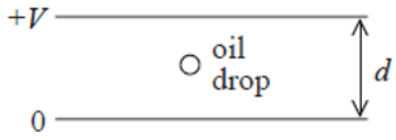
Questions

Q1.

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 ☒ .

An oil drop with charge q and mass m remains stationary between two metal plates with a potential difference V across them. The plates are separated by distance d.



What is the charge on the oil drop?

☐ **A** $\frac{md}{V}$

☐ **B** $\frac{mV}{d}$

☐ **C** $\frac{mgd}{V}$

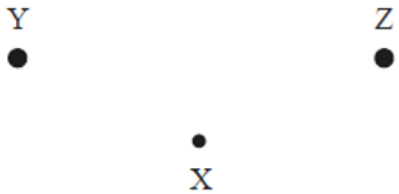
☐ **D** $\frac{mgV}{d}$

(Total for question = 1 mark)

Q2.

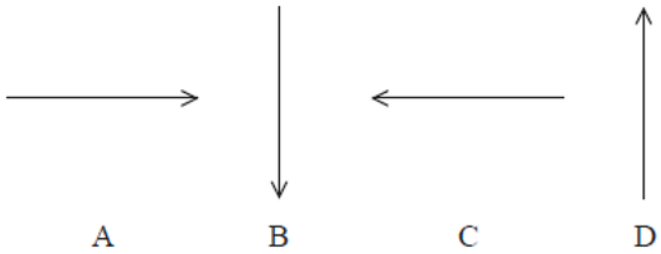
Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

Two equal positive charges are placed at Y and Z.



Point X is equidistant from Y and Z.

Which of the following shows the direction of the electric field at point X?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q3.

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 ☒ .

When a point object with charge $+Q$ is placed a distance d away from another point object with charge $+2Q$ the force between them is F.

The charges are increased to $+2Q$ and $+4Q$ and the distance is increased to $2d$.

Which of the following gives the new force?

☒ **A** $\frac{F}{4}$

☒ **B** $\frac{F}{2}$

☒ **C** F

☒ **D** $2F$

(Total for question = 1 mark)

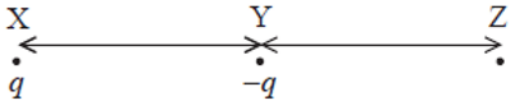
Q4.

Point charges of $+q$ and $-q$ are placed at X and Y respectively.

When another charge is placed at Z, the resultant force on the charge at X is zero.

Distance XY equals distance YZ.

Which of the following is the charge placed at Z?



☒ **A** $\frac{q}{4}$

☒ **B** $\frac{q}{2}$

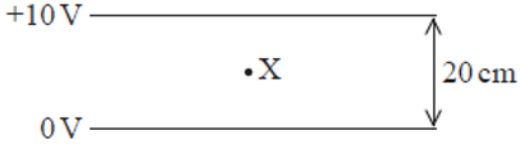
☒ **C** $2q$

☒ **D** $4q$

(Total for question = 1 mark)

Q5.

The diagram shows a potential difference applied across two conducting parallel plates.



Point X is midway between the plates.

Which of the following is the electric field strength at point X?

