CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



EXAM QUESTION PACK

18 ELECTRIC FIELDS

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Chapter 10

Electric fields

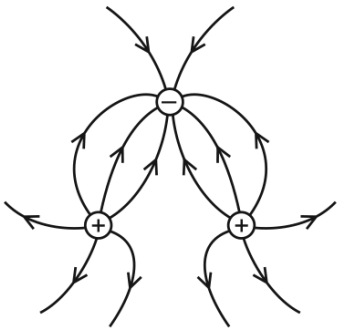
10.1 Concept of an electric field

1008. 9702_m20_qp_12 Q: 30

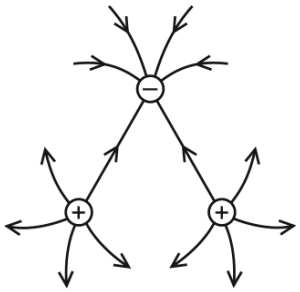
Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram represents the electric field surrounding the charges?

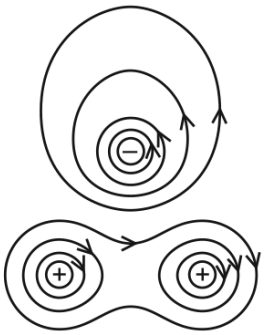
A



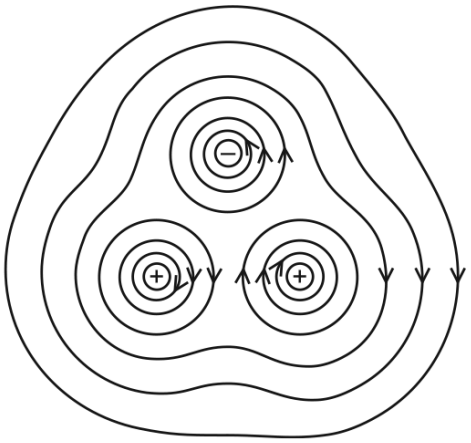
B



C



D



STEMUP.CO.UK

1009. 9702_s20_qp_11 Q: 31

A small charge q is placed in the electric field of a large charge Q.

Both charges experience a force F.

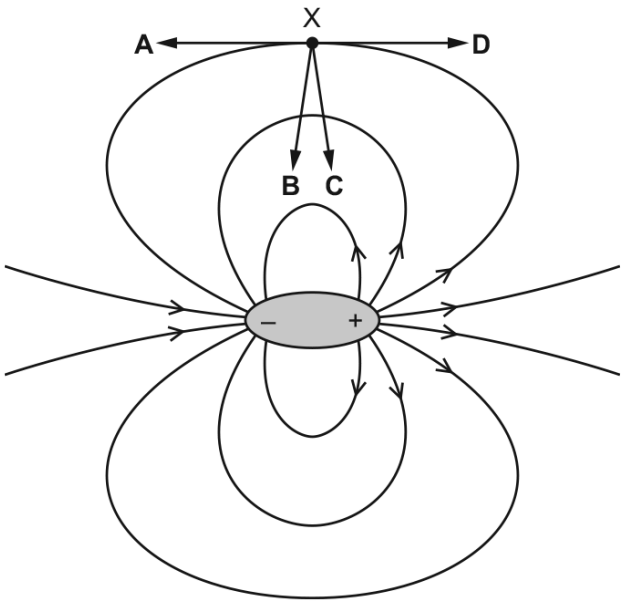
What is the electric field strength of the charge Q at the position of the charge q?

A $\frac{F}{Qq}$ **B** $\frac{F}{Q}$ **C** FqQ **D** $\frac{F}{q}$

1010. 9702_s20_qp_12 Q: 31

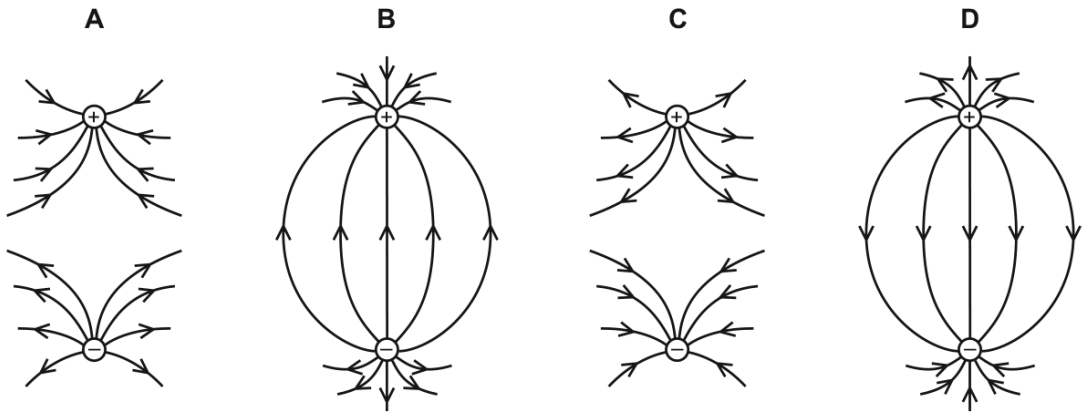
A dipole is a pair of charges of equal magnitude, one negative and one positive. The electric field of a dipole is shown below.

In which direction does the force act on an electron when at point X?



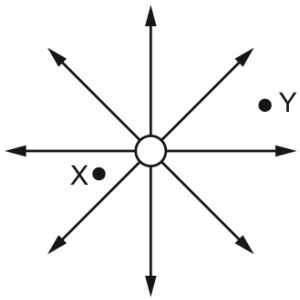
1011. 9702_s20_qp_13 Q: 31

Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?



1012. 9702_m19_qp_12 Q: 31

The diagram shows the electric field near a point charge and two electrons X and Y.



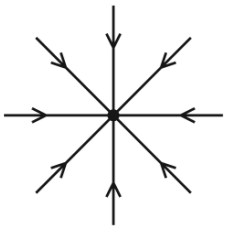
Which row describes the forces acting on X and on Y?

	direction of force	magnitude of force on X
A	radially inwards	less than force on Y
B	radially inwards	greater than force on Y
C	radially outwards	less than force on Y
D	radially outwards	greater than force on Y

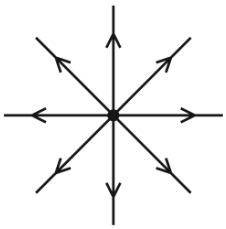
1013. 9702_s19_qp_11 Q: 31

Which diagram shows the pattern of the electric field lines due to a negative point charge?

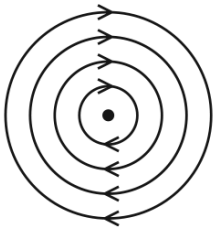
A



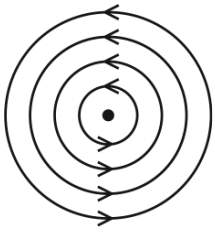
B



C



D



1014. 9702_s19_qp_11 Q: 32

In an electrolyte, the electric current is carried by charged particles (ions) in solution.

What is **not** a possible value for the charge on an ion in solution?

A -4.8×10^{-19} C

B $+1.6 \times 10^{-19}$ C

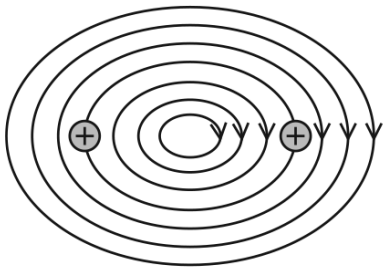
C $+3.2 \times 10^{-19}$ C

D $+4.0 \times 10^{-19}$ C

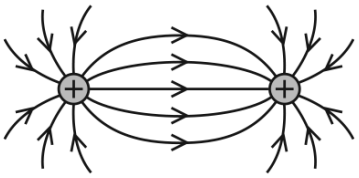
1015. 9702_s19_qp_13 Q: 31

Which diagram represents the electric field line pattern due to a combination of two positive charges?

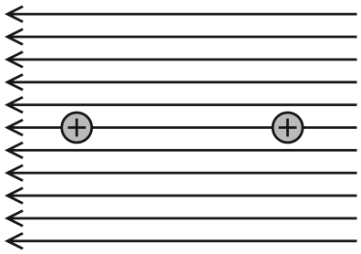
A



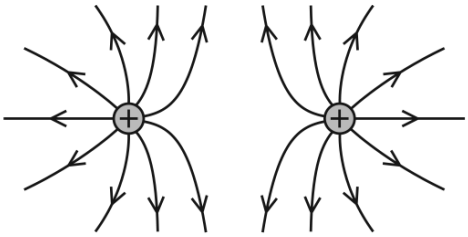
B



C



D



1016. 9702_w19_qp_12 Q: 29

P is a point near to charge X as shown.



When a negatively charged test charge is placed at point P, it is found to experience a force of repulsion from X that is radially away from X.

Which arrow correctly shows the direction of the electric field at point P due to the charge X?

A

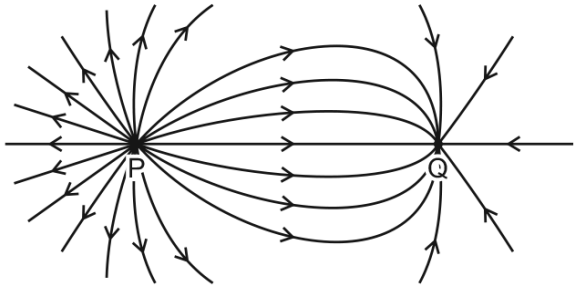
B

C

D

1017. 9702_w19_qp_13 Q: 31

The diagram shows the electric field pattern between two opposite and unequal point charges P and Q.



Which statement about the charges is correct?

A P is negatively charged and has a smaller charge than Q.

B P is negatively charged and has a greater charge than Q.

C P is positively charged and has a smaller charge than Q.

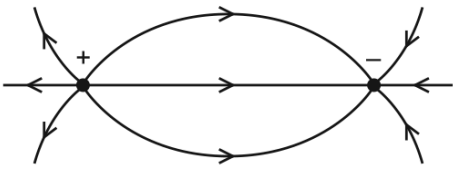
D P is positively charged and has a greater charge than Q.

1018. 9702_s18_qp_12 Q: 31

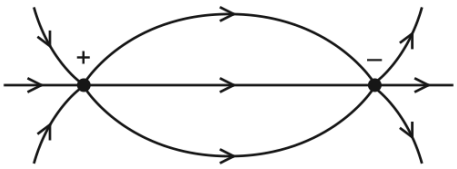
Four diagrams representing the electric field between two oppositely-charged point charges are shown.

Which diagram correctly shows the electric field lines?

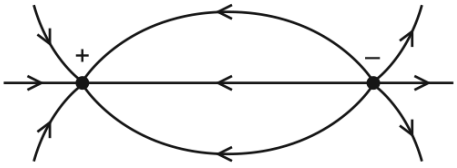
A



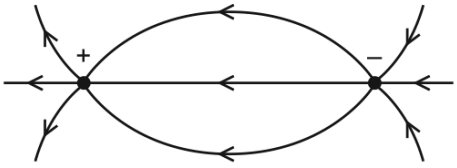
B



C

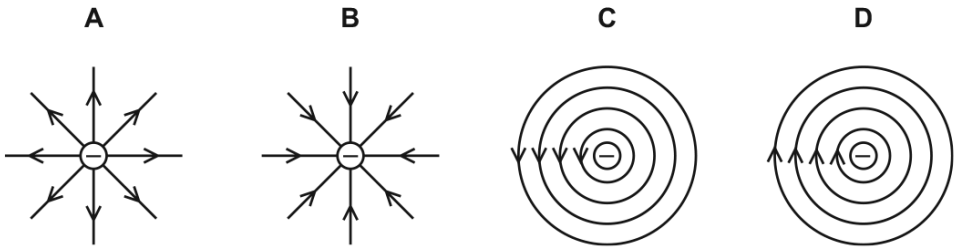


D



1019. 9702_w18_qp_11 Q: 30

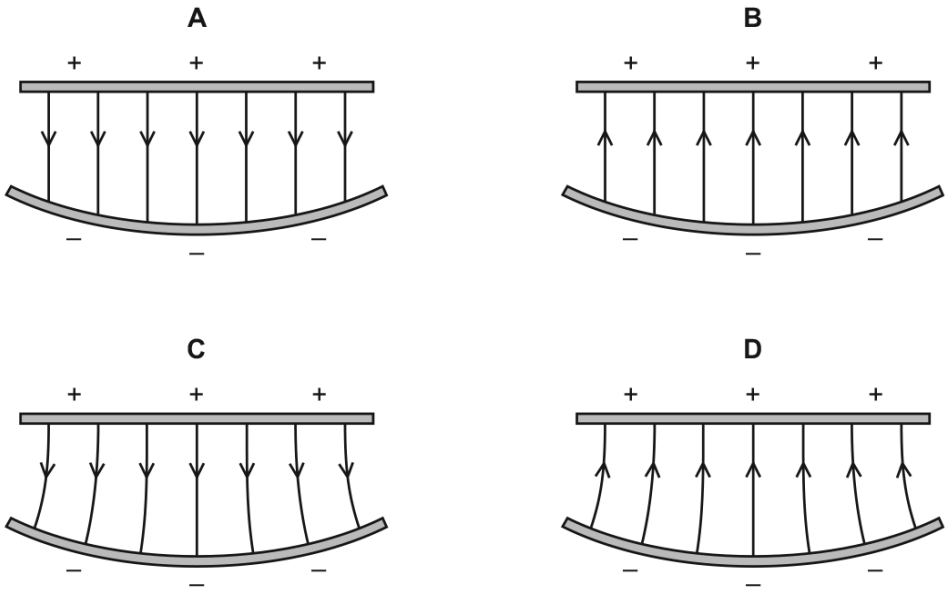
Which diagram shows the electric field lines surrounding an isolated negative point charge?



1020. 9702_w18_qp_12 Q: 31

A flat plate is positively charged and a curved plate is negatively charged.

Which diagram shows the electric field lines between the two plates?

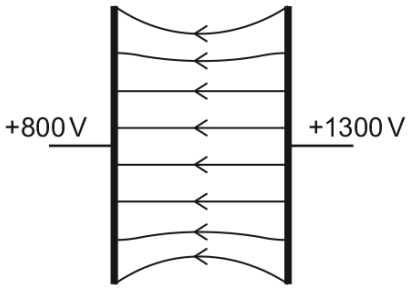


1021. 9702_w18_qp_13 Q: 30

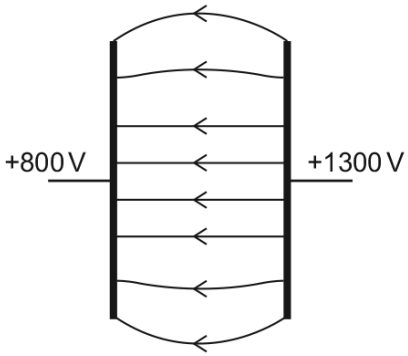
Two parallel metal plates are at electric potentials of +800 V and +1300 V.

Which diagram best represents the electric field between the metal plates?

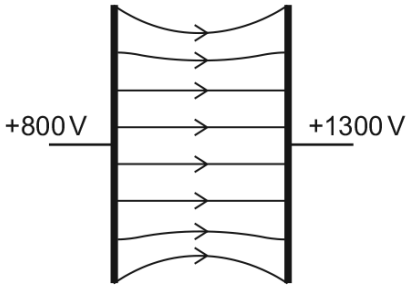
A



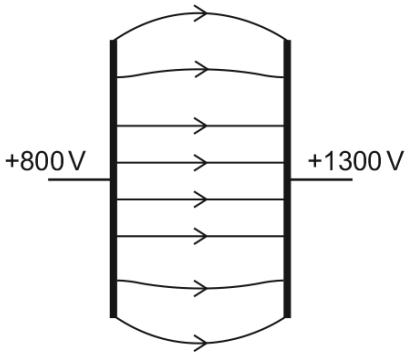
B



C



D

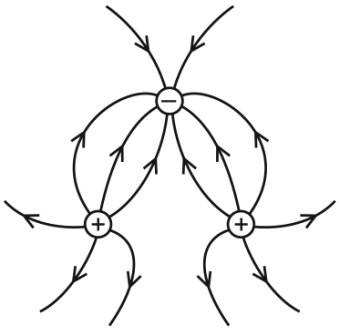


1022. 9702_m17_qp_12 Q: 30

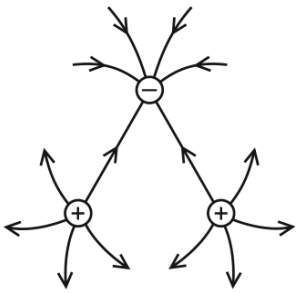
Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram best represents the electric field surrounding the charges?

