous motion.

A demonstration of the principle of Gordon's device is shown.

A light, conducting sphere of radius r is suspended from an insulating thread between two parallel metal plates. A large potential difference V is applied between the plates.



(a) There is an electrostatic force on the sphere when the sphere is charged.

The capacitance C of the sphere is given by

$$C = 4\pi\varepsilon_0 r$$

where r is the radius of the conducting sphere.

The sphere is charged by touching it onto one of the plates. The plates are a distance d apart.

Calculate the electrostatic force exerted on the sphere.

$V = 4500\,\text{V}$
$d = 5.0\,\text{cm}$
$r = 3.5\,\text{cm}$

(5)

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Electrostatic force on sphere = ...

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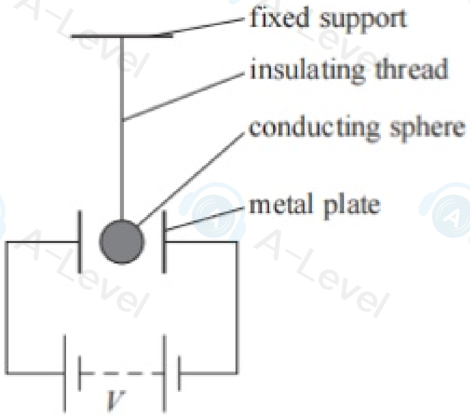

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Electrostatic force on sphere = ...

(b) After the sphere has been charged, the sphere starts to oscillate between the plates. The sphere touches each plate alternately.

Explain why the conducting sphere oscillates between the two plates.

(3)

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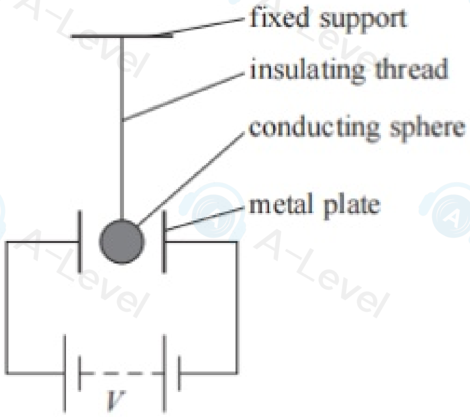

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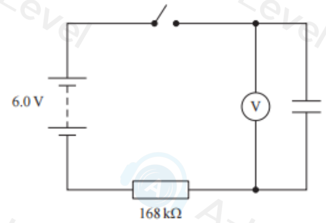
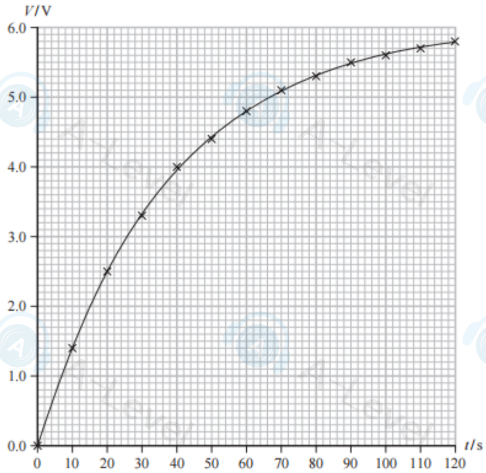
18 A student used the circuit shown to investigate the charging of a capacitor.



The student closed the switch to charge the capacitor and started a stopwatch. She recorded the voltmeter reading V every 10 s as the capacitor charged.

The graph shows how V varied with time t.



(a) (i) Determine a value for the capacitance C of the capacitor.

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C = ...

(ii) Sketch on the axes below how current I in the circuit would vary with t.

You should include the value of the maximum current.

(3)

