Name: ____

Electric Fields

Date:

Time:

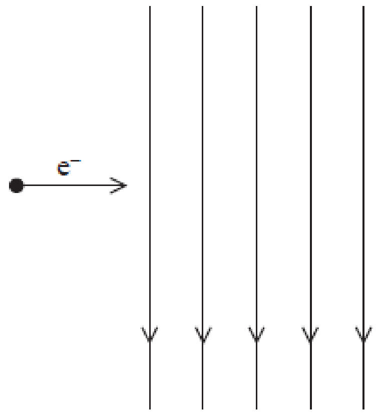
Total marks available:

Total marks achieved: ______

Questions

Q1.

An electron travelling horizontally enters a uniform electric field which acts vertically downwards as shown in the diagram.



Which of the following statements is **incorrect**?

☒ **A** The electron follows a parabolic path.

☒ **B** The electron accelerates while in the field.

☒ **C** The electric force on the electron acts downwards.

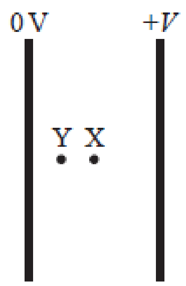
☒ **D** The speed of the electron increases.

(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

A potential difference *V* is applied across two parallel plates. An electron midway between the two plates at point X experiences an electric force *F*.



The electron moves to point Y which is halfway between point X and the left-hand plate.

Which of the following is the electric force experienced by the electron at Y?

☒ **A** 2*F*

☒ **B** *F*

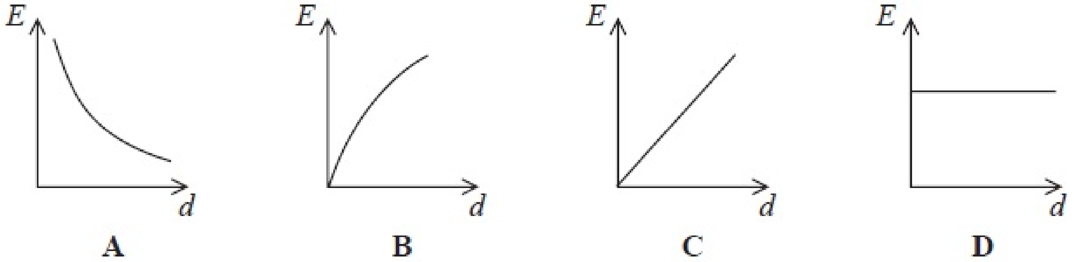
☒ **C** $\frac{F}{2}$

☒ **D** $\frac{F}{4}$

(Total for question = 1 mark)

Q3. Two parallel, conducting plates are connected to a battery. One plate is connected to the positive terminal and the other plate to the negative terminal. The plate separation *d* is gradually increased while the plates stay connected to the battery.

Select the graph that shows how the electric field strength *E* between the plates varies with separation *d*.



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question = 1 mark)

Q4.

What is the acceleration of an electron at a point in an electric field where the electric field strength is 2.0×10^4 N C^{-1}?

☒ **A** 2.8×10^{-16} m s^{-2}

☒ **B** 3.2×10^{-15} m s^{-2}

☒ **C** 1.8×10^{11} m s^{-2}

☒ **D** 3.5×10^{15} m s^{-2}

(Total for question = 1 mark)

Q5.

Which of the following is a property of a uniform electric field?

☒ **A** A field that doesn't change over time.

☒ **B** A field that acts equally in all directions.

☒ **C** A field that only produces a force on moving charged particles.

☒ **D** A field that has the same strength at all points.

(Total for question = 1 mark)

Q6. Two protons, separated by a distance x, experience a repulsive force F.

If the separation is reduced to $x/3$ the force between the protons will be

☒ **A** $F/9$

☒ **B** $F/3$

☒ **C** $3F$

☒ **D** $9F$

(Total for Question = 1 mark)

Q7.

Electric field strength can have the unit of

☒ **A** V m

☒ **B** V C^{-1}

☒ **C** N m^{-1}

☒ **D** N C^{-1}

(Total for question = 1 mark)

Q8.

A potential difference of 50 V is applied between two identical parallel aluminium plates. The plates are separated by a distance of 10 mm.

Which combination of potential difference and separation would double the electric field strength?

	Separation/mm	Potential difference/ V
☒ **A**	20	100
☒ **B**	20	25
☒ **C**	10	100
☒ **D**	10	25

(Total for question = 1 mark)

Q9.

Sketch the electric field around a positive point charge.