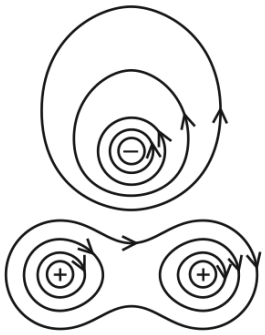
A



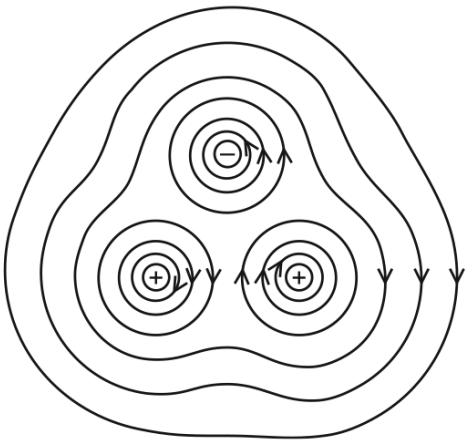
B



C



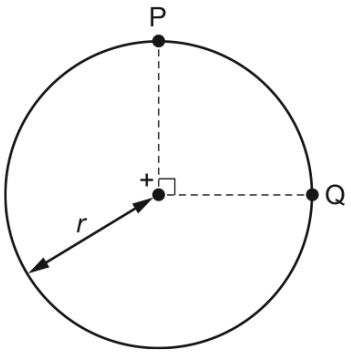
D



1023. 9702_s17_qp_11 Q: 30

The diagram shows two points P and Q which lie 90° apart on a circle of radius r.

A positive point charge at the centre of the circle creates an electric field of magnitude E at both P and Q.



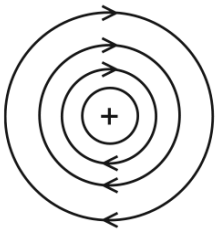
Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

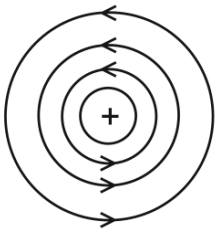
1024. 9702_s17_qp_12 Q: 30

Which diagram best illustrates the electric field around a positive point charge?

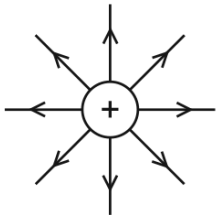
A



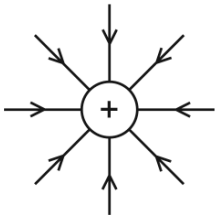
B



C



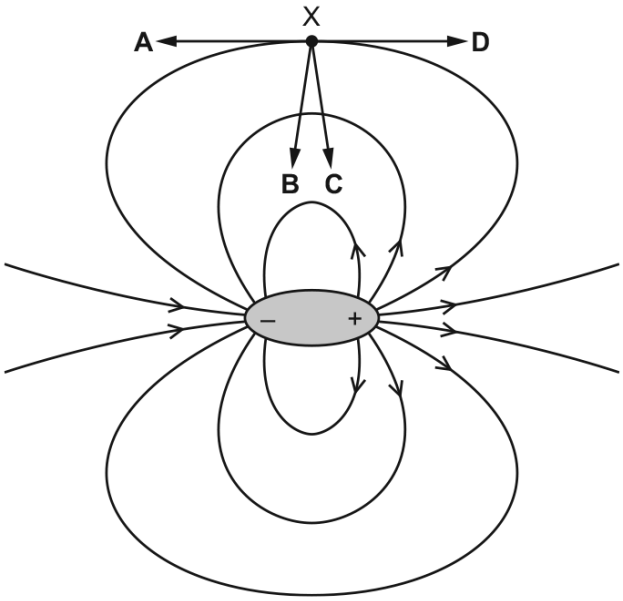
D



1025. 9702_s17_qp_13 Q: 29

A dipole is a pair of charges of equal magnitude, one negative and one positive. The electric field of a dipole is shown below.

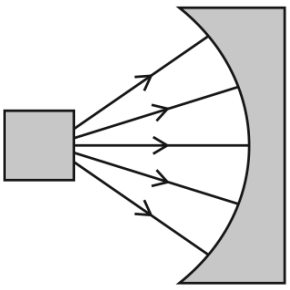
In which direction does the force act on an electron when at point X?



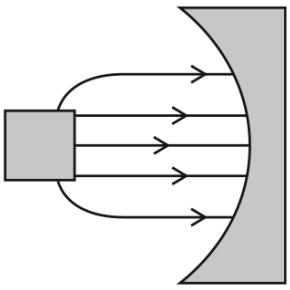
1026. 9702_s16_qp_11 Q: 29

Which diagram could represent the electric field lines between two oppositely charged conducting surfaces?

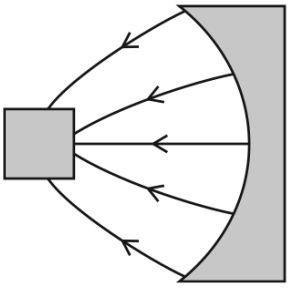
A



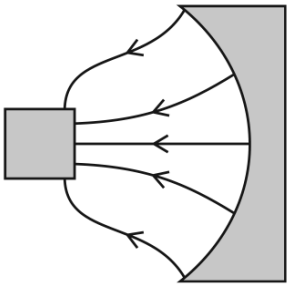
B



C

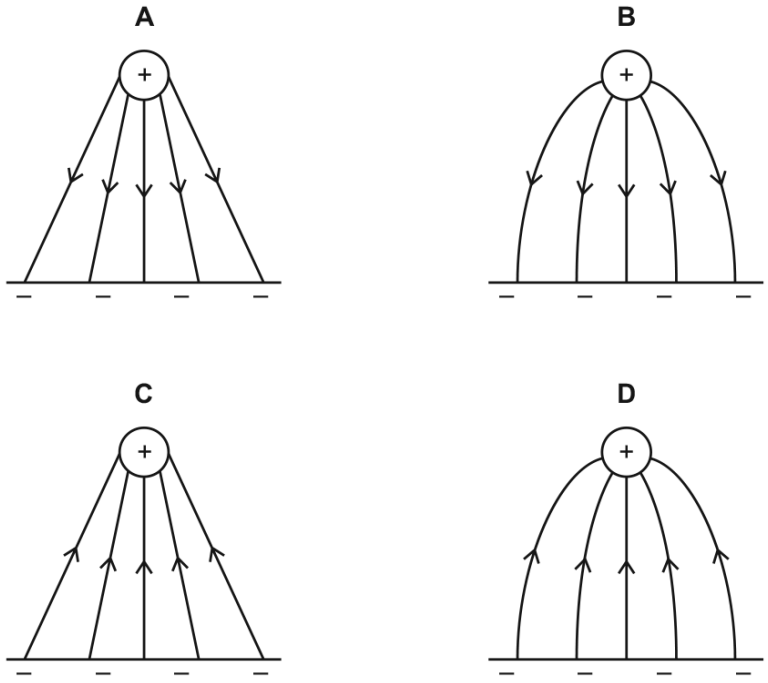


D



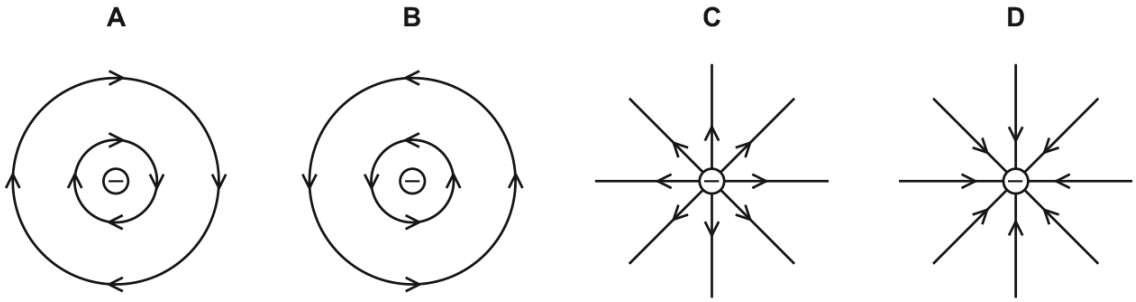
1027. 9702_s16_qp_12 Q: 29

Which diagram shows the pattern of the electric field between a positively charged metal sphere and a negatively charged metal plate?



1028. 9702_s16_qp_13 Q: 29

Which diagram shows the electric field pattern of an isolated negative point charge?

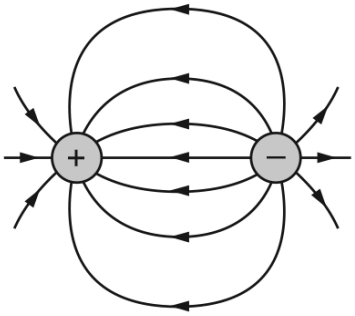


1029. 9702_s15_qp_12 Q: 29

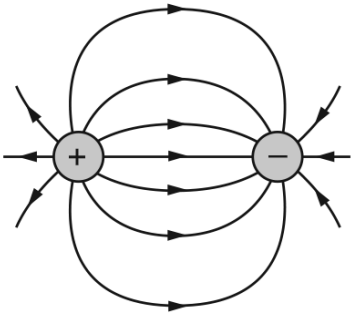
A positive charge and a negative charge of equal magnitude are placed a short distance apart.

Which diagram best represents the associated electric field?

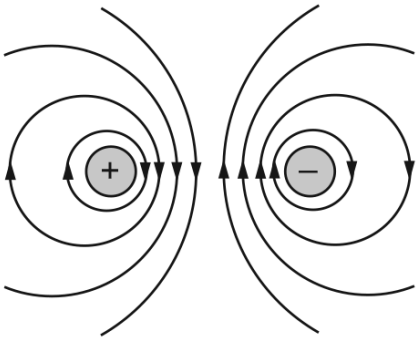
A



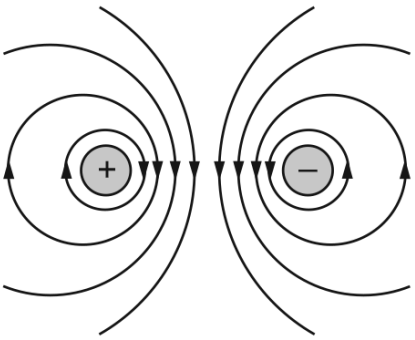
B



C



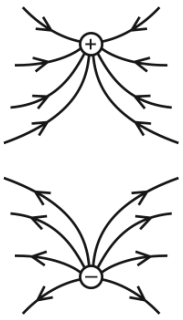
D



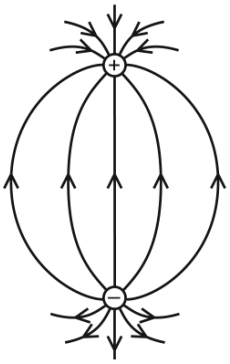
1030. 9702_s15_qp_13 Q: 31

Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?

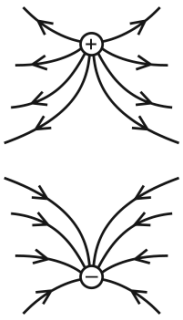
A



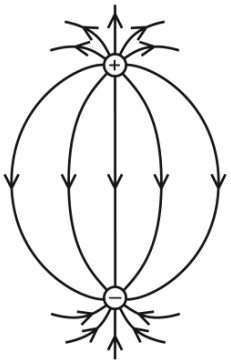
B



C



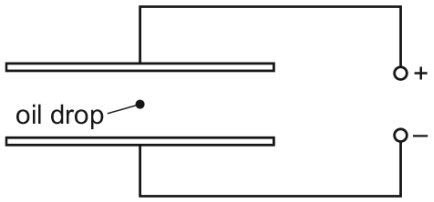
D



10.2 Uniform electric fields

1031. 9702_m20_qp_12 Q: 31

A negatively charged oil drop is held stationary, equidistant between two plates connected to a high voltage supply, as shown.



Which change would **not** increase the upward electrical force on the drop?

A decreasing the distance between the plates whilst keeping the drop equidistant from them

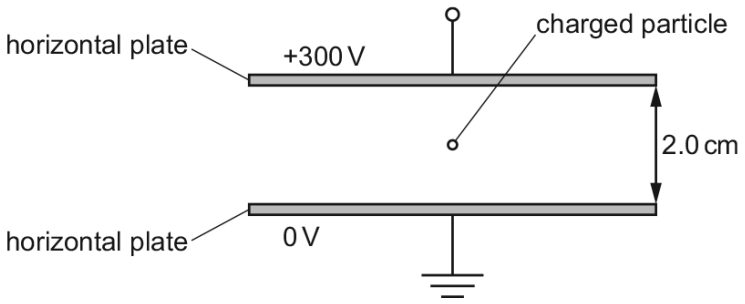
B increasing the amount of negative charge on the drop

C increasing the supply voltage

D moving the drop closer to the positive plate

1032. 9702_s20_qp_11 Q: 32

A charged particle is in a vacuum between two horizontal metal plates as shown.



The acceleration of the particle is $7.15 \times 10^{11}\,\text{m s}^{-2}$ downwards. The particle has a mass of $3.34 \times 10^{-27}\,\text{kg}$.

What is the charge on the particle?

A $+1.6 \times 10^{-19}\,\text{C}$

B $-1.6 \times 10^{-19}\,\text{C}$

C $+1.6 \times 10^{-17}\,\text{C}$

D $-1.6 \times 10^{-17}\,\text{C}$

1033. 9702_s20_qp_12 Q: 32

A charged oil droplet of mass m is falling, initially freely, in a vacuum between two horizontal metal plates that are separated by a distance x.

A potential difference (p.d.) V is then applied across the plates. This results in the oil droplet continuing to accelerate downwards but with a reduced acceleration a.

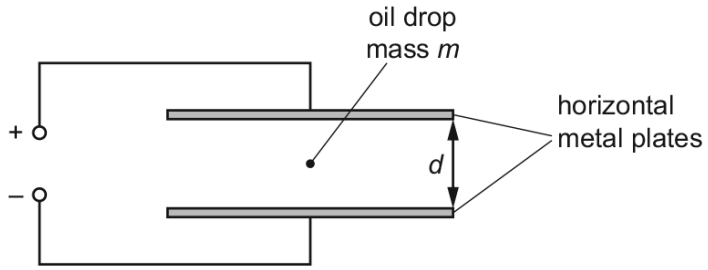
The polarity of the applied p.d. is then reversed so that the direction of the electric force on the droplet is reversed. This results in the downwards acceleration of the oil droplet increasing to $3a$.

What is the magnitude of the charge on the oil droplet?

A $\frac{max}{V}$ **B** $2\frac{max}{V}$ **C** $3\frac{max}{V}$ **D** $4\frac{max}{V}$

1034. 9702_s20_qp_13 Q: 32

A negatively charged oil drop of mass m is between two horizontal parallel metal plates a distance d apart.



When the potential difference (p.d.) between the plates is V_1 the oil drop rises at a constant speed. When the p.d. is decreased to a value V_2 the oil drop falls at the same constant speed.

Air resistance acts on the drop when it is moving. The upthrust on the drop is negligible.

The acceleration of free fall is g.

What is the charge on the oil drop?

A $\frac{mdg}{V_1 - V_2}$ **B** $\frac{mdg}{V_1 + V_2}$ **C** $\frac{2mdg}{V_1 - V_2}$ **D** $\frac{2mdg}{V_1 + V_2}$

1035. 9702_m19_qp_12 Q: 30

Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

What is the electric field strength E at a point midway between the plates?

A $1.0 \times 10^4\,\text{V m}^{-1}$ downwards

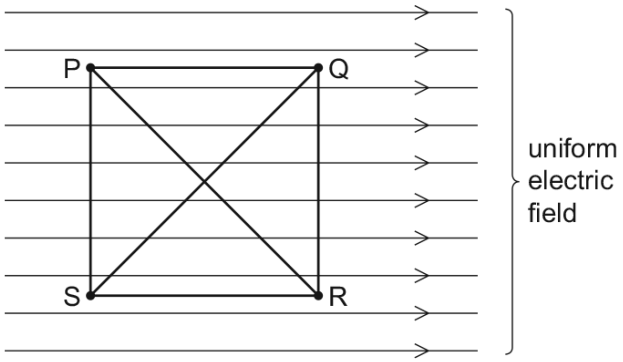
B $1.0 \times 10^4\,\text{V m}^{-1}$ upwards

C $2.0 \times 10^4\,\text{V m}^{-1}$ downwards

D $2.0 \times 10^4\,\text{V m}^{-1}$ upwards

1036. 9702_s19_qp_12 Q: 13

A small positive charge can move inside a uniform electric field.