☒ **A** 50 V m^{-1} upwards

☒ **B** 50 V m^{-1} downwards

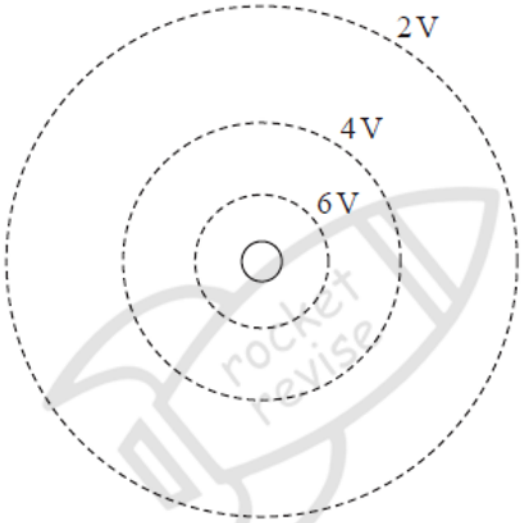
☒ **C** 100 V m^{-1} upwards

☒ **D** 100 V m^{-1} downwards

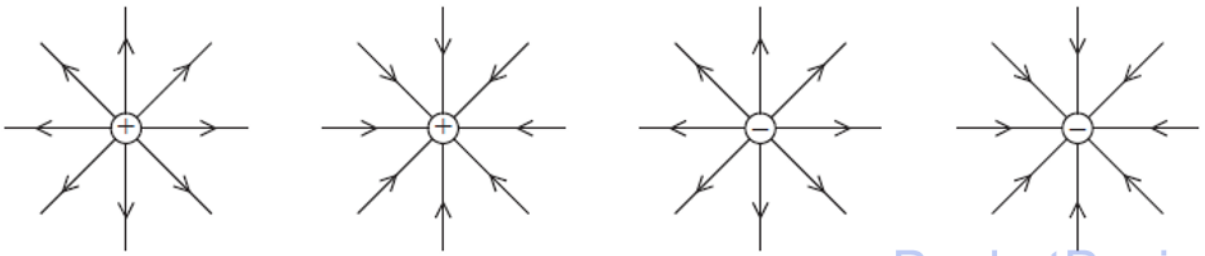
(Total for question = 1 mark)

Q6.

The diagram shows equipotential lines about a point charge.



Which of the following diagrams shows a possible combination of electric field lines and polarity of point charge to produce this pattern?



☒ **A** ☒ **B** ☒ **C** ☒ **D**

(Total for question = 1 mark)

Q7.

At distance d from a point charge of magnitude q the potential is V.

Which of the following is the potential at a distance $4d$ from a point charge of magnitude $2q$?

☒ **A** $\frac{V}{4}$

☒ **B** $\frac{V}{2}$

☒ **C** V

☒ **D** $2V$

(Total for question = 1 mark)

Q8.

Some spiders may be seen suddenly moving up into the air, even when there is no wind. This happens when they let out strands of web.

The spiders are pulled upwards as the electrically charged strands of web interact with the Earth's electric field.

The average strength of the Earth's electric field is 120 V m^{-1} downwards.

(a) State, with a reason, the polarity of the charge on the strands of web.

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(b) A spider moves upwards after letting out a strand of web.

Determine the initial upwards acceleration of the spider.

mass of spider = 3.00×10^{-6} kg

total magnitude of charge on a strand of web = 3.00×10^{-7} C

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Acceleration = ...

(c) The Earth has an electric field because charge is distributed over its surface.

Determine the quantity of charge on 1 m^2 of the Earth's surface which would cause an electric field of 120 V m^{-1}.

You should assume that the charge is distributed evenly.

radius of Earth = 6400 km

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Charge = ...

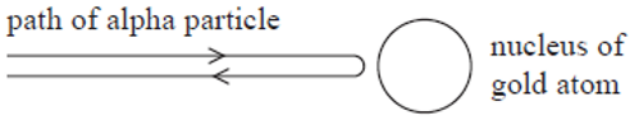
(Total for question = 9 marks)

Q9.

In the early part of the 20th century, experiments were carried out in which alpha particles were directed at thin sheets of metal.

A few alpha particles were deviated through small angles and a very small proportion were reflected back.

(a) The diagram represents an alpha particle reflected back through 180° as it approached the nucleus of a gold atom.



Calculate the maximum acceleration of the alpha particle as it reaches the point of minimum separation from the nucleus. Assume that the gold nucleus remains at rest.

speed of alpha particle = 1.74×10^{7} m s^{-1}

mass of alpha particle = 6.64×10^{-27} kg

atomic number of gold = 79

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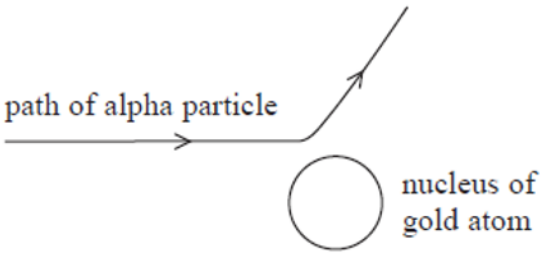
Maximum acceleration = ...