(3)

(Total for question = 3 marks)

Q10.

A magician did a trick which he claimed was the most dangerous ever. He positioned himself midway between two charged spheres which were separated by a distance of about two metres. Each sphere was charged to a potential that would cause ionisation at a distance of one metre. He wore a protective suit of chain mail and a helmet consisting of a metal cage. The protective suit and helmet were earthed to a potential of 0 V.

A scientist said "there is no danger in this and I would happily do it tomorrow".

Explain whether this statement is justified.

(3)

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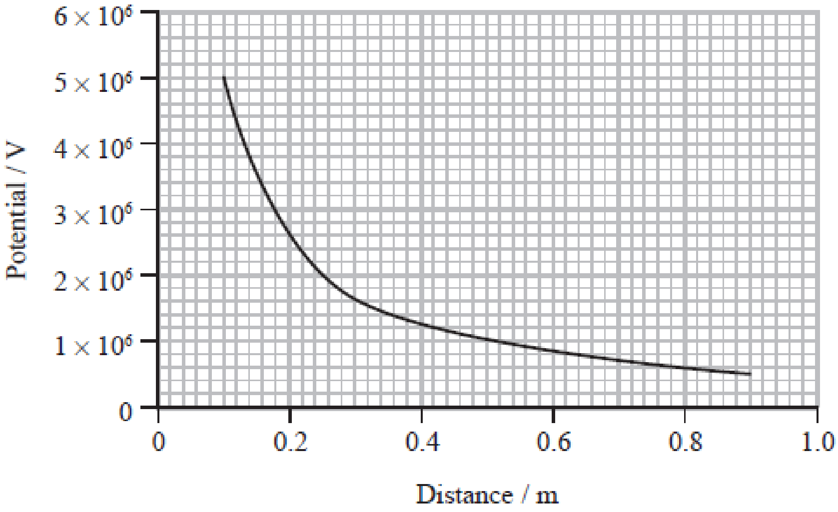
(Total for question = 3 marks)

Q11.

The graph shows how potential varies with distance from the centre of a charged sphere.



Air molecules will be ionised if the electric field strength exceeds 3×10^6 V m^{-1}.

Deduce whether air molecules will be ionised at a distance of 30 cm from the centre of this sphere.

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(Total for question = 4 marks)

Q12.

Electric fields are caused by both point charges and by parallel plates with a potential difference across them.

Describe the difference between the electric field caused by a point charge and the electric field between parallel plates. Your answer should include a diagram of each type of field and reference to electric field strength.

(5)

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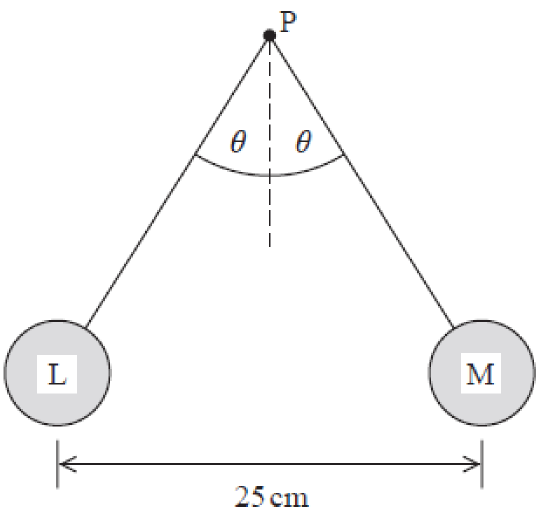
Q13.

Two small spheres L and M are attached to non-conducting threads and suspended from a point P. Each sphere is given an equal positive charge of 4.0×10^{-7} C. The spheres hang in equilibrium as shown in the diagram.

The mass of each sphere is 2.7 g.



By considering the forces acting on one of the spheres, calculate the tension in the thread and the angle θ.

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Tension = ...

θ = ...

Q14.

Our understanding of the atom has developed over time, from early models in which atoms were considered to be hard incompressible spheres, through to the nuclear model of the atom and the ladder model in which electrons exist in a discrete number of allowed energy states.

The nuclear model of the atom was established following a series of experiments in which alpha particles were directed at thin gold foil.

(i) An alpha particle approaching a gold nucleus, $^{197}_{79}Au$, head-on will be brought to rest and returned along its original path.

Calculate the minimum distance between the alpha particle and the nucleus for alpha particles of energy of 5.5 MeV.

(4)

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Minimum distance = ...

(ii) It is observed that electrons, with energy of 5.5 keV, are diffracted as they pass through the thin gold foil.