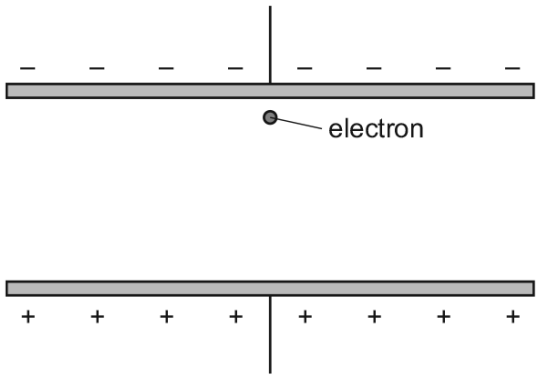
The charge moves along different straight paths between points P, Q, R and S.

Which row gives two paths that result in the same total work done on the charge?

	path 1	path 2
A	P to R	Q to S
B	P to R	P to S
C	S to Q	S to R
D	S to Q	R to P

1037. 9702_s19_qp_12 Q: 32

An electron is situated in a vacuum between two charged plates, as shown.



Which statement describes the motion of the electron due to the uniform electric field?

A It moves downwards with a constant acceleration.

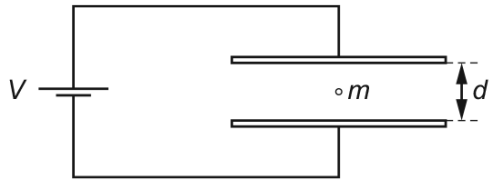
B It moves downwards with zero acceleration.

C It moves upwards with a constant acceleration.

D It moves upwards with a decreasing acceleration.

1038. 9702_w19_qp_12 Q: 30

A charged oil drop of mass m, with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d.



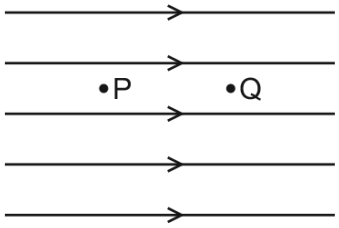
The voltage between the plates is V, the elementary charge is e and the acceleration of free fall is g.

What is the value of n?

A $\frac{eV}{mgd}$ **B** $\frac{mgd}{eV}$ **C** $\frac{meV}{gd}$ **D** $\frac{gd}{meV}$

1039. 9702_w19_qp_13 Q: 32

A uniform electric field is represented by five horizontal field lines.



P and Q are two points in the field. The field causes a positively charged particle in a vacuum to move from P to Q.

Which statement must be correct?

A The acceleration of the particle between P and Q is increasing.

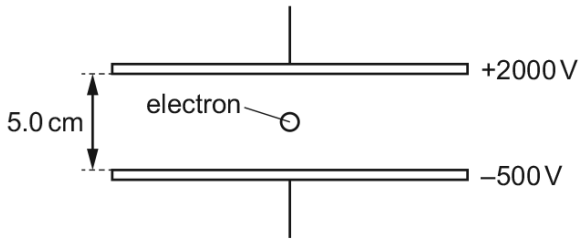
B The kinetic energy of the particle at P is the same as the kinetic energy of the particle at Q.

C The force on the particle at Q is greater than the force on the particle at P.

D Work is done on the particle as it moves from P to Q.

1040. 9702_m18_qp_12 Q: 30

An electron passes into the space between two parallel plates that are 5.0 cm apart and which are maintained at electric potentials of +2000 V and –500 V, respectively.



What is the electric force on the electron?

A 1.6×10^{-15} N

B 4.8×10^{-15} N

C 6.4×10^{-15} N

D 8.0×10^{-15} N

1041. 9702_m18_qp_12 Q: 31

Which statement about electric charges in a uniform electric field is **not** correct?

A Electric charges of the same magnitude, whether positive or negative, experience the same magnitude of force when placed in the same uniform electric field.

B The direction of the force on a positive charge placed in a uniform electric field is independent of the magnitude of the charge.

C The magnitude of the force on a positive charge placed in a uniform electric field is proportional to the magnitude of the electric field strength.

D The work done to move a positive charge a certain distance in a uniform electric field is independent of the direction of the movement.

1042. 9702_s18_qp_11 Q: 28

A particle has a charge of +2.0 mC and is in a vertical uniform electric field. An electric force of 1.0×10^{-2} N acts upwards on the particle.

What is the electric field strength?

A $0.20\,\text{V m}^{-1}$ downwards

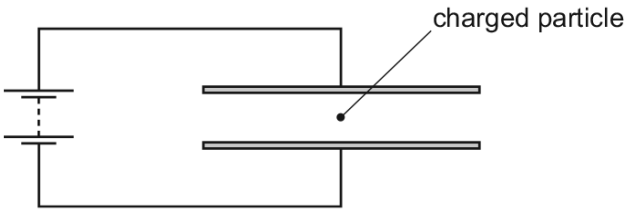
B $0.20\,\text{V m}^{-1}$ upwards

C $5.0\,\text{V m}^{-1}$ downwards

D $5.0\,\text{V m}^{-1}$ upwards

1043. 9702_s18_qp_11 Q: 29

A charged particle is in the electric field between two horizontal metal plates connected to a battery, as shown. There is a force F on the particle due to the electric field.



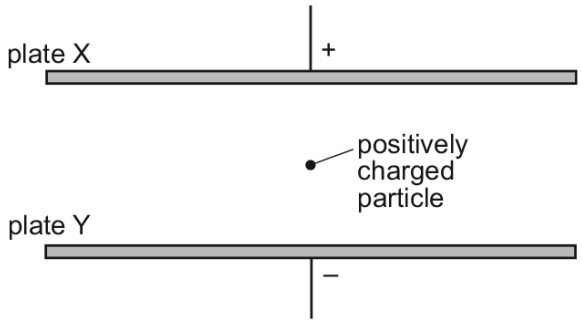
The separation of the plates is doubled.

What is the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

1044. 9702_s18_qp_12 Q: 30

Two large parallel metal plates X and Y are situated in a vacuum as shown.



Plates X and Y carry equal and opposite charges.

What happens to the force on a positively charged particle as it moves from plate X to plate Y?

A It decreases because the positively charged particle is moving away from the positively charged plate.

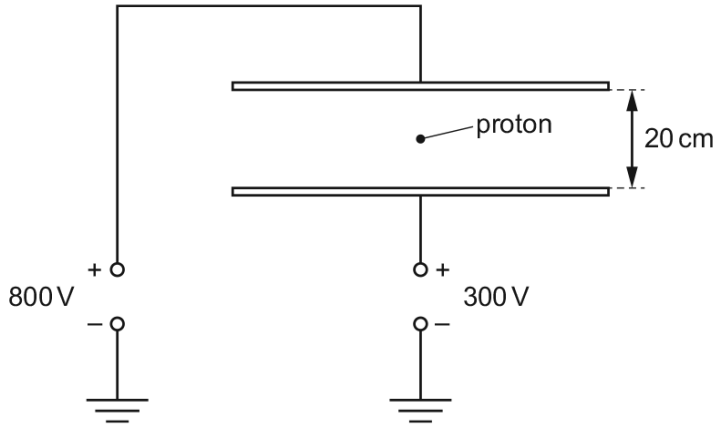
B It decreases because the positively charged particle is moving in the direction of the electric field between the plates.

C It increases because the positively charged particle is moving closer to a negatively charged plate.

D It remains constant because the positively charged particle is in the uniform electric field between the plates.

1045. 9702_s18_qp_13 Q: 27

Two parallel metal plates are situated 20 cm apart in a vacuum. They are connected to two sources of potential difference as shown.



A proton is released in the space between the plates.

What is the magnitude and direction of the acceleration of the proton?

A $2.4 \times 10^{11}\,\text{m s}^{-2}$ downwards

B $2.4 \times 10^{11}\,\text{m s}^{-2}$ upwards

C $5.3 \times 10^{11}\,\text{m s}^{-2}$ downwards

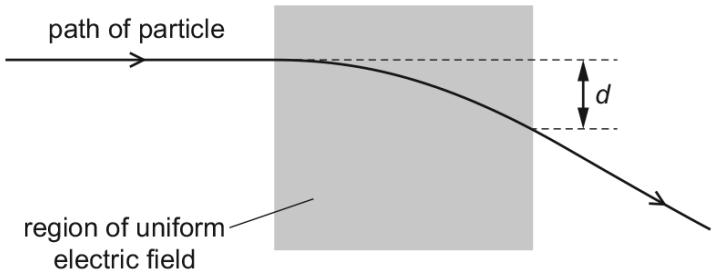
D $5.3 \times 10^{11}\,\text{m s}^{-2}$ upwards

1046. 9702_s18_qp_13 Q: 28

A particle having mass m and charge $+q$ enters a uniform electric field with speed v.

Initially, the particle is travelling at right-angles to the electric field.

During its movement through the field, the particle is deflected through distance d, as shown.



A second particle of mass $2m$, charge $+q$ and speed v enters the electric field along the same path.

What is the distance through which this particle is deflected in the electric field?

A $\frac{d}{4}$ **B** $\frac{d}{2}$ **C** $2d$ **D** $4d$

1047. 9702_w18_qp_11 Q: 31

A beam of electrons is directed into an electric field and is deflected by it.

Diagram 1 represents an electric field in the plane of the paper.
Diagram 2 represents an electric field directed perpendicular to the plane of the paper.

The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of the electrons inside the field?

diagram 1

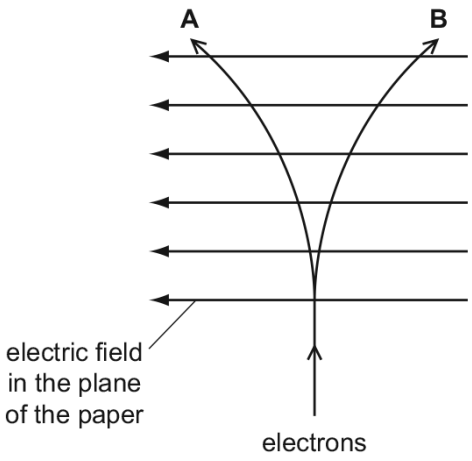
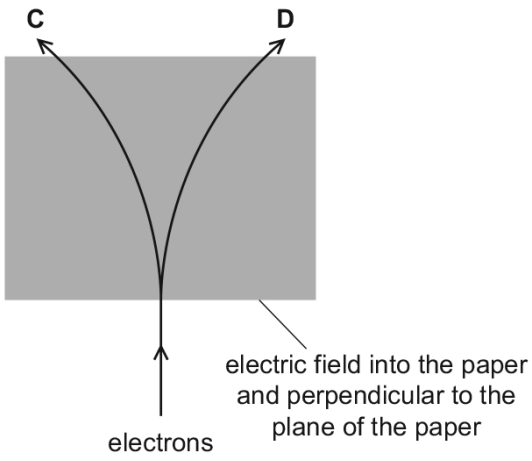


diagram 2



1048. 9702_w18_qp_11 Q: 32

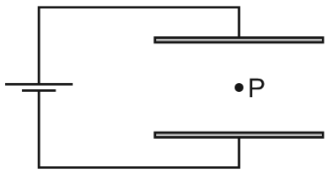
A charged particle of charge q and mass m is initially at rest in a uniform electric field. The field is produced by parallel metal plates separated by a distance d and having a potential difference V between them.

What is an expression for the acceleration of the charged particle?

A $\frac{md}{qV}$ **B** $\frac{mV}{qd}$ **C** $\frac{qd}{mV}$ **D** $\frac{qV}{md}$

1049. 9702_w18_qp_12 Q: 32

Two parallel metal plates are connected to a d.c. supply, as shown.

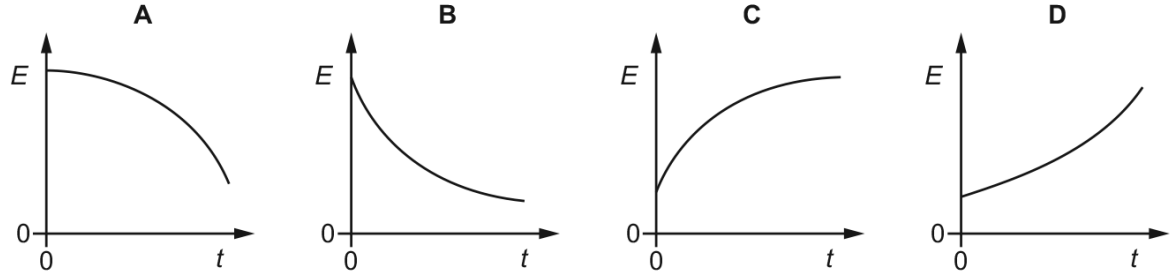


The two plates are moved towards each other at constant speed.

It may be assumed that the electric field between the plates is uniform.

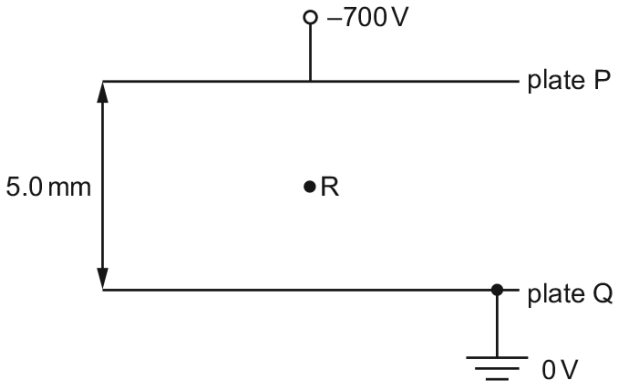
Point P is mid-way between the two plates.

Which graph shows the variation with time *t* of the electric field strength *E* at point P?



1050. 9702_w18_qp_13 Q: 31

The diagram shows two metal plates P and Q. There is a potential difference of 700 V between the plates. Plate Q is earthed.



What is the magnitude and direction of the electric field at point R?

A $1.4 \times 10^2\,\text{N C}^{-1}$ from P towards Q

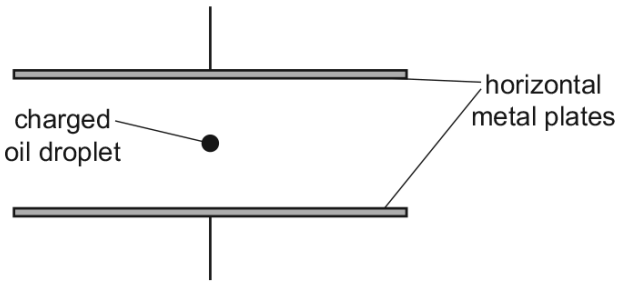
B $1.4 \times 10^2\,\text{N C}^{-1}$ from Q towards P

C $1.4 \times 10^5\,\text{N C}^{-1}$ from P towards Q

D $1.4 \times 10^5\,\text{N C}^{-1}$ from Q towards P

1051. 9702_m17_qp_12 Q: 31

A constant potential difference is applied between two horizontal metal plates. A charged oil droplet is held stationary by the electric field between the plates.



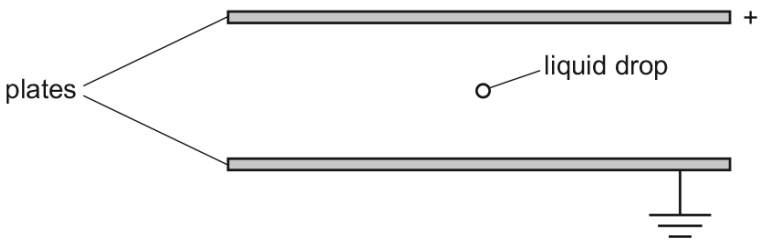
As some of the oil evaporates, the droplet loses mass and starts to accelerate. Its charge remains constant.

In which direction does the droplet accelerate, and which change needs to be made to the separation of the plates in order to stop this acceleration?

	direction of acceleration	separation of the plates
A	downwards	decrease
B	downwards	increase
C	upwards	decrease
D	upwards	increase

1052. 9702_s17_qp_11 Q: 31

The diagram shows two parallel horizontal metal plates. The top plate is positively charged and the bottom plate is earthed.