(b) The diagram represents the path of an alpha particle with the same initial speed as in (a) that is deflected through a smaller angle.



Explain whether the maximum acceleration would be the same as for the alpha particle reflected back through 180°.

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(Total for question = 9 marks)

Q10.

In 1909 Robert Millikan carried out experiments to determine the magnitude of the charge on an electron.

His experiments involved the motion of small, electrically charged droplets of oil between two charged metal plates.

Some students carried out a similar experiment in a school laboratory.

(a) The terminal velocity v of an oil droplet was measured as it fell a known distance in air when the plates were uncharged. Stokes' law was then used to determine the radius r of the oil droplet. Upthrust was ignored.

(i) Show that $r =$

$$\sqrt{\frac{9\eta v}{2\rho g}}$$

η = viscosity of air

ρ = density of oil

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(ii) For a particular oil droplet, the terminal velocity was measured to be 5.35×10^{-4} m s^{-1}.

Calculate the radius of this oil droplet.

$\eta = 1.86 \times 10^{-5}$ Pa s

$\rho = 904$ kg m^{-3}

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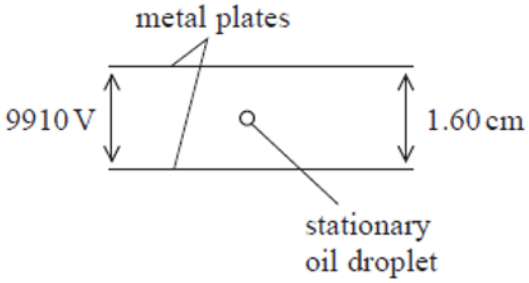
Radius = ...

(iii) A potential difference (p.d.) was applied across the plates and adjusted until a charged oil droplet was stationary between them.



Calculate the charge on the oil droplet.