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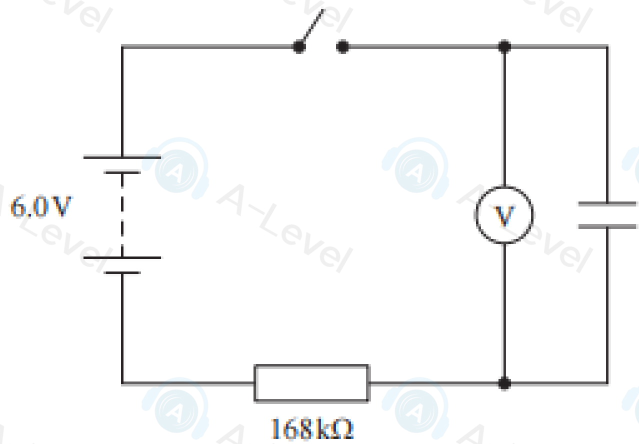
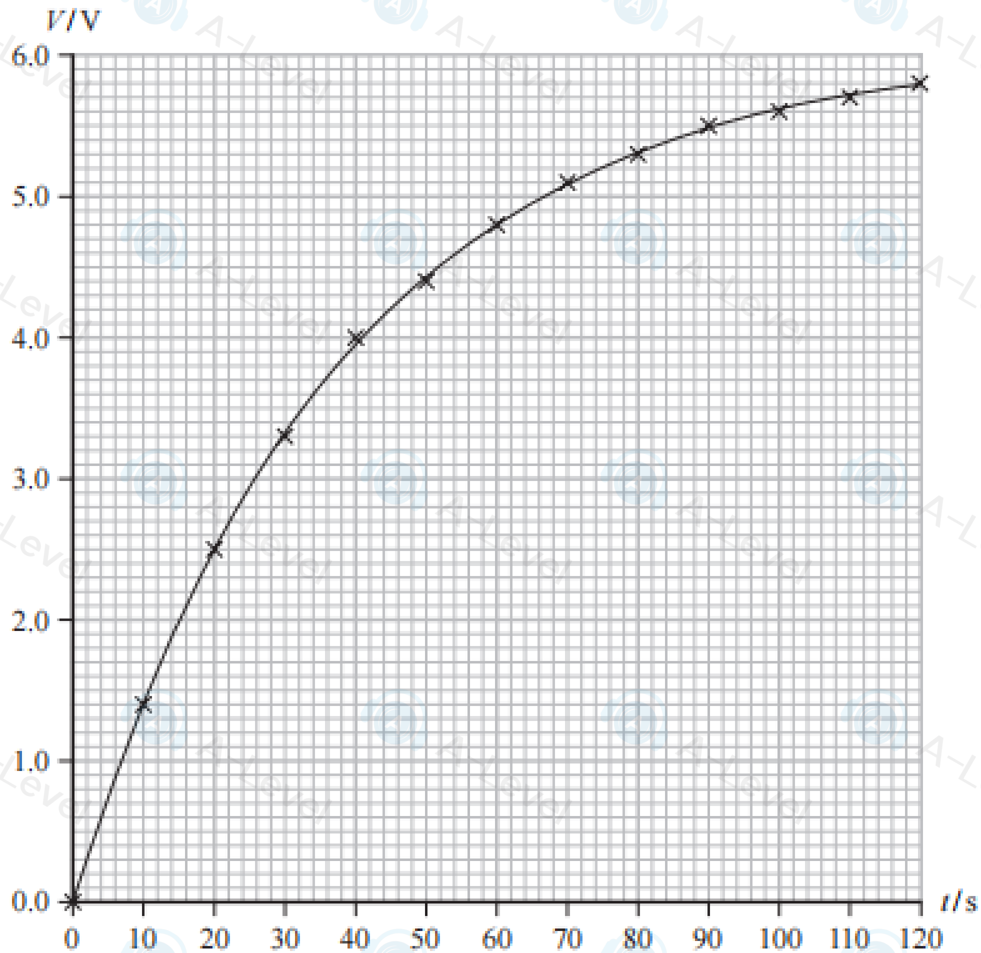
18 A student used the circuit shown to investigate the charging of a capacitor.



The student closed the switch to charge the capacitor and started a stopwatch. She recorded the voltmeter reading *V* every 10 s as the capacitor charged.

The graph shows how *V* varied with time *t*.



(b) The student connected a second 168 kΩ resistor in parallel with the first resistor.

Explain how the time taken to charge the capacitor would change.

You do not need to do any further calculations.

(3)

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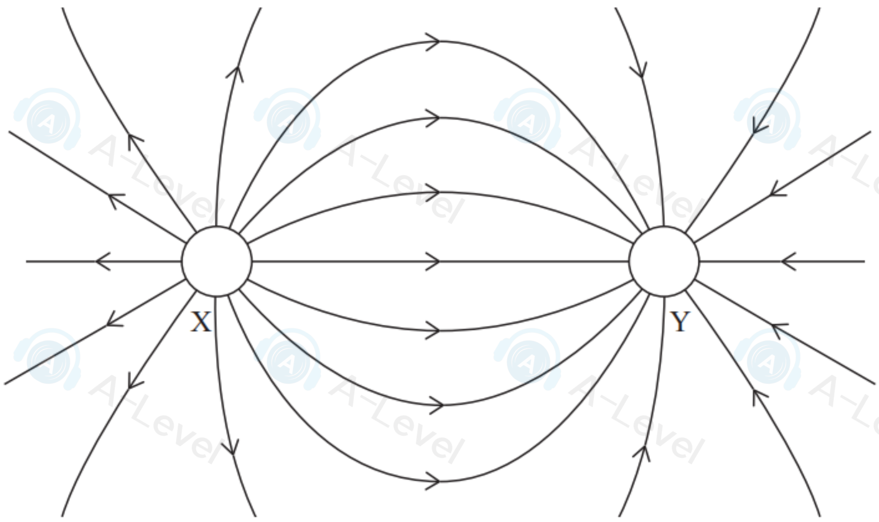
17 Scientists are developing safe methods for removing old satellites from orbit.

Some scientists plan to use electrostatic forces. A spacecraft will fire a beam of electrons at a satellite. This will give the satellite a negative charge and the spacecraft a positive charge.

There will be an electrostatic force of attraction between the satellite and the spacecraft. The spacecraft will then move away, taking the satellite with it.

(a) The diagram shows the electric field around the spacecraft X and the satellite Y when they have equal and opposite charge. You may assume that the spacecraft and the satellite are both spherical and have the same diameter.



(i) Add dashed lines to the electric field diagram to show equipotentials at intervals of equal potential difference.

(3)

(ii) Label the equipotential that represents 0 V.

(1)

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(b) After some time, the charge on the spacecraft will be $+1.5 \times 10^{-6}$ C and the charge on the satellite will be -1.5×10^{-6} C.

(i) Calculate the minimum energy, in joules, required for an electron leaving the surface of the spacecraft to reach the surface of the satellite.

Assume that the charge on each object does **not** affect the potential at the surface of the other object.

radius of satellite = 2.5 m
radius of spacecraft = 2.5 m

(3)

(ii) The spacecraft moves to a new position, taking the satellite with it.

The distance between the satellite and the spacecraft remains constant, so the electrostatic force is constant.

The scientists estimate that the satellite could be moved a distance of 300 km in about 60 days.

Deduce whether this estimate is correct.

Assume gravitational forces are negligible and the satellite is initially at rest.

distance between centre of satellite and centre of spacecraft = 20 m
mass of satellite = 2500 kg

(4)

(c) In reality, the magnitude of the positive charge on the spacecraft may be greater than the magnitude of the negative charge on the satellite.

Suggest why.

(1)