A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

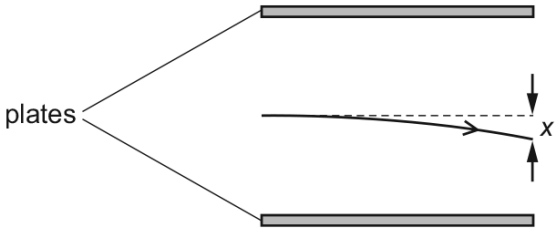
The acceleration of free fall is g and the electric field strength is E.

What is the polarity of the charge on the drop, and the ratio of charge to mass of the drop?

	polarity	$\frac{\text{charge}}{\text{mass}}$
A	negative	$\frac{E}{g}$
B	negative	$\frac{g}{E}$
C	positive	$\frac{E}{g}$
D	positive	$\frac{g}{E}$

1053. 9702_s17_qp_12 Q: 31

The path of an electron with initial speed v in the uniform electric field between two parallel plates is shown.



The vertical deflection x is measured at the right-hand edge of the plates.

The distance between the plates is halved. The potential difference between the plates remains the same.

What will be the new deflection of the electron with the same initial speed v?

A x **B** $\sqrt{2}x$ **C** $2x$ **D** $4x$

1054. 9702_s17_qp_13 Q: 30

In a uniform electric field, which statement is correct?

A All charged particles experience the same force.

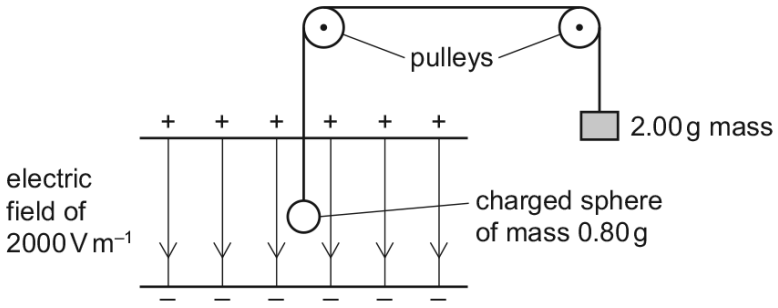
B All charged particles move with the same velocity.

C All electric field lines are directed towards positive charges.

D All electric field lines are parallel.

1055. 9702_w17_qp_11 Q: 31

A small charged sphere of mass 0.80 g hangs from a light thread inside a vertical uniform electric field of strength 2000 V m^{-1}. The thread passes over two frictionless pulleys and a mass of 2.00 g hangs on the other end.



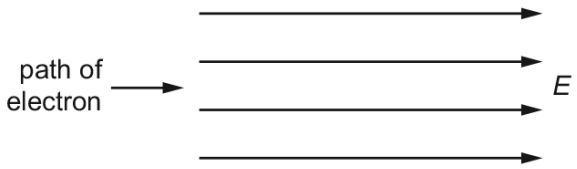
The sphere is in equilibrium.

What is the charge on the sphere?

A –5.9 μC **B** +0.60 μC **C** +5.9 μC **D** +9.8 μC

1056. 9702_w17_qp_11 Q: 32

An electron enters a region of space where there is a uniform electric field *E* as shown.



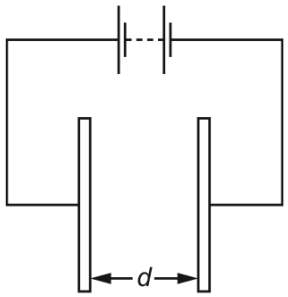
Initially, the electron is moving parallel to, and in the direction of, the electric field.

What is the subsequent path and change of speed of the electron caused by the electric field?

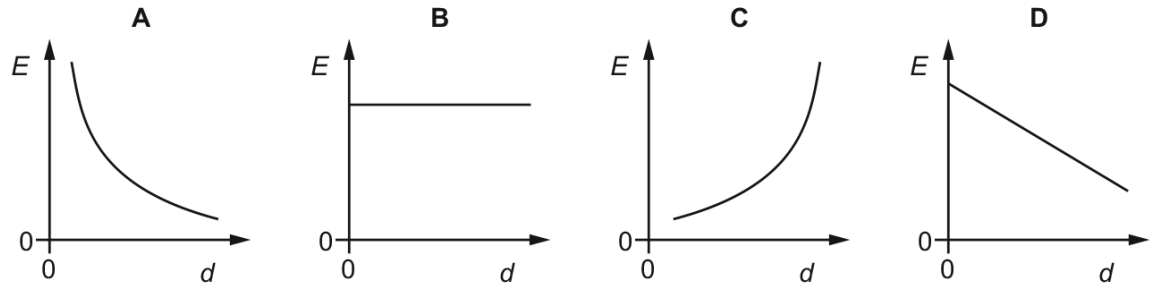
	path of electron	speed of electron
A	curved	decreases
B	curved	increases
C	linear	decreases
D	linear	increases

1057. 9702_w17_qp_12 Q: 31

The diagram shows two metal plates connected to a constant high voltage.

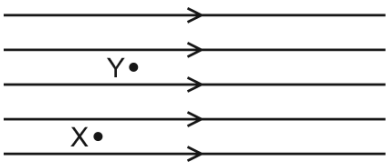


Which graph shows the variation of the electric field strength *E* midway between the two plates as the distance *d* between the two plates is increased?



1058. 9702_w17_qp_12 Q: 32

An electron moves between two points X and Y in a uniform electric field, as shown.



The distance between X and Y is 4.0 cm and the line XY is at an angle of 60° to the direction of the field.

The field exerts the only force on the electron.

The field strength is 100 N C^{-1}.

What is the change in the kinetic energy of the electron as it moves from X to Y?

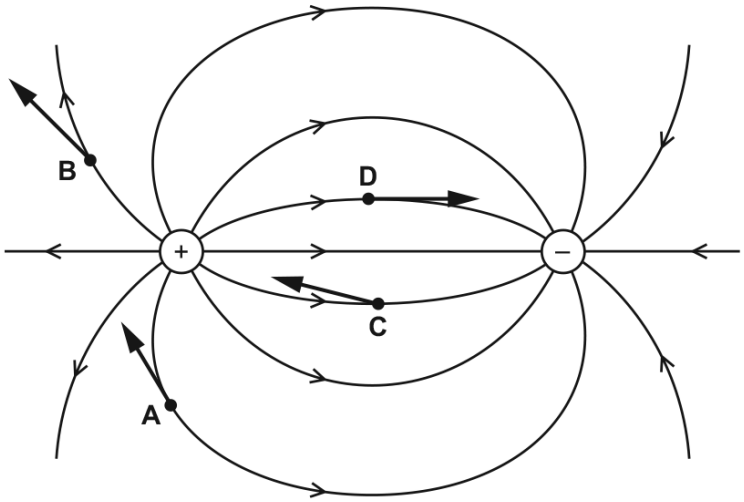
A −4 eV **B** −2 eV **C** +2 eV **D** +4 eV

1059. 9702_w17_qp_13 Q: 31

The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

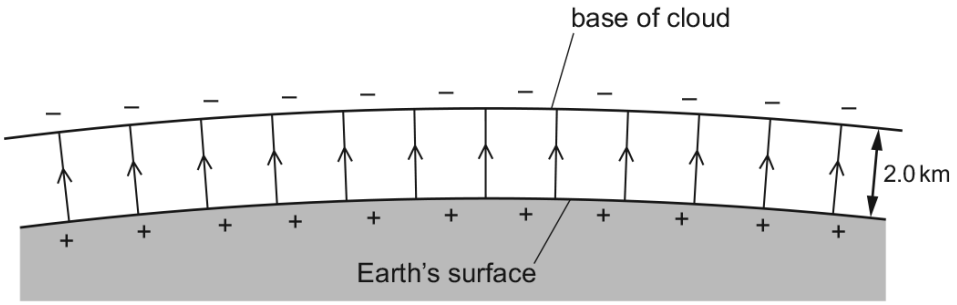
Four electrons **A**, **B**, **C** and **D** are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?



1060. 9702_w17_qp_13 Q: 32

Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kN C^{-1}. The diagram shows the electric field between the base of a cloud and the Earth's surface.



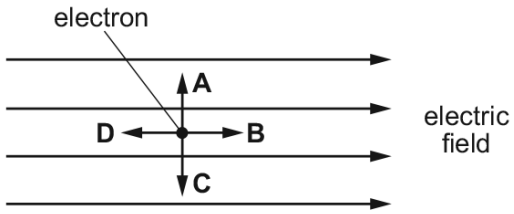
What is the minimum potential difference between the Earth and the base of a cloud, 2.0 km high, for lightning to occur?

A 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV

1061. 9702_m16_qp_12 Q: 27

The diagram shows an electron in a uniform electric field.

In which direction will the field accelerate the electron?



1062. 9702_m16_qp_12 Q: 28

The electric field strength at a certain distance from an isolated alpha particle is $3.0 \times 10^{7}\,\text{N C}^{-1}$.

What is the force on an electron when at that distance from the alpha particle?

A $4.8 \times 10^{-12}\,\text{N}$

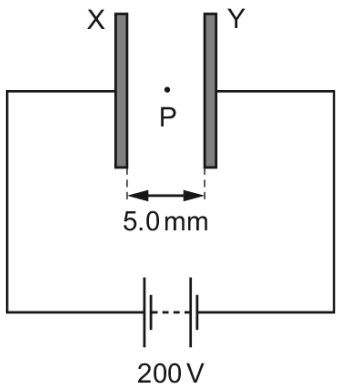
B $9.6 \times 10^{-12}\,\text{N}$

C $3.0 \times 10^{7}\,\text{N}$

D $6.0 \times 10^{7}\,\text{N}$

1063. 9702_m16_qp_12 Q: 29

Two large parallel plates X and Y are placed a distance of 5.0 mm apart and connected to the terminals of a 200 V d.c. supply, as shown.



A small oil drop at P carries one excess electron.

What is the magnitude of the electrostatic force acting on the oil drop due to the electric field between the plates?

A 6.4×10^{-15} N

B 6.4×10^{-18} N

C 1.6×10^{-19} N

D 4.0×10^{-24} N

1064. 9702_s16_qp_11 Q: 28

A charged particle is moving in a uniform electric field.

For the motion of the particle due to the field, which quantity has a constant non-zero value?

A acceleration

B displacement

C rate of change of acceleration

D velocity

1065. 9702_s16_qp_12 Q: 30

Before a thunderstorm, the hairs on your head sometimes stand on end.

A hair with mass 0.50 mg and charge 1.0 pC is supported by a force due to an electric field. Ignore any forces other than the weight of the hair and the electric force.

What is the electric field strength?

A $4.9 \times 10^{3}\,\text{N C}^{-1}$

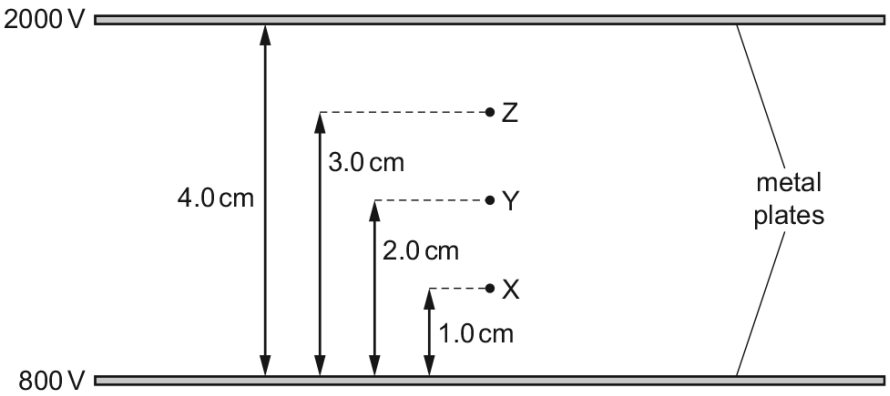
B $4.9 \times 10^{5}\,\text{N C}^{-1}$

C $4.9 \times 10^{6}\,\text{N C}^{-1}$

D $4.9 \times 10^{9}\,\text{N C}^{-1}$

1066. 9702_s16_qp_12 Q: 31

Two parallel metal plates, 4.0 cm apart, are at electric potentials of 800 V and 2000 V. Points X, Y and Z are situated in the space between the plates at distances of 1.0 cm, 2.0 cm and 3.0 cm from the lower plate.



What is the electric field strength, in V m^{-1}, at X, Y and Z?

	X	Y	Z
A	300	600	900
B	1100	1400	1700
C	3.0×10^{4}	3.0×10^{4}	3.0×10^{4}
D	5.0×10^{4}	5.0×10^{4}	5.0×10^{4}

1067. 9702_s16_qp_13 Q: 30

An electron is in an electric field of strength $5 \times 10^4\,\text{V m}^{-1}$. The field is the only influence on the electron.

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

A the force on the electron

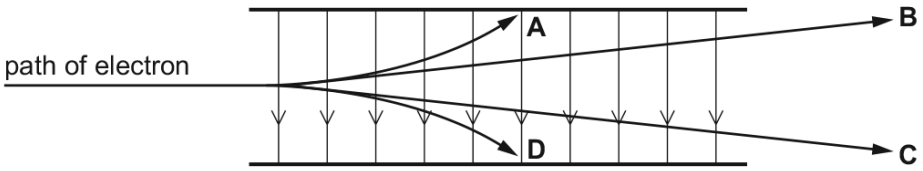
B the momentum of the electron

C the kinetic energy of the electron

D the speed of the electron

1068. 9702_w16_qp_11 Q: 30

Which path shows a possible movement of an electron in the electric field shown?



1069. 9702_w16_qp_11 Q: 32

Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of –80 V.

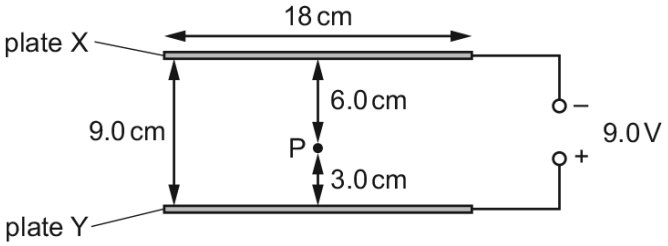


Which potential should be applied to the upper plate to create an electric field of strength $60\,000\,\text{V m}^{-1}$ upwards in the space between the plates?

A –320 V **B** –160 V **C** +160 V **D** +320 V

1070. 9702_w16_qp_12 Q: 30

Two parallel circular metal plates X and Y, each of diameter 18 cm, have a separation of 9.0 cm. A potential difference of 9.0 V is applied between them.



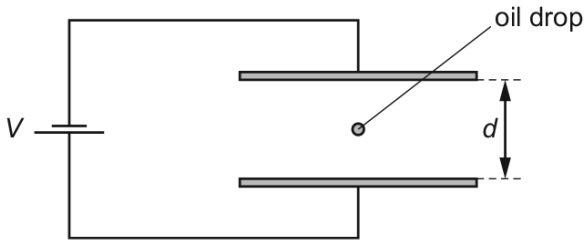
Point P is 6.0 cm from the surface of plate X and 3.0 cm from the surface of plate Y.

What is the electric field strength at P?

A $50\,\text{N C}^{-1}$ **B** $100\,\text{N C}^{-1}$ **C** $150\,\text{N C}^{-1}$ **D** $300\,\text{N C}^{-1}$

1071. 9702_w16_qp_12 Q: 31

An oil drop has mass m and charge q. The drop is held stationary in an electric field between two parallel horizontal plates, distance d apart, as shown.



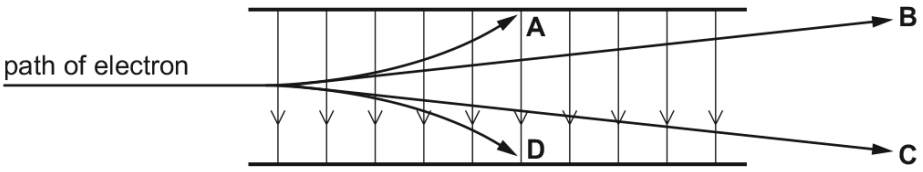
The potential difference between the plates is V and the acceleration of free fall is g.

What is the charge-to-mass ratio $\frac{q}{m}$ of the oil drop?

A $\frac{gd}{V}$ **B** $\frac{V}{dg}$ **C** $\frac{gV}{d}$ **D** $\frac{d}{Vg}$

1072. 9702_w16_qp_13 Q: 30

Which path shows a possible movement of an electron in the electric field shown?



1073. 9702_w16_qp_13 Q: 32

Two large horizontal metal plates are separated by 4 mm. The lower plate is at a potential of –80 V.