mass of oil droplet = 3.03×10^{-14} kg

p.d. = 9910 V

separation of plates = 1.60 cm

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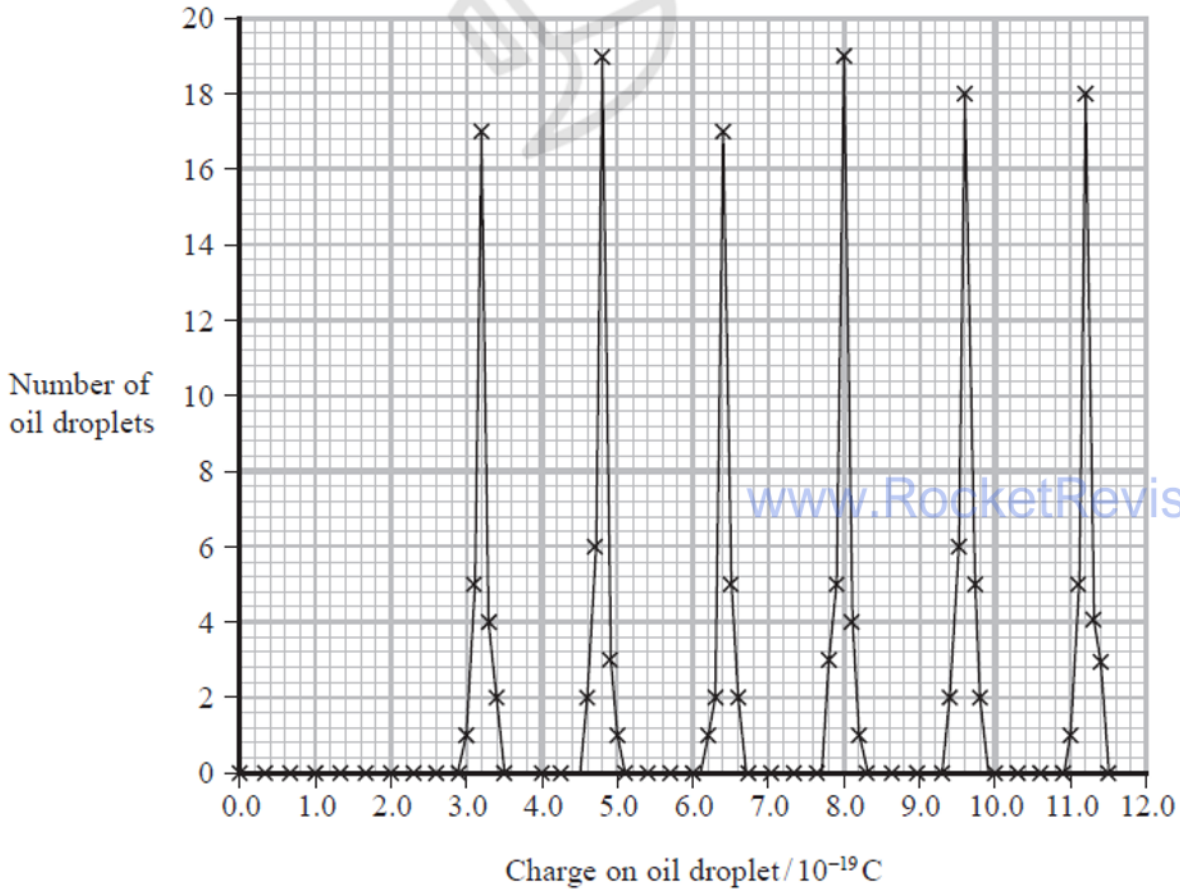
Charge = ...

(b) The students repeated the experiment for a large number of oil droplets.

The graph shows the number of oil droplets with each measured charge.



The teacher states that charge can only be transfered in integer multiples of 1.6×10^{-19} C.

Explain the extent to which the students' results support this statement.

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(c) In 1909 Millikan concluded that the charge on the electron was 1.592×10^{-19} C whereas the accepted value today is 1.602×10^{-19} C. This was because the value for the viscosity of air used by Millikan was incorrect.

Deduce whether the value for the viscosity used by Millikan was too large or too small.

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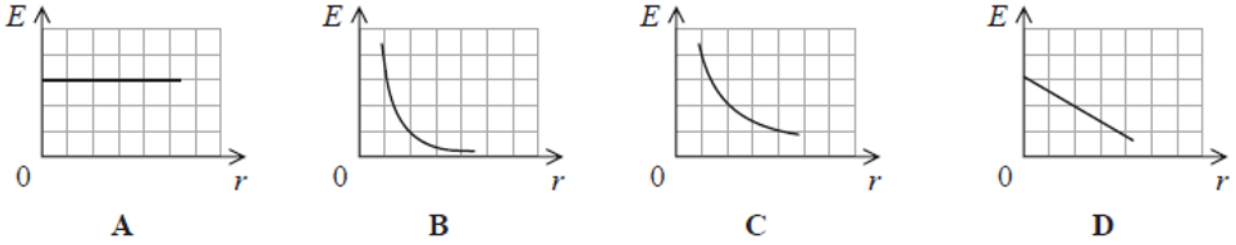
(Total for question = 15 marks)

Q11.

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 ☒.

Which of the following graphs shows how the electric field strength *E* varies with distance *r* from a positive point charge?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q12.

Point charges of 2 μC and 3 μC are placed 1.2 m apart as shown.

What is the electric field strength at the point labelled X?

