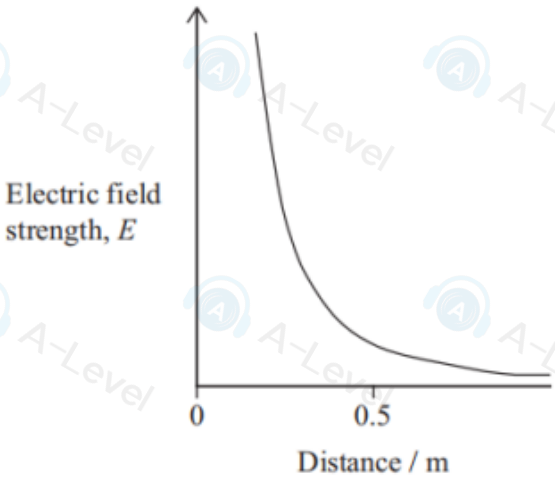
7 The diagram shows the paths of two charged particles, X and Y, moving at the same speed in a uniform magnetic field.

Which row of the table describes the properties of Y compared with the properties of X?

		Mass of Y	Charge of Y
☒	**A**	greater than	the same as
☒	**B**	less than	greater than
☒	**C**	the same as	less than
☒	**D**	greater than	less than

(Total for Question 7 = 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)

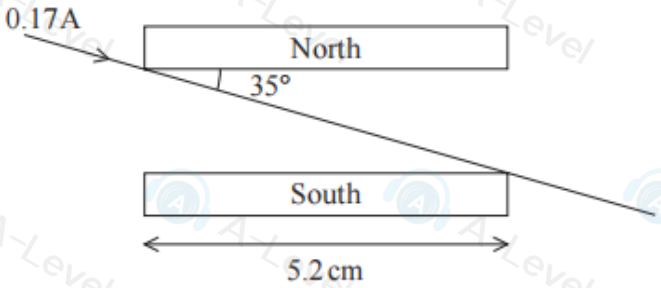
2 What is the process by which electrons are released from a heated filament?

- ☒ **A** excitation
- ☒ **B** ionisation
- ☒ **C** photoelectric emission
- ☒ **D** thermionic emission

(Total for Question 2 = 1 mark)

DO NOT WRITE IN THIS AREA

10 The diagram shows a current-carrying wire between two magnetic poles.



The magnetic flux density between the poles is 0.85 T.

Which of the following gives the force on the wire in newtons?

- ☒ **A** $0.085 \times 0.17 \times 0.052$ into the page
- ☒ **B** $0.085 \times 0.17 \times 0.052 \times \sin 35°$ into the page
- ☒ **C** $0.085 \times 0.17 \times 0.052$ out of the page
- ☒ **D** $0.085 \times 0.17 \times 0.052 \times \sin 35°$ out of the page

(Total for Question 10 = 1 mark)

DO NOT WRITE IN THIS AREA

8 In the early 20th century, scientists carried out alpha particle scattering experiments.

Which of the following is **not** a conclusion from the scientists' observations during these experiments?

- ☒ **A** Most of the atom is empty space.
- ☒ **B** The nucleus contains most of the mass of the atom.
- ☒ **C** The nucleus is made up of protons and neutrons.
- ☒ **D** There is a concentration of charge in the atom.

(Total for Question 8 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

A current-carrying wire is placed between two bar magnets, as shown.

The current in the wire is into the page.

3 Which diagram shows the direction of the force on the wire due to the magnetic field?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 3 = 1 mark)

DO NOT WRITE IN THIS AREA

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

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

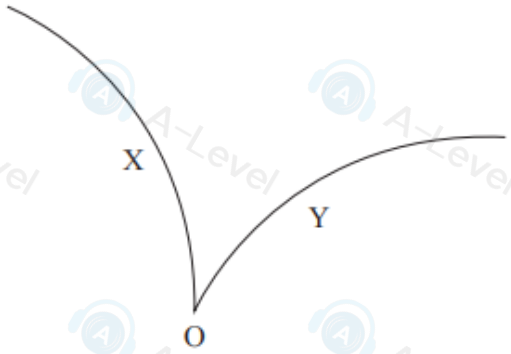
☒ **D** $\dfrac{(1.6 \times 10^{-19})^2}{4\pi \times 8.85 \times 10^{-12} \times 0.77}$

(Total for Question 3 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS A

6 A particle detector shows tracks produced by two particles X and Y. The particles were created by the decay of a kaon at O.