Which potential should be applied to the upper plate to create an electric field of strength 60 000 V m^{-1} upwards in the space between the plates?

A –320 V **B** –160 V **C** +160 V **D** +320 V

1074. 9702_s15_qp_11 Q: 31

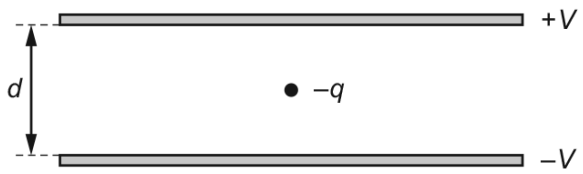
Two parallel metal plates, a distance of 2 mm apart, have a potential difference of 1000 V across them.

What is the electric field strength between the plates?

A 500 V m^{-1} **B** 50 000 V m^{-1} **C** 50 000 N C^{-1} **D** 500 000 N C^{-1}

1075. 9702_s15_qp_11 Q: 32

An oil droplet has charge $-q$ and is situated between two horizontal metal plates as shown in the diagram.



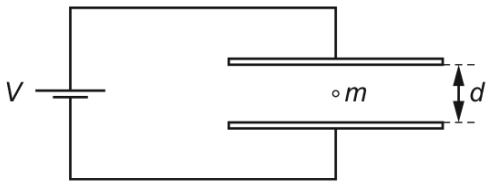
The separation of the plates is d. The droplet is observed to be stationary when the upper plate is at potential $+V$ and the lower plate is at potential $-V$.

For this to occur, what is the weight of the droplet?

A $\frac{Vq}{d}$ **B** $\frac{2Vq}{d}$ **C** $\frac{Vd}{q}$ **D** $\frac{2Vd}{q}$

1076. 9702_s15_qp_12 Q: 30

A charged oil drop of mass m, with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d.



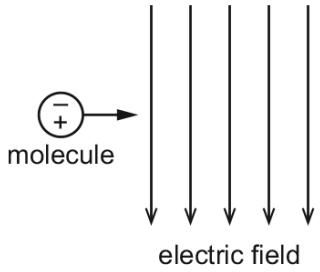
The voltage between the plates is V, the elementary charge is e and the acceleration of free fall is g.

What is the value of n?

A $\frac{eV}{mgd}$ **B** $\frac{mgd}{eV}$ **C** $\frac{meV}{gd}$ **D** $\frac{gd}{meV}$

1077. 9702_s15_qp_13 Q: 30

A molecule behaves as an electric dipole consisting of two equal point charges, of opposite sign, separated by a fixed distance. The molecule moves with constant horizontal velocity as it enters a vertical uniform electric field, as shown.



The positive and negative charges of the molecule enter the field at the same time.

Which row describes the velocity of the molecule in the field?

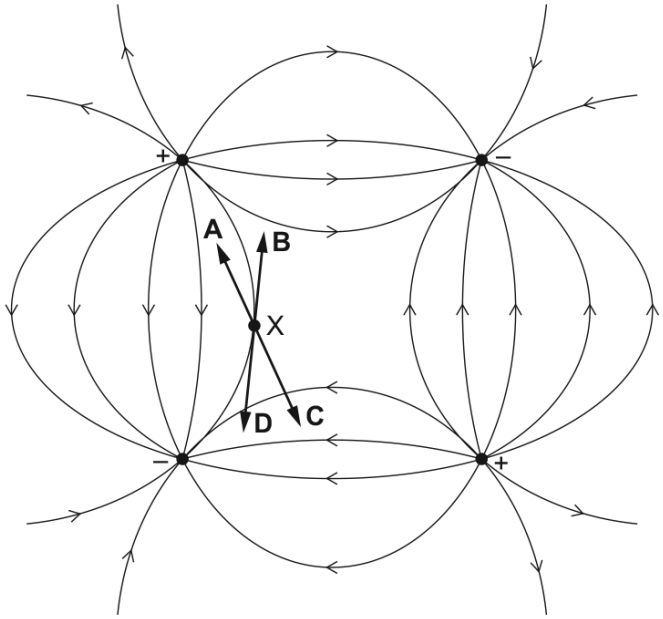
	horizontal component of velocity	vertical component of velocity
A	constant	increases
B	constant	zero
C	increases	increases
D	increases	zero

10.3 Electric forces between point charges

1078. 9702_w16_qp_11 Q: 31

The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

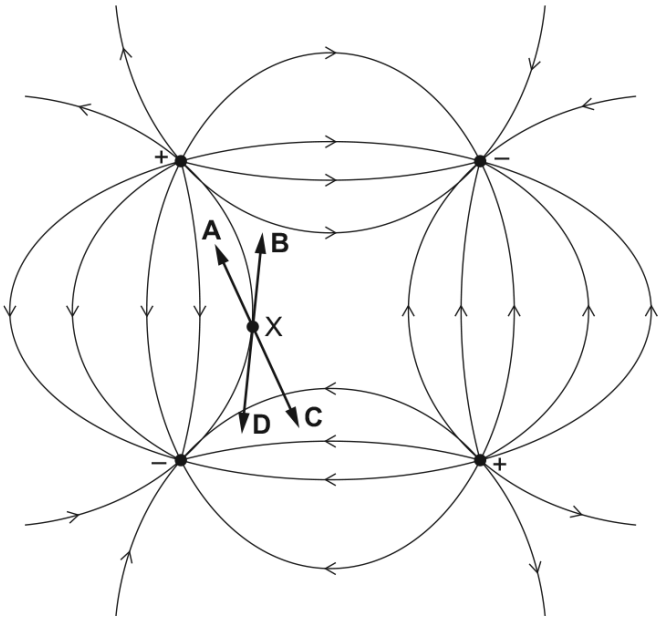
In which direction does the force act on an electron at point X?



1079. 9702_w16_qp_13 Q: 31

The diagram shows an electric field pattern caused by two positive and two negative point charges of equal magnitude placed at the four corners of a square.

In which direction does the force act on an electron at point X?



Chapter 10

Electric fields

STEMUP.CO.UK

10.1 Concept of an electric field

186. 9702_m17_qp_22 Q: 5

An electron is travelling in a straight line through a vacuum with a constant speed of $1.5 \times 10^{7}\,\text{m s}^{-1}$. The electron enters a uniform electric field at point A, as shown in Fig. 5.1.

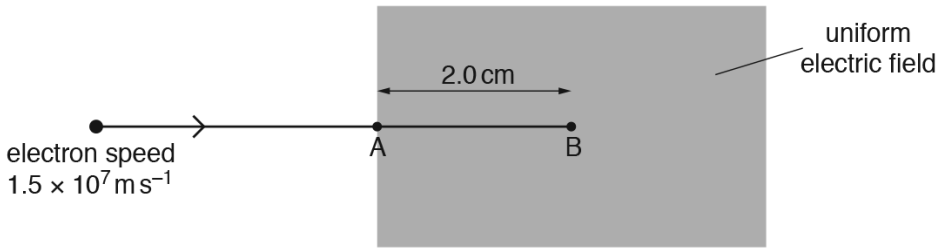


Fig. 5.1

The electron continues to move in the same direction until it is brought to rest by the electric field at point B. Distance AB is 2.0 cm.

(a) State the direction of the electric field.

.....[1]

(b) Calculate the magnitude of the deceleration of the electron in the field.

deceleration = ...m s^{-2} [2]

(c) Calculate the electric field strength.

electric field strength = ...V m^{-1} [3]

(d) The electron is at point A at time $t = 0$.

On Fig. 5.2, sketch the variation with time t of the velocity v of the electron until it reaches point B. Numerical values of v and t do not need to be shown.

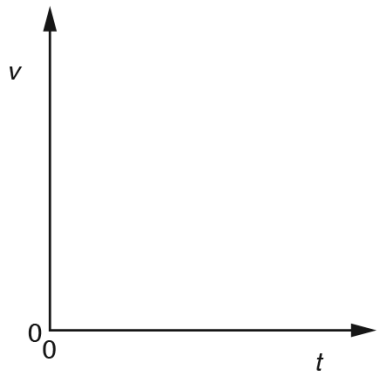


Fig. 5.2

[1]

[Total: 7]

187. 9702_s17_qp_23 Q: 3

(a) Define *electric field strength.*

.....

.....[1]

(b) An electron is accelerated from point A to point B by a uniform electric field, as illustrated in Fig. 3.1.

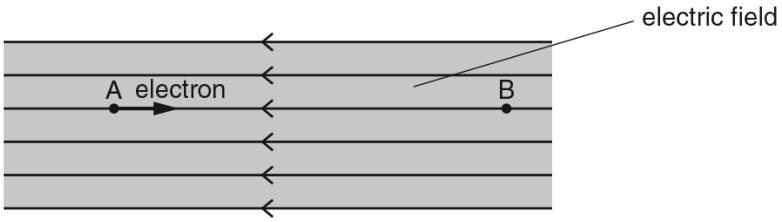


Fig. 3.1

The distance between A and B is 12 mm. The velocity of the electron at A is 2.5 km s^{-1} and at B is 18 Mm s^{-1}.

Calculate

(i) the acceleration of the electron,

acceleration = ...m s^{-2} [2]

(ii) the change in kinetic energy of the electron,

change in kinetic energy = ...J [3]

(iii) the electric field strength.

electric field strength = ... $V\,m^{-1}$ [3]

(c) An α-particle moves from A to B in the electric field in **(b)**.

Describe and explain how the change in the kinetic energy of the α-particle compares with that of the electron. Numerical values are not required.

.....

.....

.....

.....

.....[3]

[Total: 12]

10.2 Uniform electric fields

188. 9702_m19_qp_22 Q: 4

(a) Define *electric field strength*.

.....

.....[1]

(b) Two very small metal spheres X and Y are connected by an insulating rod of length 72 mm. A side view of this arrangement is shown in Fig. 4.1.

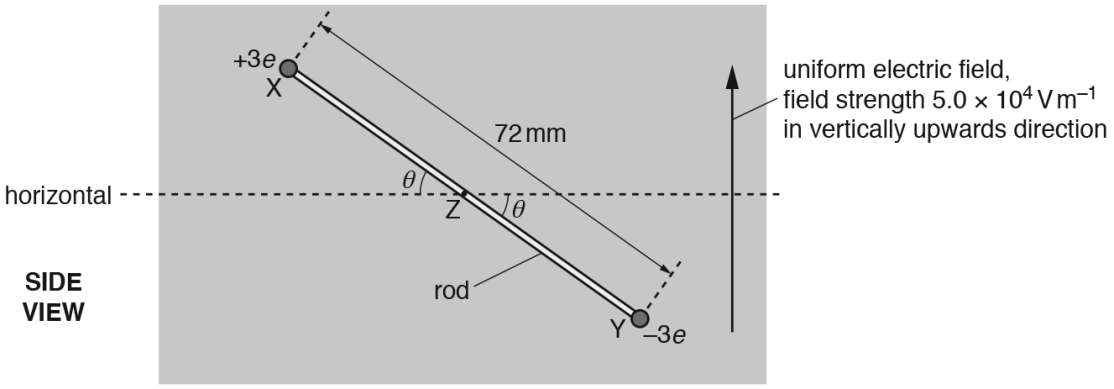


Fig. 4.1 (not to scale)

Sphere X has a charge of +3*e* and sphere Y has a charge of –3*e*, where *e* is the elementary charge. The rod is held at its mid point Z at an angle θ to the horizontal. The rod and spheres have negligible mass and are in a uniform electric field. The electric field strength is $5.0 \times 10^4\,\text{V m}^{-1}$. The direction of this field is vertically upwards.

(i) The electric field is produced by applying a potential difference of 4.0 kV between two charged parallel metal plates.

1. Calculate the separation between the plates.

separation = ... m [2]

2. Describe the arrangement of the two plates. Include in your answer a statement of the sign of the charge on each plate. You may draw on Fig. 4.1.

.....

.....

.....

.....[2]

(ii) Determine the magnitude and direction of the force on sphere Y.

magnitude = ... N

direction .....
[2]

(iii) The electric forces acting on the two spheres form a couple. This couple acts on the rod with a torque of 6.2×10^{-16} N m.

Calculate the angle θ of the rod to the horizontal.

θ = ... ° [2]

[Total: 9]

189. 9702_s19_qp_21 Q: 4

(a) A spherical oil drop has a radius of 1.2×10^{-6} m. The density of the oil is 940 kg m^{-3}.

(i) Show that the mass of the oil drop is 6.8×10^{-15} kg.

[2]

(ii) The oil drop is charged. Explain why it is impossible for the magnitude of the charge to be 8.0×10^{-20} C.

.....

.....[1]

(b) The charged oil drop in **(a)** is in a vacuum between two horizontal metal plates, as illustrated in Fig. 4.1.

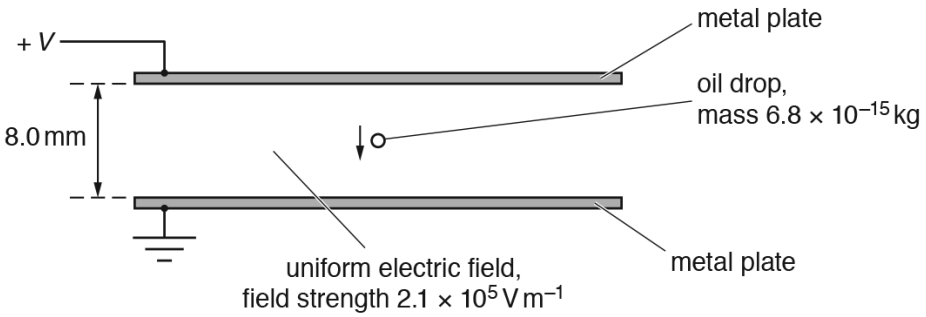


Fig. 4.1

The plates are separated by a distance of 8.0 mm. The electric field between the plates is uniform and has a field strength of 2.1×10^5 V m^{-1}.

The oil drop moves vertically downwards with a constant speed.

(i) Calculate the potential difference V between the plates.

V = ... V [2]

(ii) Explain how the motion of the oil drop shows that it is in equilibrium.

.....

.....[1]

(iii) Determine the charge on the oil drop.

charge = ... C

sign of charge .....
[3]

(c) The magnitude of the potential difference between the plates in **(b)** is decreased.

(i) Explain why the oil drop accelerates downwards.

.....

.....

.....

.....[2]

(ii) Describe the change to the pattern of the field lines (lines of force) representing the uniform electric field as the potential difference decreases.

.....

.....[1]

(d) Two types of force, X and Y, can act on an oil drop when it is in air, but cannot act on an oil drop when it is in a vacuum. Force X can act on an oil drop when it is stationary or when it is moving. Force Y can only act on an oil drop when it is moving.

State the name of:

(i) force X

.....[1]

(ii) force Y.

.....[1]

[Total: 14]

190. 9702_s19_qp_23 Q: 4

Two vertical metal plates in a vacuum are separated by a distance of 0.12 m.
Fig. 4.1 shows a side view of this arrangement.

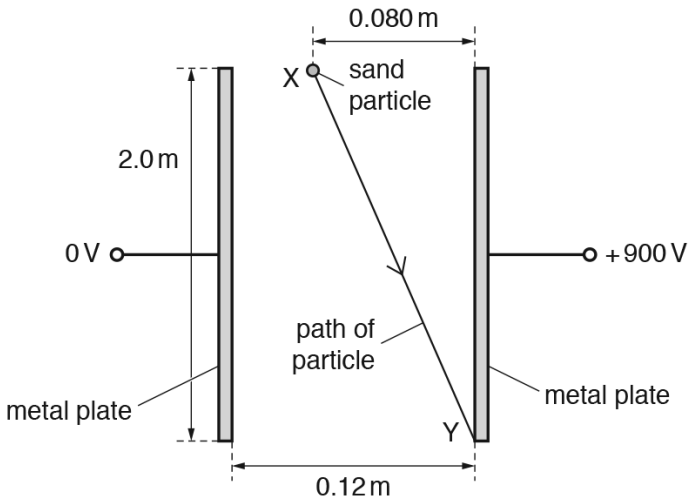


Fig. 4.1 (not to scale)

Each plate has a length of 2.0 m. The potential difference between the plates is 900 V. The electric field between the plates is uniform.

A negatively charged sand particle is released from rest at point X, which is a horizontal distance of 0.080 m from the top of the positively charged plate. The particle then travels in a straight line and collides with the positively charged plate at its lowest point Y, as illustrated in Fig. 4.1.

(a) Describe the pattern of the field lines (lines of force) between the plates.

.....

.....