Explain a conclusion about the electrons that can be made from this observation.

(3)

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(Total for question = 7 marks)

Q15.

(a) Explain what is meant by the term electric field strength.

(2)

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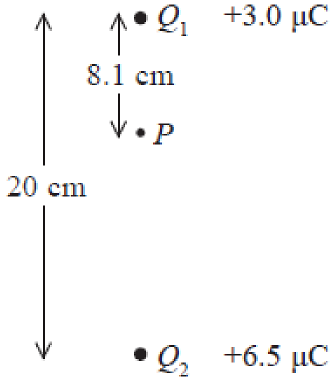
(b) (i) Two point charges Q_1 and Q_2 are placed 20 cm apart. Q_1 has a charge of +3.0 μC and Q_2 has a charge of +6.5 μC.



At point *P*, a distance 8.1 cm from Q_1, the electric field strength is approximately zero.

Demonstrate by calculation that this statement is correct.

(3)

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(ii) A charge of +4.5 μC is placed at point *P*.
State the magnitude of the force acting on this charge.

(1)

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(iii) The + 4.5 μC charge is moved from point *P* to a point half way between Q_1 and Q_2.

Explain qualitatively why energy would be needed for this movement.

(2)

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(Total for question = 8 marks)

Q16. In an experiment to investigate the structure of the atom, α-particles are fired at a thin metal foil, which causes the α-particles to scatter.

(a) (i) State the direction in which the number of α-particles detected will be a maximum.

(1)

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(ii) State what this suggests about the structure of the atoms in the metal foil.

(1)

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(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

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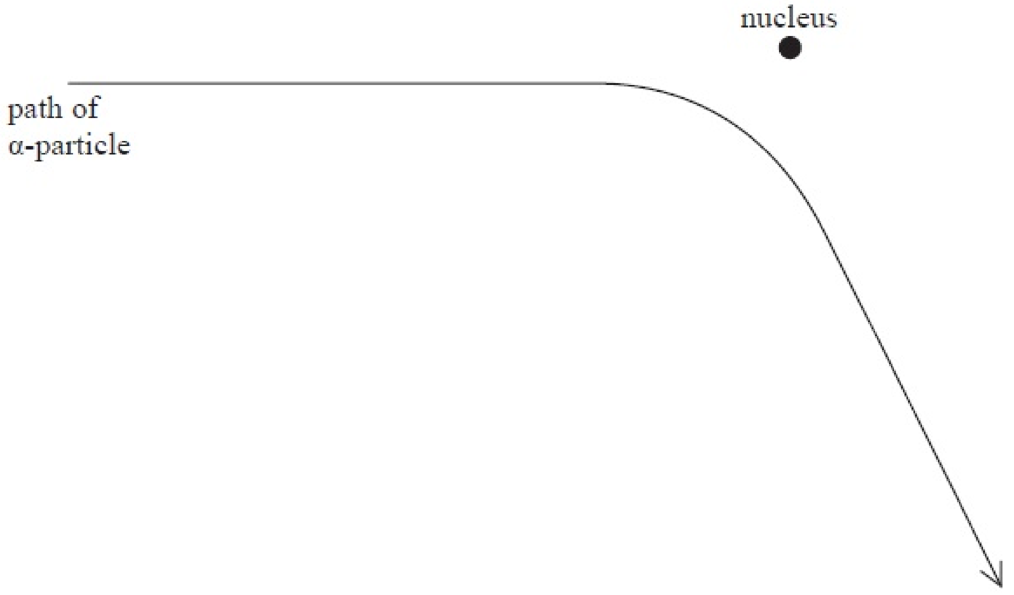
(c) The diagram shows the path of an α-particle passing near to a single nucleus in the metal foil.



(i) Name the force that causes the deflection of the α-particle.

(1)

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(ii) On the diagram, draw an arrow to show the direction of the force acting on the α-particle at the point where the force is a maximum. Label the force F.