☒ **A** $\frac{2\times10^{-6}}{4\pi\varepsilon_0(0.4)^2}+\frac{3\times10^{-6}}{4\pi\varepsilon_0(0.8)^2}$

☒ **B** $\frac{2\times10^{-6}}{4\pi\varepsilon_0(0.4)^2}-\frac{3\times10^{-6}}{4\pi\varepsilon_0(0.8)^2}$

☒ **C** $\frac{2\times10^{-6}}{4\pi\varepsilon_0(0.8)^2}+\frac{3\times10^{-6}}{4\pi\varepsilon_0(0.4)^2}$

☒ **D** $\frac{2\times10^{-6}}{4\pi\varepsilon_0(0.8)^2}-\frac{3\times10^{-6}}{4\pi\varepsilon_0(0.4)^2}$

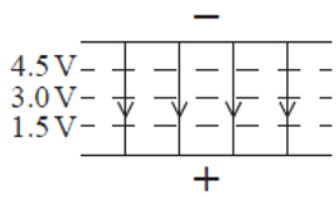
(Total for question = 1 mark)

Q13.

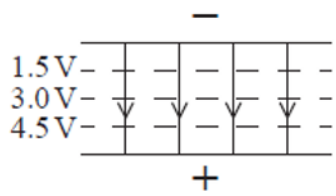
A 6 V battery is connected across two parallel metal plates.

Which of the following shows the electric field lines and equipotentials in the region between the plates?

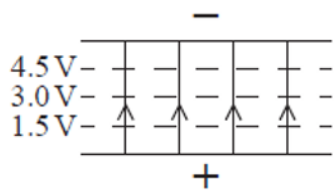
☒ **A**



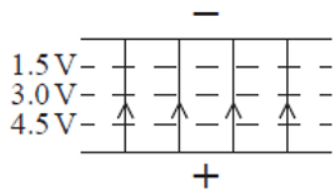
☒ **B**



☒ **C**



☒ **D**



(Total for question = 1 mark)

Q14.

In 1931, Sloan and Lawrence built a linear accelerator (linac) with several drift tubes. They used the linac to accelerate mercury ions up to energies of 1.26 MeV. The behaviour of the particles was non-relativistic.

(a) The kinetic energy of a non-relativistic particle of mass m with momentum p is given by

$$E_k = \frac{p^2}{2m}$$

Derive this formula.

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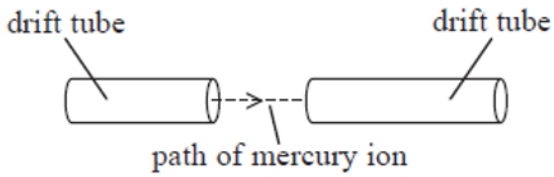
(b) A mercury ion with kinetic energy 6.42×10^{-15} J leaves a drift tube, as shown.



Calculate the momentum of the mercury ion when it reaches the next drift tube.

mass of mercury ion = 3.32×10^{-25} kg
charge of mercury ion = 1.60×10^{-19} C
electric field strength between drift tubes = 7.64×10^{6} V m^{-1}
distance between drift tubes = 5.50×10^{-3} m

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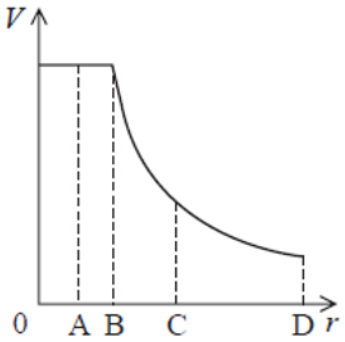
Momentum = ...

(Total for question = 6 marks)

Q15.

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 ☒.

The electric potential *V* varies with the distance *r* from a charged object as shown.



At which distance, A, B, C or D, does the electric field strength have its maximum value?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q16.

The diagram represents a negative point charge.

Draw field lines to show the electric field around the charge.