.....[2]

(b) State the names of the **two** forces acting on the particle as it moves from X to Y.

.....[1]

(c) By considering the vertical motion of the sand particle, show that the time taken for the particle to move from X to Y is 0.64 s.

[2]

(d) Calculate the horizontal component of the acceleration of the particle.

horizontal component of acceleration = ... $m\,s^{-2}$ [2]

(e) **(i)** Calculate the magnitude of the electric field strength.

electric field strength = ... $N\,C^{-1}$ [2]

(ii) The sand particle has mass m and charge q. Use your answers in **(d)** and **(e)(i)** to determine the ratio $\frac{q}{m}$.

ratio = ... $C\,kg^{-1}$ [2]

(f) Another particle has a smaller magnitude of the ratio $\frac{q}{m}$ than the sand particle. This particle is also released from point X.

For the movement of this particle, state the effect, if any, of the decreased magnitude of the ratio on:

(i) the vertical component of the acceleration

.....[1]

(ii) the horizontal component of the acceleration.

.....[1]

[Total: 13]

191. 9702_w19_qp_21 Q: 2

A small charged glass bead of weight 5.4×10^{-5} N is initially at rest at point A in a vacuum. The bead then falls through a uniform horizontal electric field as it moves in a straight line to point B, as illustrated in Fig. 2.1.

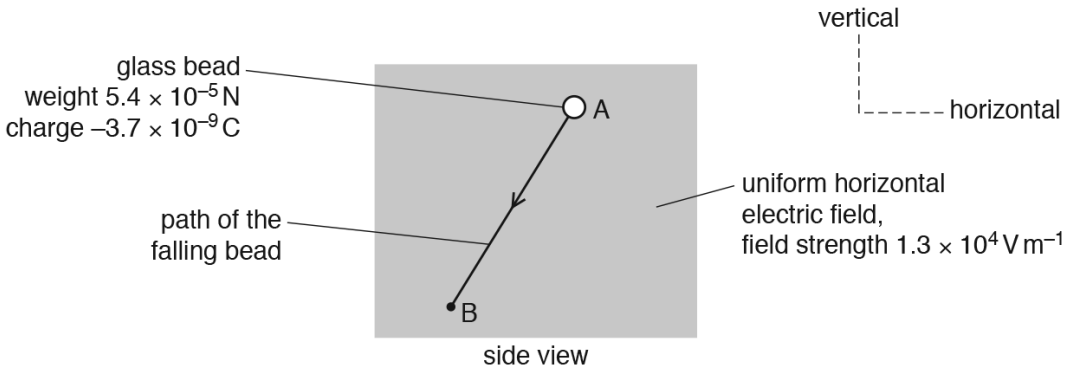


Fig. 2.1 (not to scale)

The electric field strength is 1.3×10^4 V m^{-1}. The charge on the bead is -3.7×10^{-9} C.

(a) Describe how two metal plates could be used to produce the electric field. Numerical values are not required.

.....

.....

..... [2]

(b) Determine the magnitude of the electric force acting on the bead.

electric force = ... N [2]

(c) Use your answer in **(b)** and the weight of the bead to show that the resultant force acting on it is 7.2×10^{-5} N.

[1]

(d) Explain why the resultant force on the bead of 7.2×10^{-5} N is constant as the bead moves along path AB.

.....

.....

.....

..... [2]

(e) **(i)** Calculate the magnitude of the acceleration of the bead along the path AB.

acceleration = ... $m\,s^{-2}$ [2]

(ii) The path AB has length 0.58 m.

Use your answer in **(i)** to determine the speed of the bead at point B.

speed = ... $m\,s^{-1}$ [2]

[Total: 11]

192. 9702_w19_qp_23 Q: 3

(a) State the property of an object that experiences a force when the object is placed in:

(i) a gravitational field

..... [1]

(ii) an electric field.

..... [1]

(b) A potential difference of 1.2×10^3 V is applied between a pair of horizontal metal plates in a vacuum, as shown in Fig. 3.1.

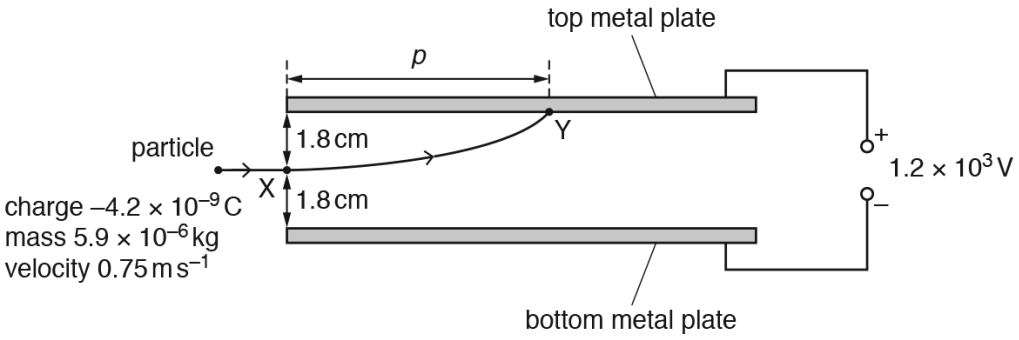


Fig. 3.1 (not to scale)

The separation of the plates is 3.6 cm. The electric field between the plates is uniform.

A particle of mass 5.9×10^{-6} kg and charge -4.2×10^{-9} C enters the field at point X with a horizontal velocity of 0.75 m s^{-1} along a line midway between the two plates.
The particle is deflected by the field and hits the top plate at point Y.

(i) Calculate the magnitude of the electric force acting on the particle in the field.

electric force = ... N [3]

(ii) By considering the resultant vertical force acting on the particle, show that the acceleration of the particle in the electric and gravitational fields is $14\,m\,s^{-2}$.

[4]

(iii) Determine:

1. the time taken for the particle to move from X to Y

time taken = ... s [2]

2. the distance p of point Y from the left-hand edge of the top plate.

p = ... m [1]

[Total: 12]

193. 9702_w17_qp_21 Q: 6

(a) Define *electric field strength*.

.....

.....[1]

(b) Two parallel metal plates in a vacuum are separated by a distance of 15 mm, as shown in Fig. 6.1.

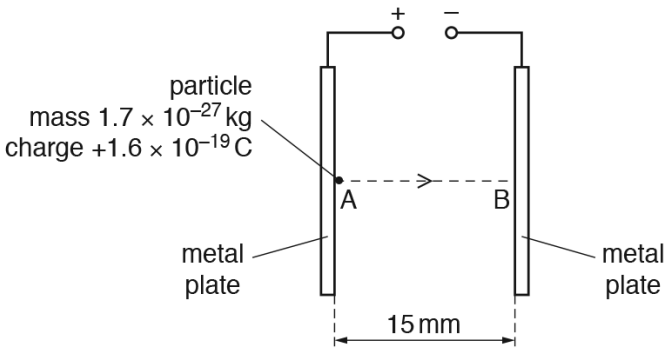


Fig. 6.1

A uniform electric field is produced between the plates by applying a potential difference between them.

A particle of mass 1.7×10^{-27} kg and charge $+1.6 \times 10^{-19}$ C is initially at rest at point A on one plate. The particle is moved by the electric field to point B on the other plate. The particle reaches point B with kinetic energy 2.4×10^{-16} J.

(i) Calculate the speed of the particle at point B.

speed = ... $m\,s^{-1}$ [2]

(ii) State the work done by the electric field to move the particle from A to B.

work done = ... J [1]

(iii) Use your answer in **(ii)** to determine the force on the particle.

force = ... N [2]

(iv) Determine the potential difference between the plates.

potential difference = ... V [3]

(v) On Fig. 6.2, sketch a graph to show the variation of the kinetic energy of the particle with the distance x from point A along the line AB.
Numerical values for the kinetic energy are not required.

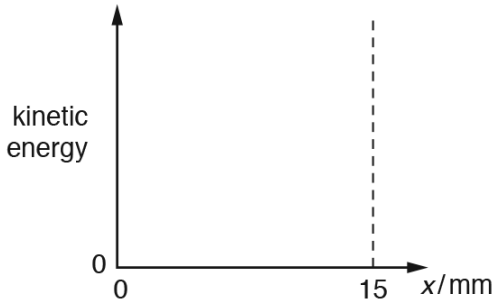


Fig. 6.2

[1]

[Total: 10]

194. 9702_w17_qp_23 Q: 5

(a) Define *electric field strength*.

.....

.....[1]

(b) Two parallel metal plates in a vacuum are separated by 0.045 m. A potential difference V is applied between the plates, as shown in Fig. 5.1.

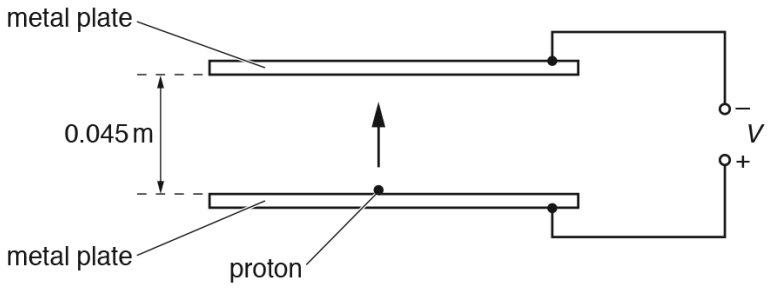


Fig. 5.1

A proton is initially at rest on the surface of the positive plate. The proton in the uniform electric field takes a time of 1.5×10^{-7} s to reach the negative plate.

(i) Show that the acceleration of the proton is $4.0 \times 10^{12}\,\text{m s}^{-2}$.

[2]

(ii) Calculate the electric force on the proton.

force = ... N [1]

(iii) Use your answer in **(ii)** to determine

1. the electric field strength,

field strength = ... NC^{-1} [2]

2. the potential difference V between the plates.

V = ... V [2]

(c) An α particle is now accelerated between the two metal plates in **(b)** by the electric field.

Calculate the ratio

$$\frac{\text{acceleration of } \alpha \text{ particle}}{\text{acceleration of proton}}.$$

ratio = ...[2]

[Total: 10]

195. 9702_s16_qp_22 Q: 6

Two parallel vertical metal plates are connected to a power supply, as shown in Fig. 6.1.

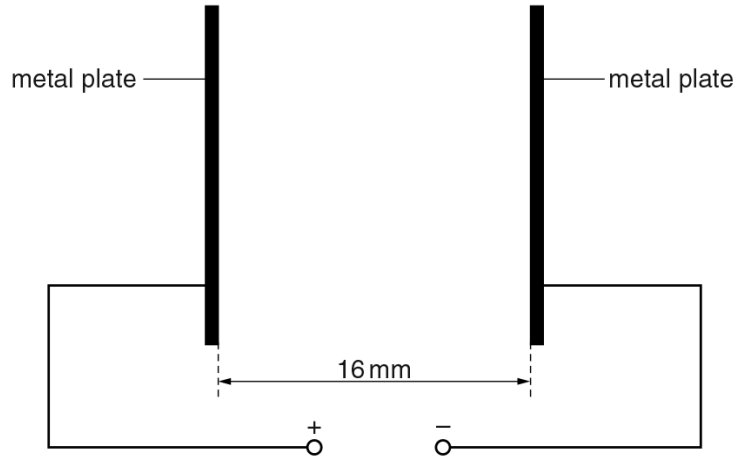


Fig. 6.1

The separation of the plates is 16 mm.

(a) On Fig. 6.1, draw at least six field lines to represent the electric field between the plates. [1]

(b) An α-particle travels in a vacuum between the two plates.

The electric field does work on the α-particle. The gain in kinetic energy of the α-particle is 15 keV.

Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ [4]

[Total: 5]

196. 9702_w16_qp_21 Q: 2

(a) Define *electric field strength*.

.....

.....[1]

(b) A potential difference of 2.5 kV is applied across a pair of horizontal metal plates in a vacuum, as shown in Fig. 2.1.

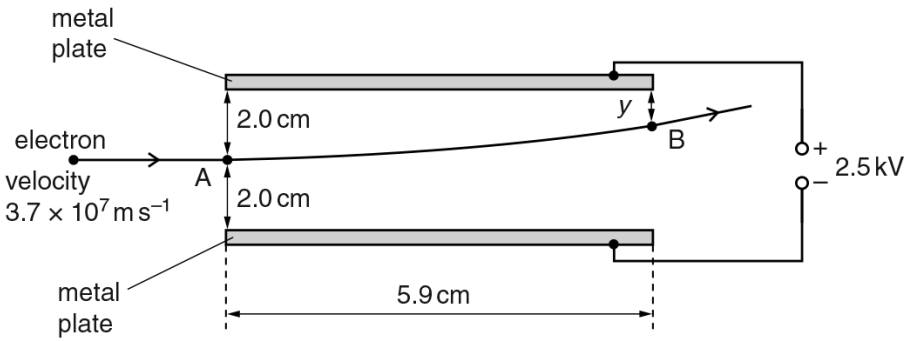


Fig. 2.1 (not to scale)

Each plate has a length of 5.9 cm. The separation of the plates is 4.0 cm. The arrangement produces a uniform electric field between the plates.
Assume the field does not extend beyond the edges of the plates.

An electron enters the field at point A with horizontal velocity $3.7 \times 10^7\,\text{m s}^{-1}$ along a line mid-way between the plates. The electron leaves the field at point B.

(i) Calculate the time taken for the electron to move from A to B.

time taken = ... s [1]

(ii) Calculate the magnitude of the electric field strength.

field strength = ... N C^{-1} [2]

(iii) Show that the acceleration of the electron in the field is $1.1 \times 10^{16}\,\text{m s}^{-2}$.

[2]

(iv) Use the acceleration given in **(iii)** and your answer in **(i)** to determine the vertical distance y between point B and the upper plate.

y = ... cm [3]

(v) Explain why the calculation in **(iv)** does not need to include the gravitational effects on the electron.

.....

.....[1]

(vi) The electron enters the field at time $t = 0$.

On Fig. 2.2, sketch graphs to show the variation with time t of

1. the horizontal component v_X of the velocity of the electron,

2. the vertical component v_Y of the velocity of the electron.

Numerical values are not required.

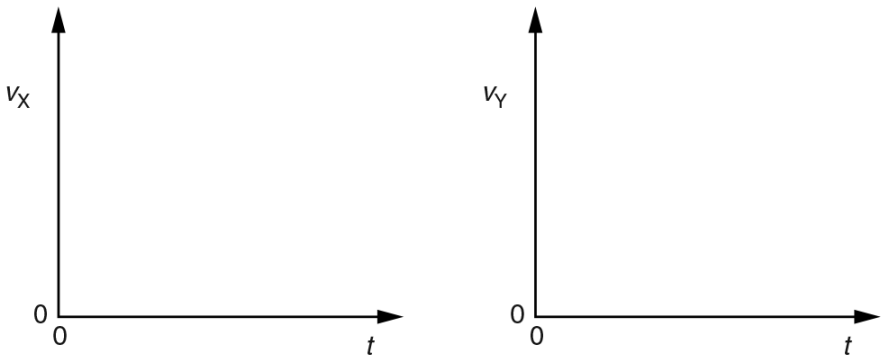


Fig. 2.2

[2]

[Total: 12]

197. 9702_w16_qp_23 Q: 2

(a) Define *electric field strength*.

.....

.....[1]

(b) A potential difference of 2.5 kV is applied across a pair of horizontal metal plates in a vacuum, as shown in Fig. 2.1.

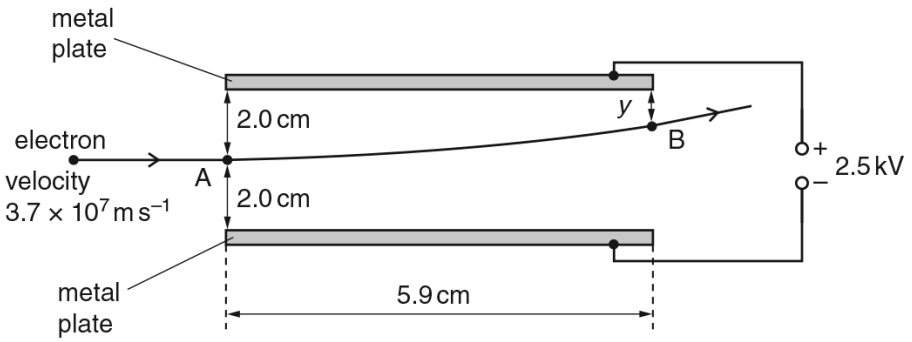


Fig. 2.1 (not to scale)

Each plate has a length of 5.9 cm. The separation of the plates is 4.0 cm. The arrangement produces a uniform electric field between the plates.
Assume the field does not extend beyond the edges of the plates.