(2)

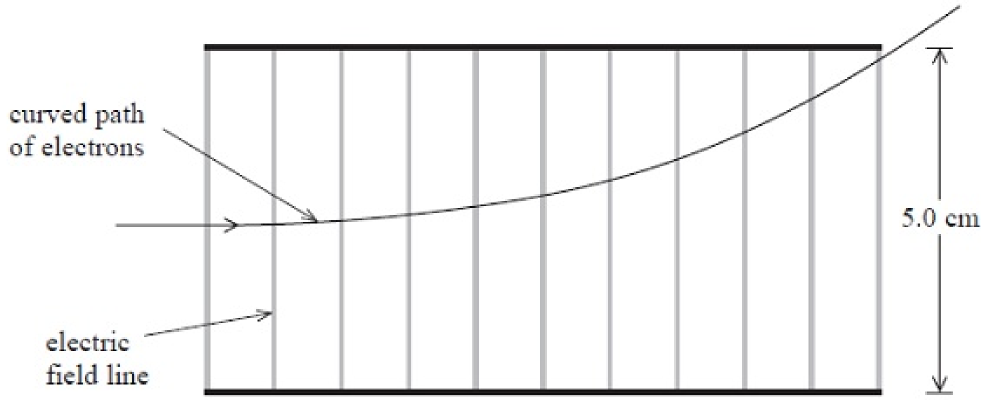
(iii) The foil is replaced by a metal of greater proton number.

Draw the path of an α-particle that has the same initial starting point and velocity as the one drawn in the diagram.

(2)

(Total for Question = 9 marks)

Q17. A teacher uses an electron beam tube to demonstrate the behaviour of electrons in an electric field. The diagram shows the path of an electron in a uniform electric field between two parallel conducting plates.



(a) Mark on the diagram the direction of the electric field.

(1)

(b) The conducting plates are 5.0 cm apart and have a potential difference of 160 V across them.

Calculate the force on the electron due to the electric field.

(3)

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Force = ...

(c) Explain why the path of the electron is curved between the plates and straight when it has left the plates.

(3)

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(d) The electron was initially released from a metal by thermionic emission and then accelerated through a potential difference before entering the region of the electric field.

(i) State what is meant by thermionic emission.

(1)

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(ii) In order to be able to just leave the plates as shown, the electron must enter the electric field between the plates with a speed of 1.2×10^{7} m s^{-1}.

Calculate the potential difference required to accelerate an electron from rest to this speed.

(3)

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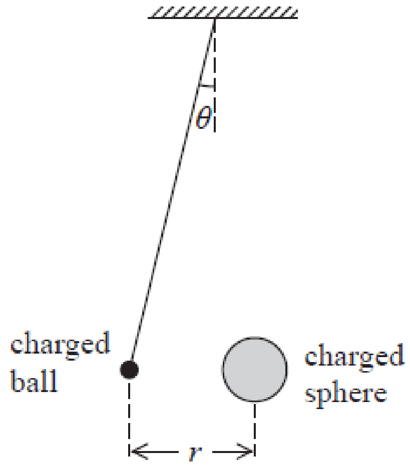
Potential difference = ...

(Total for Question = 11 marks)

Q18.

A student carries out an experiment to investigate the force acting between two charged objects. A lightweight negatively-charged ball is freely suspended from the ceiling by an insulating thread. The ball is repelled by a negatively-charged sphere that is placed near it on an insulated support.
The angle of deflection is θ and r is the distance between the centres of the ball and the sphere.



(a) (i) Draw a free-body force diagram for the suspended ball.

(2)

(ii) The weight of the suspended ball is W.

Show that the force of repulsion F on the suspended ball is given by

$$F = W \tan \theta$$

(2)

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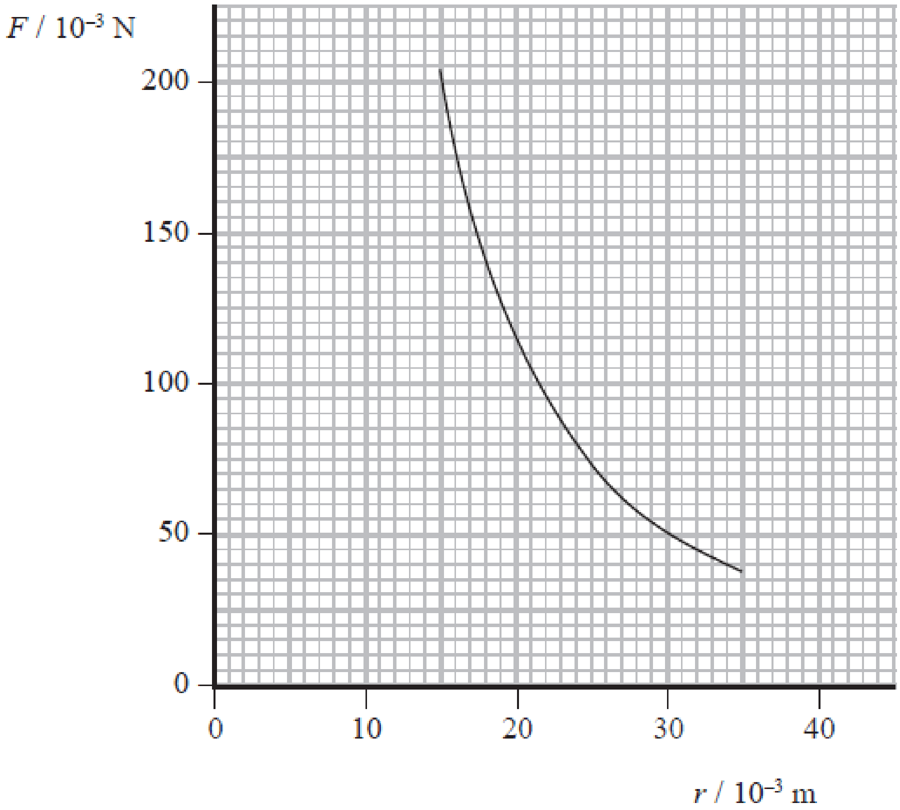
(b) (i) The student can increase the magnitude of the force by moving the sphere towards the suspended ball.
She takes pairs of measurements of r and θ and calculates the magnitude of the force F. She then plots a graph of F against r.