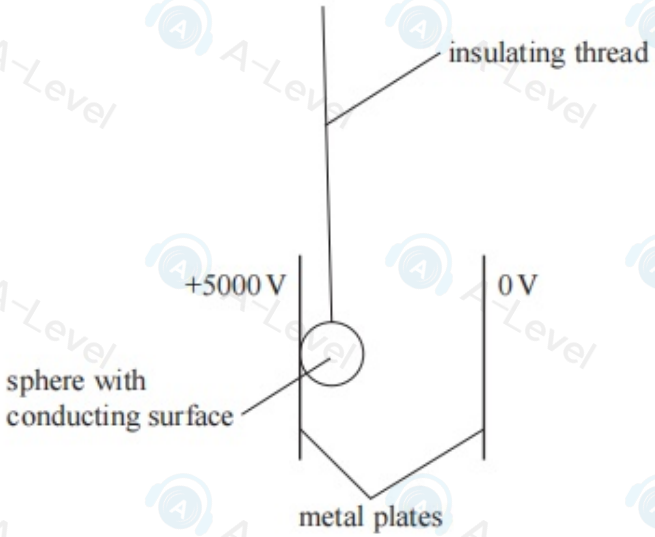
Which of the following can be concluded from the tracks?

- ☒ **A** A magnetic field acts into the page.
- ☒ **B** X is a positively charged particle.
- ☒ **C** Y is an electron.
- ☒ **D** X and Y have opposite charge.

(Total for Question 6 = 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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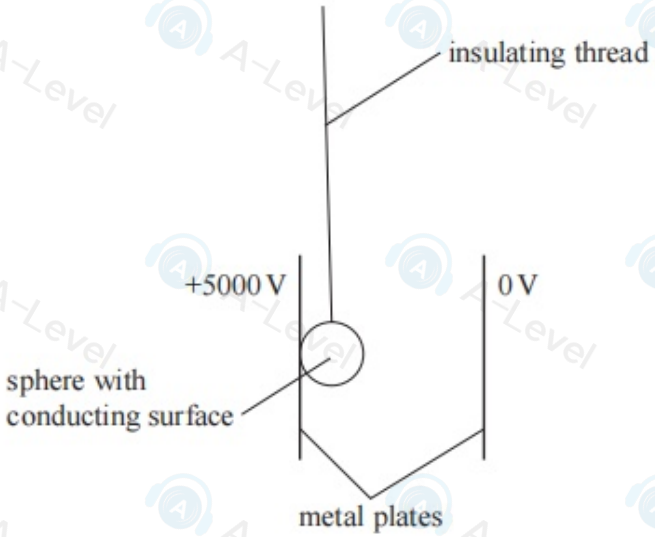

The sphere becomes positively charged.

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

(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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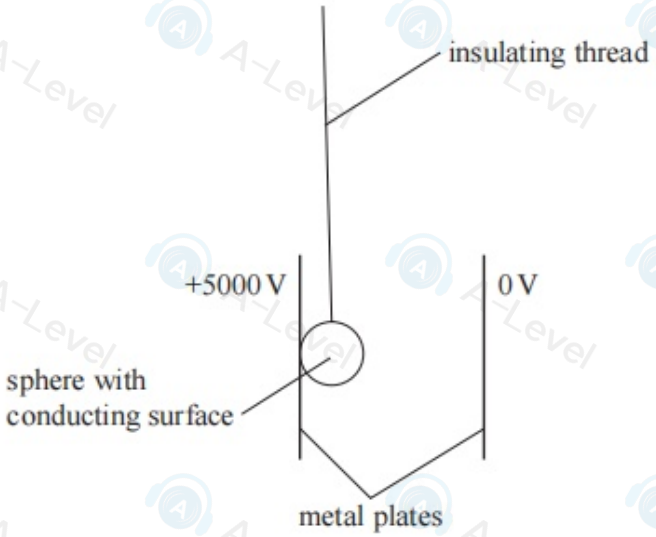

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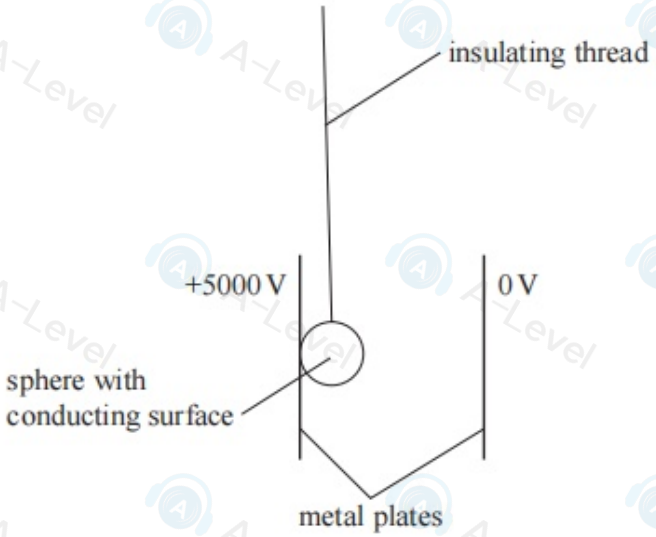

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potential at surface of sphere = 5000 V
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(2)