An electron enters the field at point A with horizontal velocity $3.7 \times 10^7\,\text{m s}^{-1}$ along a line mid-way between the plates. The electron leaves the field at point B.

(i) Calculate the time taken for the electron to move from A to B.

time taken = ... s [1]

(ii) Calculate the magnitude of the electric field strength.

field strength = ... N C^{-1} [2]

(iii) Show that the acceleration of the electron in the field is $1.1 \times 10^{16}\,\text{m s}^{-2}$.

[2]

(iv) Use the acceleration given in **(iii)** and your answer in **(i)** to determine the vertical distance y between point B and the upper plate.

y = ... cm [3]

(v) Explain why the calculation in **(iv)** does not need to include the gravitational effects on the electron.

.....

.....[1]

(vi) The electron enters the field at time $t = 0$.

On Fig. 2.2, sketch graphs to show the variation with time t of

1. the horizontal component v_X of the velocity of the electron,

2. the vertical component v_Y of the velocity of the electron.

Numerical values are not required.

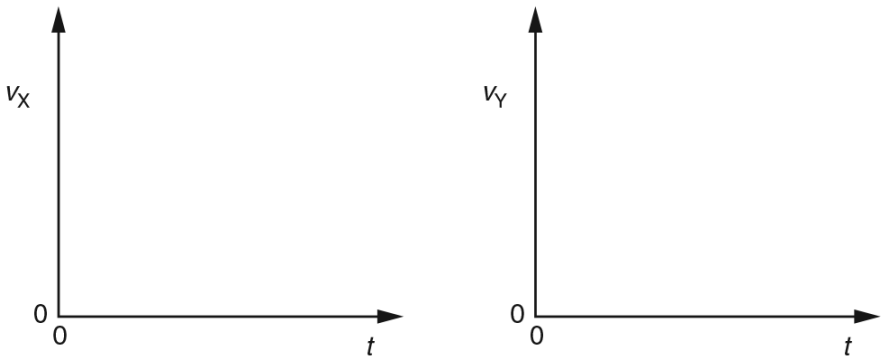


Fig. 2.2

[2]

[Total: 12]

198. 9702_s15_qp_21 Q: 7

(a) Explain what is meant by an *electric field*.

.....

.....[1]

(b) A uniform electric field is produced between two vertical metal plates AB and CD, as shown in Fig. 7.1.

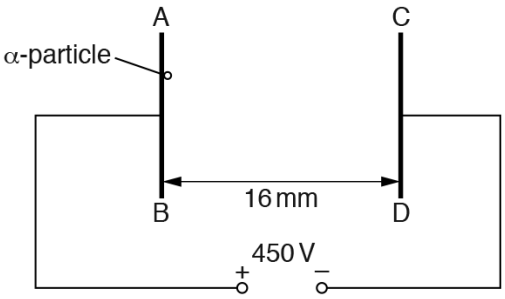


Fig. 7.1

The potential difference between the plates is 450 V and the separation of the plates is 16 mm.

An α-particle is accelerated from plate AB to plate CD.

(i) On Fig. 7.1, draw lines to represent the electric field between the plates. [2]

(ii) Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ [2]

(iii) Calculate the work done by the electric field on the α-particle as it moves from AB to CD.

work done = ... J [3]

(iv) A β-particle moves from AB to CD. Calculate the ratio

$$\frac{\text{work done by the electric field on the } \alpha\text{-particle}}{\text{work done by the electric field on the } \beta\text{-particle.}}$$

Show your working.

ratio = ... [1]

Chapter 8

Electric fields

STEMUP.CO.UK

172. 9702_s17_qp_41 Q: 5

An α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 5.1.



Fig. 5.1

The gold nucleus has charge $79e$.
The gold nucleus and the α-particle may be assumed to behave as point charges.
At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(a) The α-particle does not collide with the gold nucleus. Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m.

[3]

(b) Determine the acceleration of the α-particle for a separation of 4.7×10^{-14} m between the centres of the gold nucleus and of the α-particle.

acceleration = ... $m\,s^{-2}$ [3]

(c) In an α-particle scattering experiment, the beam of α-particles is incident on a very thin gold foil.
Suggest why the gold foil must be very thin.

.....

.....[1]

[Total: 7]

173. 9702_s20_qp_41 Q: 5

(a) State **one** similarity and **one** difference between the fields of force produced by an isolated point charge and by an isolated point mass.

similarity: .....

.....

difference: .....

.....

[2]

(b) An isolated solid metal sphere A of radius R has charge $+Q$, as illustrated in Fig. 5.1.

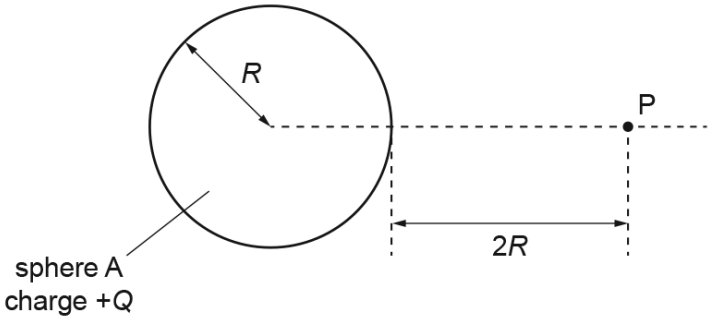


Fig. 5.1

A point P is distance $2R$ from the surface of the sphere.

Determine an expression that includes the terms R and Q for the electric field strength E at point P.

E = ... [2]

(c) A second identical solid metal sphere B is now placed near sphere A. The centres of the spheres are separated by a distance 6*R*, as shown in Fig. 5.2.

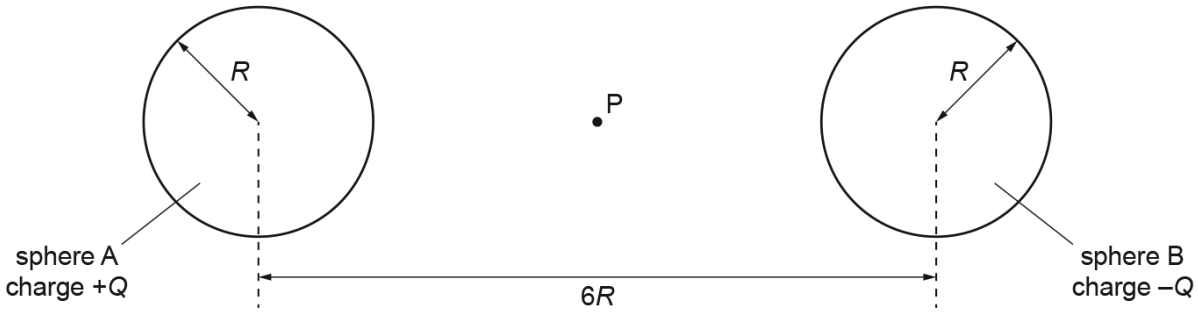


Fig. 5.2

Point P lies midway between spheres A and B.

Sphere B has charge –*Q*.

Explain why:

(i) the magnitude of the electric field strength at P is given by the sum of the magnitudes of the field strengths due to each sphere

.....

..... [1]

(ii) the electric field strength at point P due to the charged metal spheres is not, in practice, equal to 2*E*, where *E* is the electric field strength determined in **(b)**.

.....

.....

..... [2]

[Total: 7]

174. 9702_s20_qp_42 Q: 7

A metal sphere of radius *R* is isolated in space.

Point P is a distance *x* from the centre of the sphere, as illustrated in Fig. 7.1.

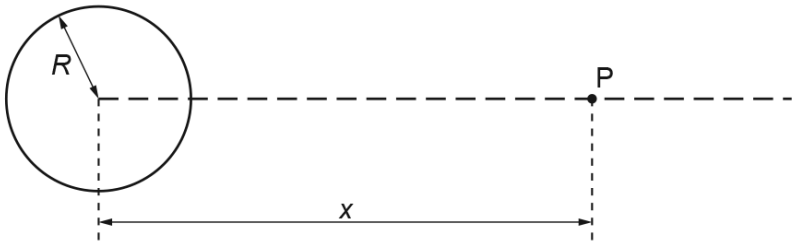


Fig. 7.1

The variation with distance *x* of the electric field strength *E* due to the charge on the sphere is shown in Fig. 7.2.

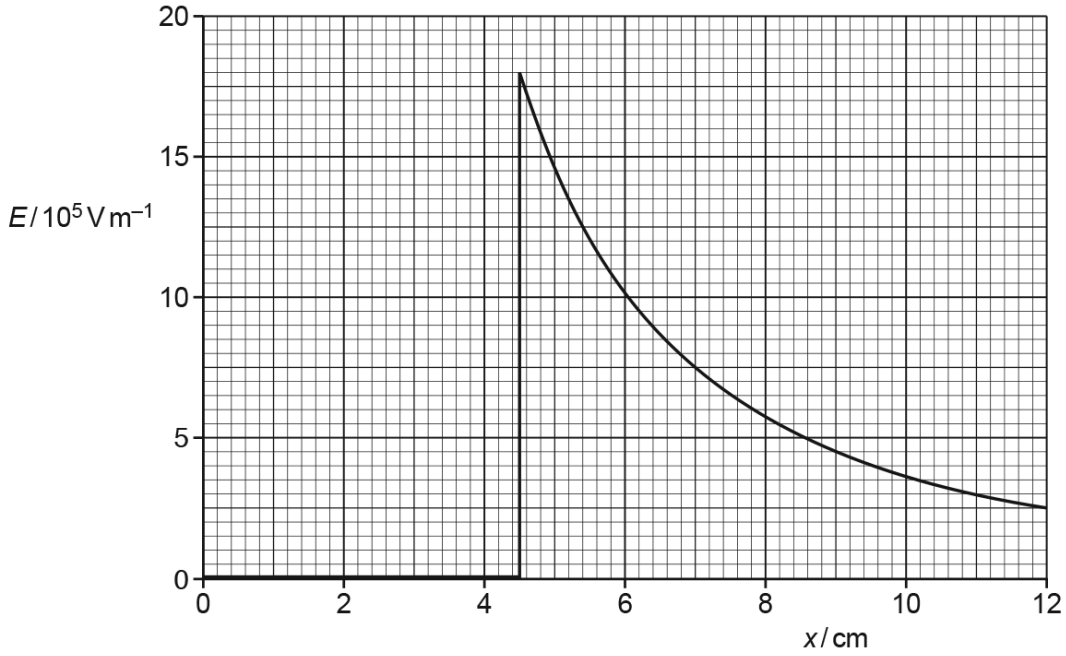


Fig. 7.2

(a) State what is meant by *electric field strength*.

.....

.....

..... [2]

(b) **(i)** Use Fig. 7.2 to determine the radius R of the sphere. Explain your working.

R = ... cm [2]

(ii) Use Fig. 7.2 to determine the charge Q on the sphere.

Q = ... C [3]

(c) An α-particle is situated a distance 8.0 cm from the centre of the sphere.

Calculate the acceleration of the α-particle.

acceleration = ... $m\,s^{-2}$ [3]

[Total: 10]

175. 9702_s20_qp_43 Q: 5

(a) State **one** similarity and **one** difference between the fields of force produced by an isolated point charge and by an isolated point mass.

similarity: .....

.....

difference: .....

.....

[2]

(b) An isolated solid metal sphere A of radius *R* has charge +*Q*, as illustrated in Fig. 5.1.

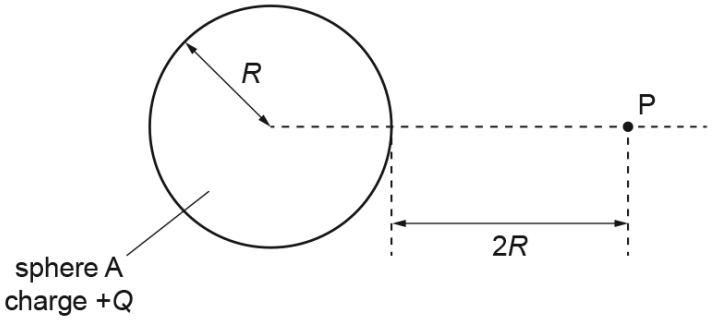


Fig. 5.1

A point P is distance 2*R* from the surface of the sphere.

Determine an expression that includes the terms *R* and *Q* for the electric field strength *E* at point P.

E = ... [2]

(c) A second identical solid metal sphere B is now placed near sphere A. The centres of the spheres are separated by a distance 6*R*, as shown in Fig. 5.2.

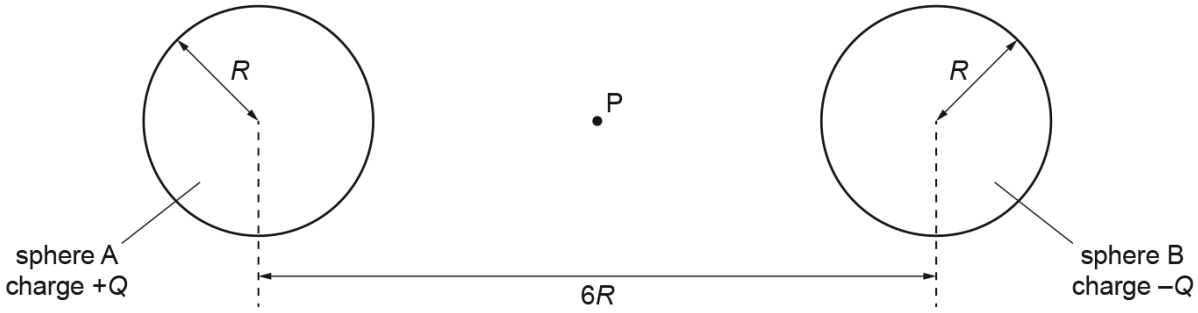


Fig. 5.2

Point P lies midway between spheres A and B.

Sphere B has charge –*Q*.

Explain why:

(i) the magnitude of the electric field strength at P is given by the sum of the magnitudes of the field strengths due to each sphere

.....

..... [1]

(ii) the electric field strength at point P due to the charged metal spheres is not, in practice, equal to 2*E*, where *E* is the electric field strength determined in **(b)**.

.....

.....

..... [2]

[Total: 7]

176. 9702_m19_qp_42 Q: 5

(a) State what is meant by an *electric field*.

.....

..... [1]

(b) An isolated solid metal sphere has radius R. The charge on the sphere is $+Q$ and the electric field strength at its surface is E.

On Fig. 5.1, draw a line to show the variation of the electric field strength with distance x from the centre of the solid sphere for values of x from $x = 0$ to $x = 3R$.

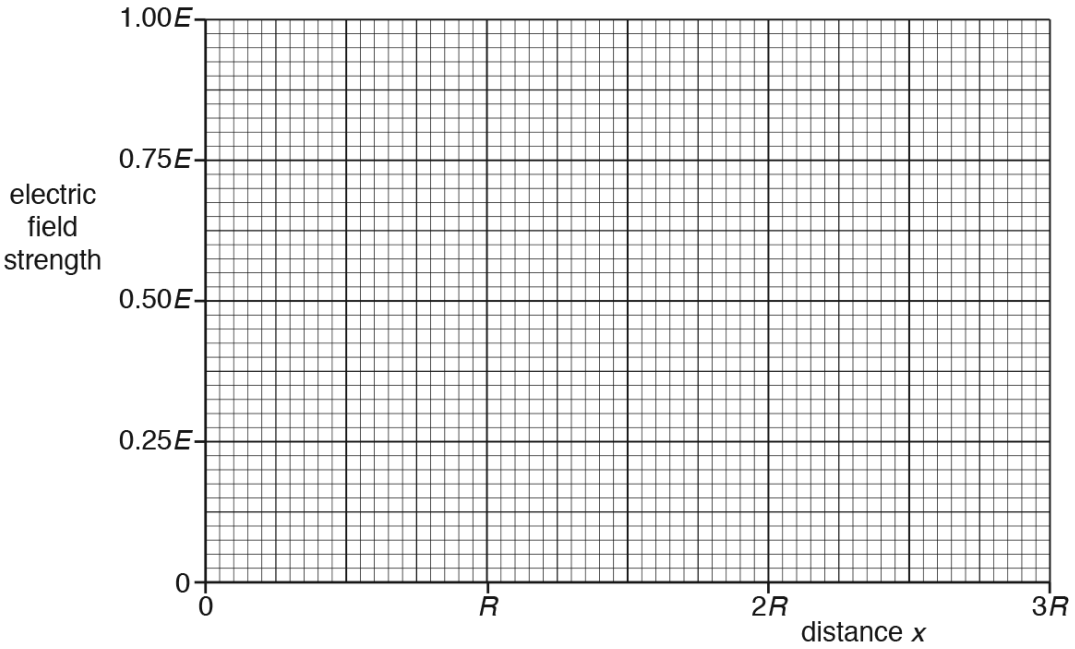


Fig. 5.1

[4]

(c) The sphere in **(b)** has radius $R = 0.26\,\text{m}$.