Use readings from the graph to demonstrate that the relationship between *F* and *r* obeys an inverse square law.

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(ii) The charge on the sphere is 100 times greater than the charge on the ball.

Calculate the charge on the ball.

(3)

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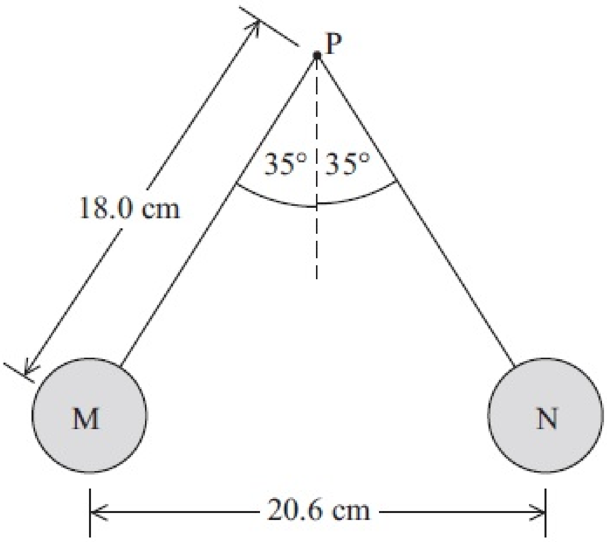
Charge = ...

(Total for question = 11 marks)

Q19.

Two identical table tennis balls, M and N, are attached to non-conducting threads and suspended from a point P. The balls are each given the same positive charge and they hang as shown in the diagram. The mass of each ball is 2.7 g.



(a) Draw a free-body force diagram for ball M, label your diagram with the names of the forces.

(2)

(b) (i) Show that the tension in one of the threads is about 3×10^{-2} N.

(3)

(ii) Show that the electrostatic force between the balls is about 2×10^{-2} N.

(2)

(iii) Calculate the charge on each ball.

(3)

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Charge = ...

(c) State and explain what would have happened if the charge given to ball M was greater than the charge given to ball N.

Calculate the charge on each ball.

(2)

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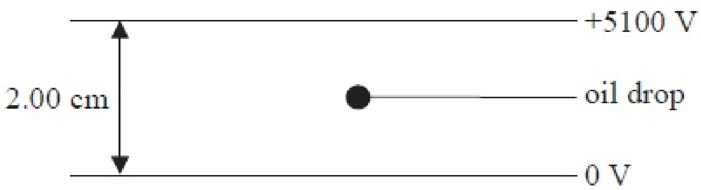
(Total for question = 12 marks)

Q20. The charge on an electron was originally measured in an experiment called the Millikan Oil Drop experiment.

In a simplified version of this experiment, an oil drop with a small electric charge is placed between two horizontal, parallel plates with a large potential difference (p.d.) across them. The p.d. is adjusted until the oil drop is stationary.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



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

(3)

(b) State whether the charge on the oil drop is positive or negative.

(1)

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(c) Complete the free-body force diagram to show the forces acting on the oil drop. You should ignore upthrust.

(2)

(d) (i) Calculate the magnitude of the charge on the oil drop.

(4)

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Charge = ...

(ii) Calculate the number of electrons that would have to be removed or added to a neutral oil drop for it to acquire this charge.

(2)

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Number of electrons = ...

(Total for Question = 12 marks)