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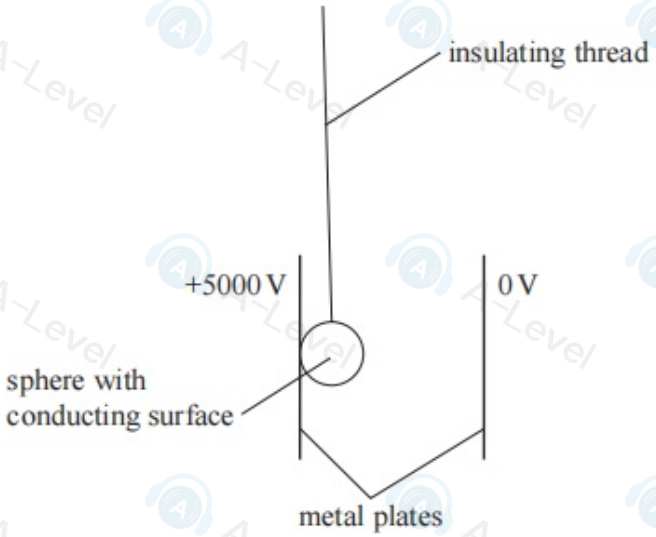

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(3)

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

(2)

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16 In the early 20th century, Millikan carried out an experiment to determine the magnitude of e, the electronic charge. Charged oil droplets were introduced into a region of electric field produced between two parallel plates.

A potential difference was connected across the two plates.

(a) Add to the diagram to show the field lines between the plates.

(2)

16 In the early 20th century, Millikan carried out an experiment to determine the magnitude of e, the electronic charge. Charged oil droplets were introduced into a region of electric field produced between two parallel plates.

A potential difference was connected across the two plates.

(a) Add to the diagram to show the field lines between the plates.

(2)

(b) A charged oil drop entered the region of electric field between the plates. The plates were 1.5 cm apart. A potential difference of 85 V was applied between the plates and the charged oil drop was brought to rest.

Deduce whether the charge on the oil drop was a whole number multiple of the electronic charge.

volume of oil drop = $5.0 \times 10^{-19}\,m^3$
density of oil = $920\,kg\,m^{-3}$

(5)

(Total for Question 16 = 7 marks)

16 Scientists at CERN are planning an upgrade to the Large Hadron Collider called the Large Hadron Electron Collider (LHeC).

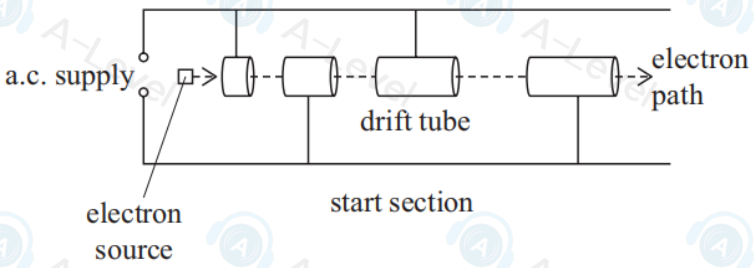
The scientists plan to use a linear accelerator (linac) to produce high energy electrons. Collisions between these electrons and high energy protons will allow the structure of protons to be investigated.

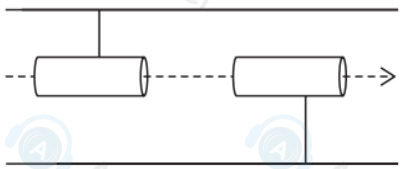
(a) The high energy electrons produced will have energy 60 GeV.

Show that these electrons will be travelling at relativistic speeds.

(3)

*(b) The diagram shows the start section of a linac and the end section of a linac.





Explain how a linac produces high energy electrons.

You should refer to the a.c. supply and to the length of the drift tubes in each section.

(6)

(c) Explain why high energies are required to investigate the structure of protons.

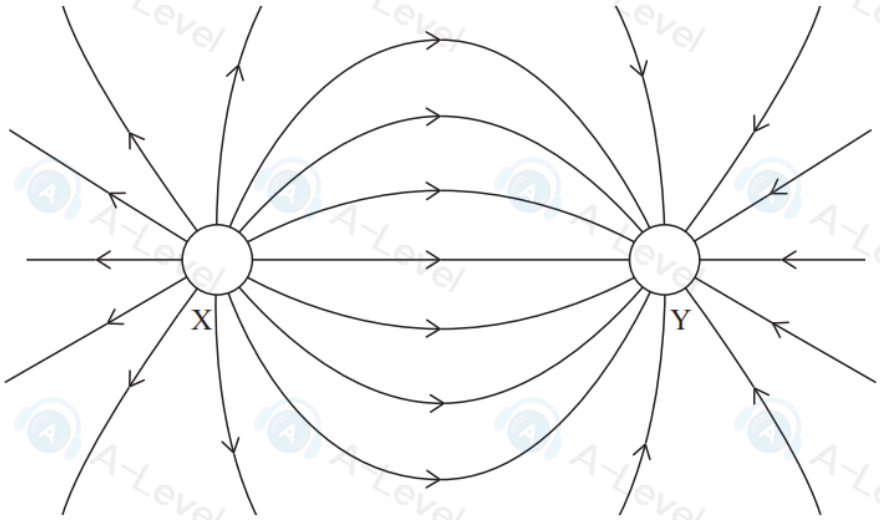
(3)

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)

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

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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.

(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)

DO NOT WRITE IN THIS AREA

(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)

DO

(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)