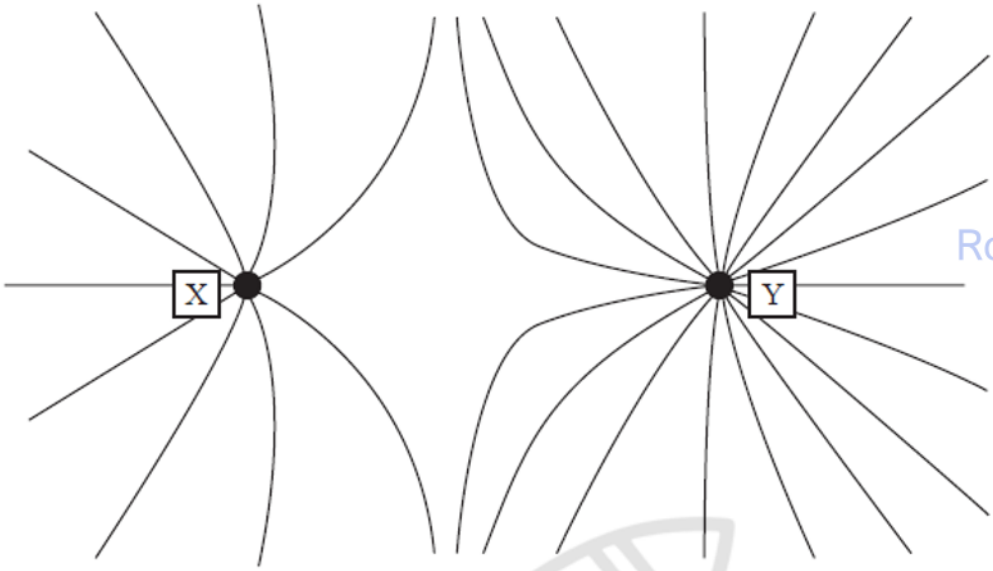
●

(Total for question = 3 marks)

Q17.

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 ☒.

The diagram shows the shape of the electric field pattern between two charged particles, X and Y.



X has a charge of –*Q*.

Which of the following could be the charge of Y?

☒ **A** –*Q*

☒ **B** –2*Q*

☒ **C** +*Q*

☒ **D** +2*Q*

(Total for question = 1 mark)

Q18.

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 ☒.

Two equally-charged ions exert a force of 4.0×10^{-9}N on each other. The distance between the centres of the ions is 2.4×10^{-10}m.

Which of the following is equal to the charge on each ion?

☒ **A** $\sqrt{\frac{4.0 \times 10^{-9} \times (2.4 \times 10^{-10})^2}{8.99 \times 10^9}}$

☒ **B** $\sqrt{\frac{4.0 \times 10^{-9} \times (2.4 \times 10^{-10})^2}{4 \times \pi \times 8.85 \times 10^{-12}}}$

☒ **C** $\frac{4.0 \times 10^{-9} \times (2.4 \times 10^{-10})^2}{8.99 \times 10^9}$

☒ **D** $\frac{4.0 \times 10^{-9} \times (2.4 \times 10^{-10})^2}{4 \times \pi \times 8.85 \times 10^{-12}}$

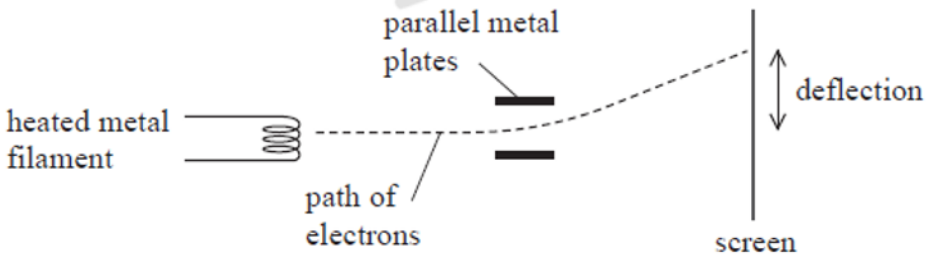
(Total for question = 1 mark)

Q19.

Select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question refers to a cathode ray tube.

The diagram shows some of the components in a cathode ray tube.



When a potential difference is applied across the parallel metal plates, the electrons are deflected.

Which of the following changes would decrease the deflection of the electrons?

☒ **A** increasing the current in the metal filament

☒ **B** increasing the distance between the plates

☒ **C** increasing the length of the plates

☒ **D** increasing the potential difference across the plates

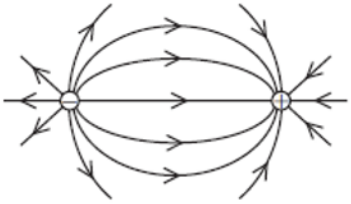
(Total for question = 1 mark)

Q20.

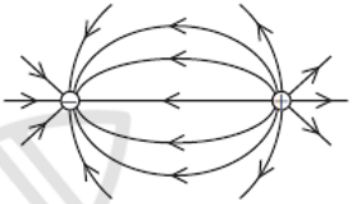
Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Point charges of equal magnitude are placed close together, as shown.

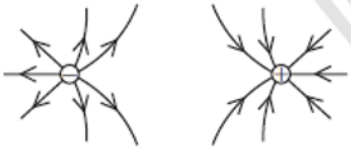
Which of the following diagrams shows the electric field around the charges?



A



B



C

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☒ **A**

☒ **B**

☒ **C**

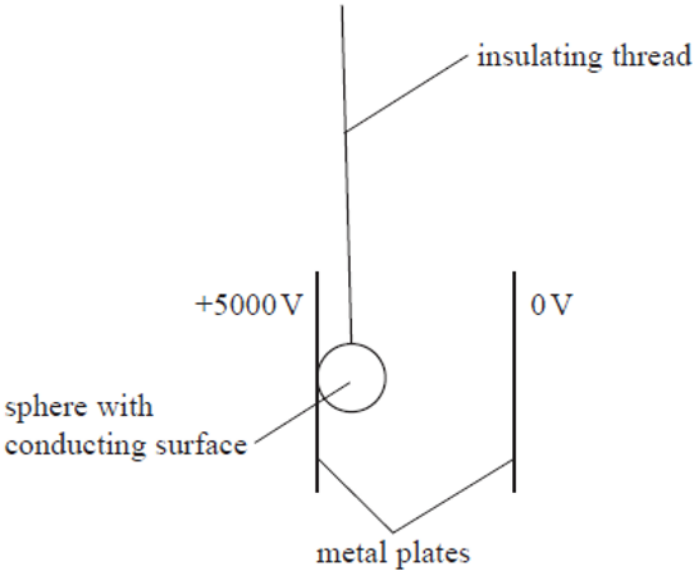
☒ **D**

(Total for question = 1 mark)

Q21.

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.

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(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

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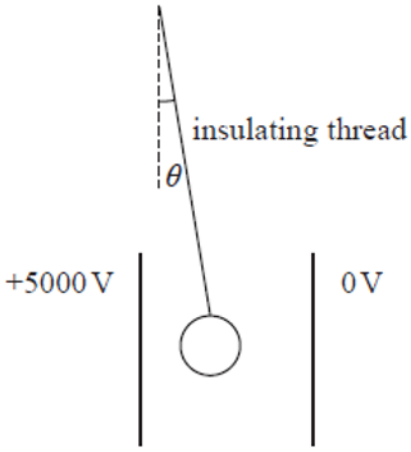
(ii) The sphere moves away from the positive plate and comes to rest at an angle θ to the vertical.



Show that the horizontal force on the sphere is about 5×10^{-4} N.

distance between plates = 10.5 cm

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(iii) Show that θ is about 1°.

mass of sphere = 2.7 g

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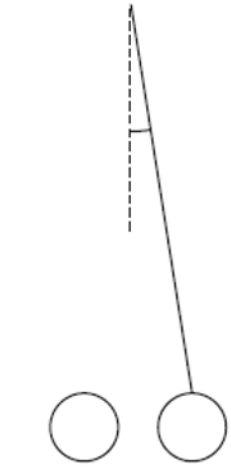
(c) A second identical charged sphere is held in a fixed position.

The first sphere, attached to the insulating thread, is placed near to the fixed sphere.

The spheres exert a repulsive force on each other.



The force between the spheres is 5.0×10^{-4} N.

Calculate the distance between the centres of the spheres.

charge on each sphere = 12 nC

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Distance between centres of spheres = ...

(Total for question = 14 marks)

Q22.

A point positive charge and a point negative charge are placed 8.0 cm apart at X and Y, as shown.

X Y

(a) Calculate the magnitude of the electric field strength midway between X and Y.

charge at X = + 2.5 × 10^{-7} C
charge at Y = – 2.5 × 10^{-7} C

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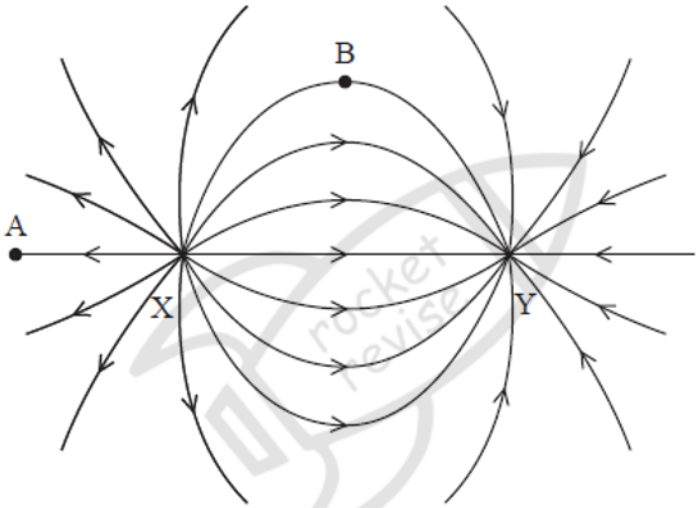
Electric field strength = ...

(b) The diagram below represents the electric field for this combination of charges.



(i) Add dashed lines to the electric field diagram to show equipotentials for this combination of charges.

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(ii) A textbook states, "An electric field line shows the path a free positive test charge follows".

Discuss the accuracy of this statement for free positive test charges placed at point A and at point B.

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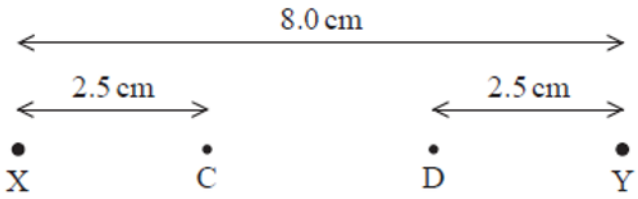
(c) The charges at X and Y are replaced by charges of twice the magnitude.



C and D are points between the charges.

Determine the magnitude of the potential difference between points C and D.

charge at X = $+5.0 \times 10^{-7}$ C
charge at Y = -5.0×10^{-7} C

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Magnitude of potential difference = ...

(Total for question = 14 marks)

Q23.

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 and then mark your new answer with a cross ☒.

A proton is accelerated by a uniform electric field. After time t the speed of the proton has increased by Δv.

A helium nucleus $^{4}_{2}\text{He}$ is accelerated by the same electric field.

After what time will the helium nucleus achieve the same change in speed?

☒ **A** $4t$

☒ **B** $2t$

☒ **C** $\frac{t}{2}$

☒ **D** $\frac{t}{4}$

(Total for question = 1 mark)

Q24.

A point charge is placed at point X, as shown.

(a) Add lines to the diagram to show equipotentials at intervals of equal potential difference.

(2)

(b) A charge of –4.5 nC is placed 4.0 cm from X.

Calculate the magnitude of the force acting on is charge due to the charge at X.

charge at X = +7.0 nC

(2)

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Magnitude of force = ...

(c) The –4.5 nC charge is moved from a distance of 4.0 cm from X to a distance of 9.0 cm from X.

Calculate the work done on the -4.5 nC charge.

(3)

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Work done = ...

(Total for question = 7 marks)