Electrical breakdown (a spark) occurs when the electric field strength at the surface of the sphere exceeds $2.0 \times 10^6\,\text{V m}^{-1}$.

Determine the maximum charge that can be stored on the sphere before electrical breakdown occurs.

charge = ... C [3]

[Total: 8]

177. 9702_s19_qp_41 Q: 5

(a) State what is meant by *electric field strength*.

.....

.....

..... [2]

(b) Two point charges A and B are situated a distance 15 cm apart in a vacuum, as illustrated in Fig. 5.1.

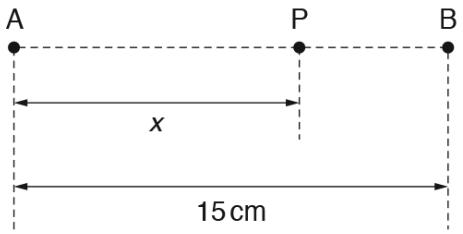


Fig. 5.1

Point P lies on the line joining the charges and is a distance x from charge A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 5.2.

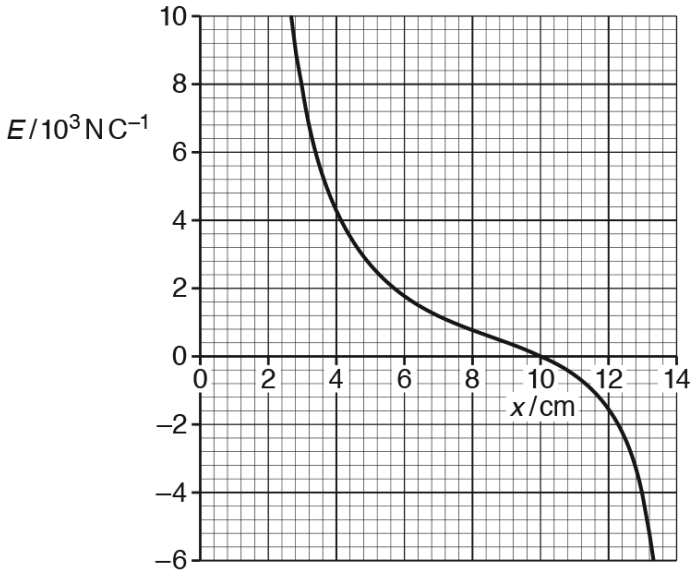


Fig. 5.2

(i) By reference to the direction of the electric field, state and explain whether the charges A and B have the same, or opposite, signs.

.....

.....

..... [2]

(ii) State why, although charge A is a point charge, the electric field strength between $x = 3\,\text{cm}$ and $x = 7\,\text{cm}$ does not obey an inverse-square law.

.....

..... [1]

(iii) Use Fig. 5.2 to determine the ratio

$$\frac{\text{magnitude of charge A}}{\text{magnitude of charge B}}.$$

ratio = ... [3]

[Total: 8]

178. 9702_s19_qp_43 Q: 5

(a) State what is meant by *electric field strength*.

.....

.....

..... [2]

(b) Two point charges A and B are situated a distance 15 cm apart in a vacuum, as illustrated in Fig. 5.1.

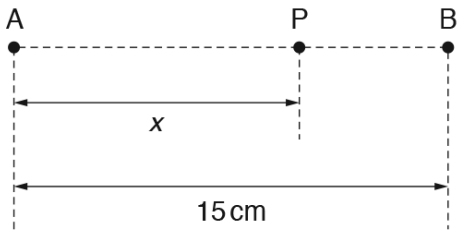


Fig. 5.1

Point P lies on the line joining the charges and is a distance x from charge A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 5.2.

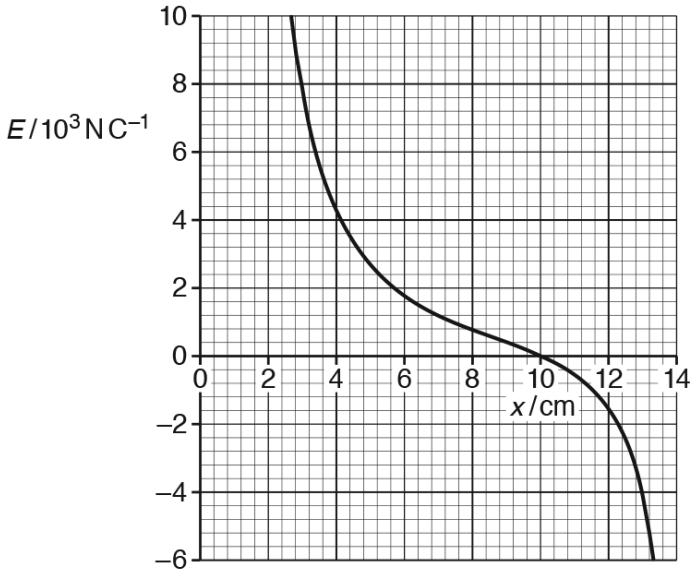


Fig. 5.2

(i) By reference to the direction of the electric field, state and explain whether the charges A and B have the same, or opposite, signs.

.....

.....

..... [2]

(ii) State why, although charge A is a point charge, the electric field strength between $x = 3\,\text{cm}$ and $x = 7\,\text{cm}$ does not obey an inverse-square law.

.....

..... [1]

(iii) Use Fig. 5.2 to determine the ratio

$$\frac{\text{magnitude of charge A}}{\text{magnitude of charge B}}.$$

ratio = ... [3]

[Total: 8]

179. 9702_w19_qp_41 Q: 6

(a) State an expression for the electric field strength E at a distance r from a point charge Q in a vacuum.
State the name of any other symbol used.

.....

.....

..... [2]

(b) Two point charges A and B are situated a distance 10.0 cm apart in a vacuum, as illustrated in Fig. 6.1.

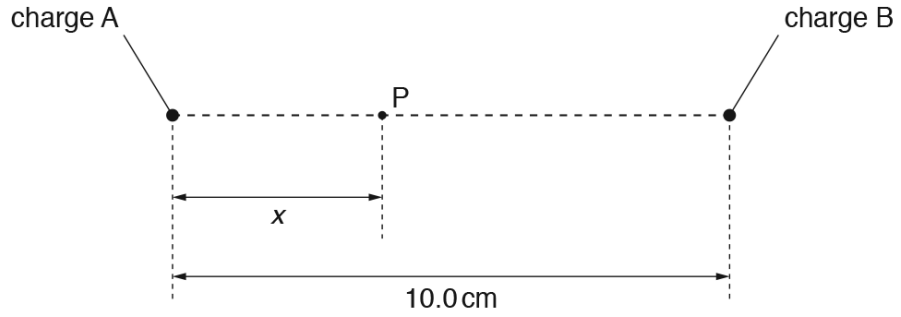


Fig. 6.1

A point P lies on the line joining the charges A and B. Point P is a distance x from A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 6.2.

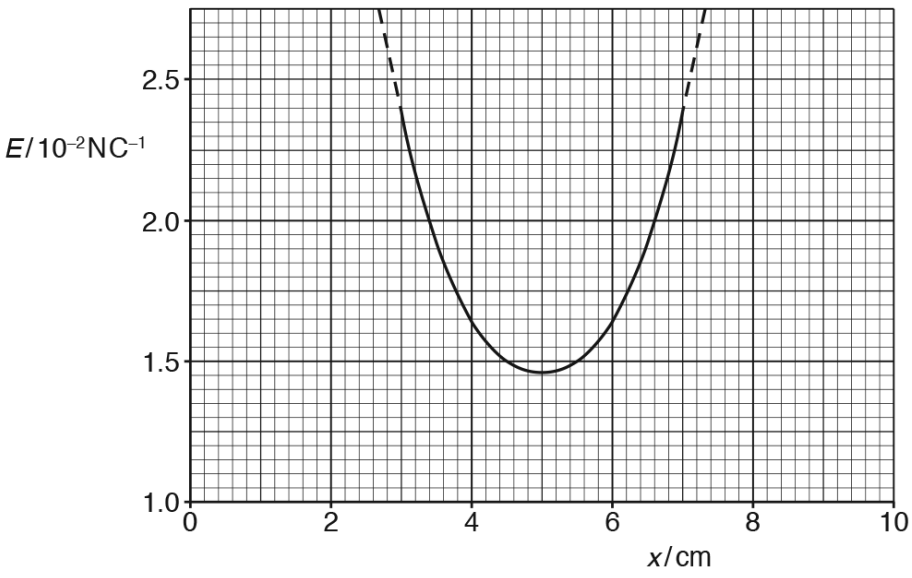


Fig. 6.2

State and explain whether the charges A and B:

(i) have the same, or opposite, signs

.....

.....

..... [2]

(ii) have the same, or different, magnitudes.

.....

.....

..... [2]

(c) An electron is situated at point P.

Without calculation, state and explain the variation in the magnitude of the acceleration of the electron as it moves from the position where $x = 3\,\text{cm}$ to the position where $x = 7\,\text{cm}$.

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

180. 9702_w19_qp_43 Q: 6

(a) State an expression for the electric field strength E at a distance r from a point charge Q in a vacuum.
State the name of any other symbol used.

.....

.....

..... [2]

(b) Two point charges A and B are situated a distance 10.0 cm apart in a vacuum, as illustrated in Fig. 6.1.

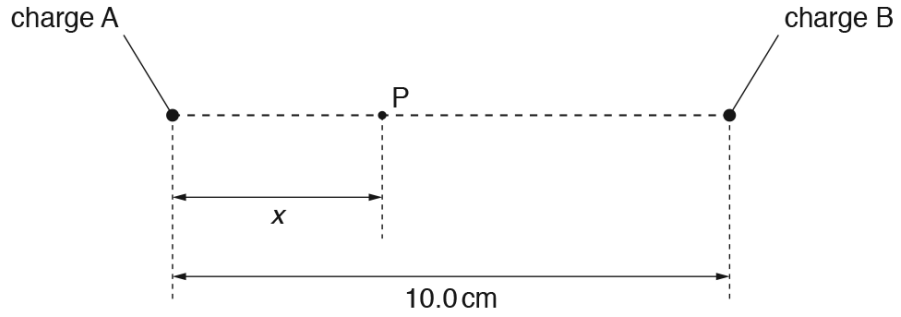


Fig. 6.1

A point P lies on the line joining the charges A and B. Point P is a distance x from A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 6.2.

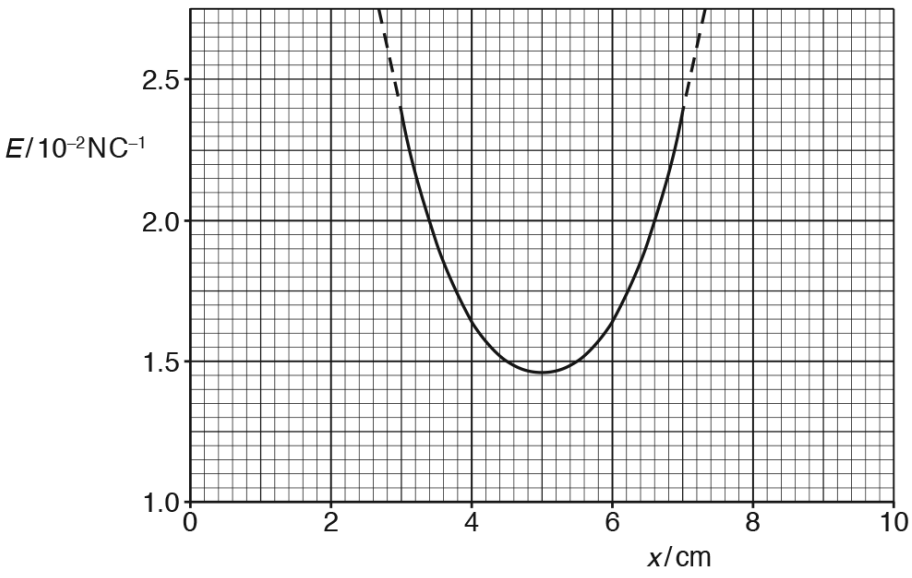


Fig. 6.2

State and explain whether the charges A and B:

(i) have the same, or opposite, signs

.....

.....

..... [2]

(ii) have the same, or different, magnitudes.

.....

.....

..... [2]

(c) An electron is situated at point P.

Without calculation, state and explain the variation in the magnitude of the acceleration of the electron as it moves from the position where $x = 3\,\text{cm}$ to the position where $x = 7\,\text{cm}$.

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

181. 9702_s18_qp_41 Q: 6

(a) State what is meant by *electric field strength*.

.....

.....[1]

(b) An isolated metal sphere A of radius 26 cm is positively charged. Sphere A is shown in Fig. 6.1.

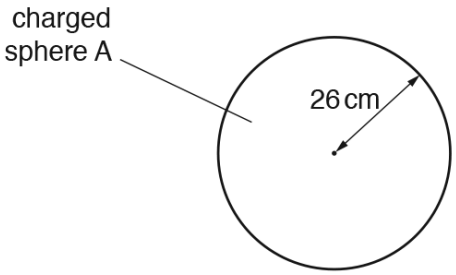


Fig. 6.1

Electrical breakdown (a spark) occurs when the electric field strength at the surface of the sphere exceeds $2.0 \times 10^4\,\text{V m}^{-1}$.

Calculate the maximum charge Q that can be stored on the sphere.

Q = ... C [2]

(c) A second isolated metal sphere B, also with charge $+Q$, has a radius of 52 cm.

Calculate the additional charge, in terms of Q, that may be stored on this sphere before electrical breakdown occurs.

additional charge = ...[2]

[Total: 5]

182. 9702_s18_qp_43 Q: 6

(a) State what is meant by *electric field strength*.

.....

.....[1]

(b) An isolated metal sphere A of radius 26 cm is positively charged. Sphere A is shown in Fig. 6.1.

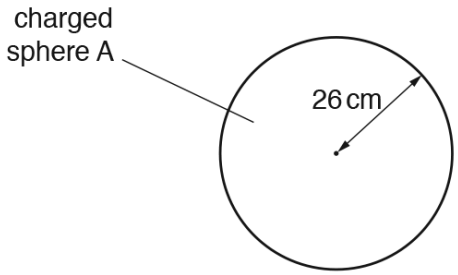


Fig. 6.1

Electrical breakdown (a spark) occurs when the electric field strength at the surface of the sphere exceeds $2.0 \times 10^4\,\text{V m}^{-1}$.

Calculate the maximum charge Q that can be stored on the sphere.

Q = ... C [2]

(c) A second isolated metal sphere B, also with charge $+Q$, has a radius of 52 cm.

Calculate the additional charge, in terms of Q, that may be stored on this sphere before electrical breakdown occurs.

additional charge = ...[2]

[Total: 5]

183. 9702_m17_qp_42 Q: 6

(a) State **one** similarity and **one** difference between the electric field lines and the gravitational field lines around an isolated positively charged metal sphere.

similarity .....

.....

difference .....

.....
[2]

(b) A positive point charge $+Q$ is positioned at a fixed point X and an identical positive point charge is positioned at a fixed point Y, as shown in Fig. 6.1.

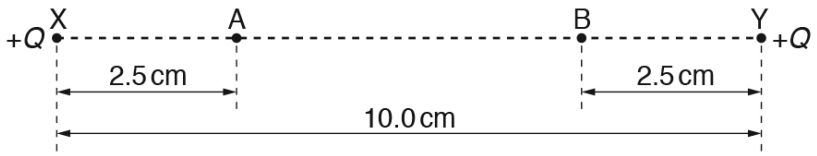


Fig. 6.1

The charges are separated in a vacuum by a distance of 10.0 cm.

Points A and B are on the line XY. Point A is a distance of 2.5 cm from X and point B is a distance of 2.5 cm from Y. The electric field strength at point A is 4.1×10^{-5} V m^{-1}.

(i) Calculate charge $+Q$.

$+Q$ = ...C [3]

(ii) On Fig. 6.2, sketch the variation of the electric field strength E with distance d from A to B, along the line AB.

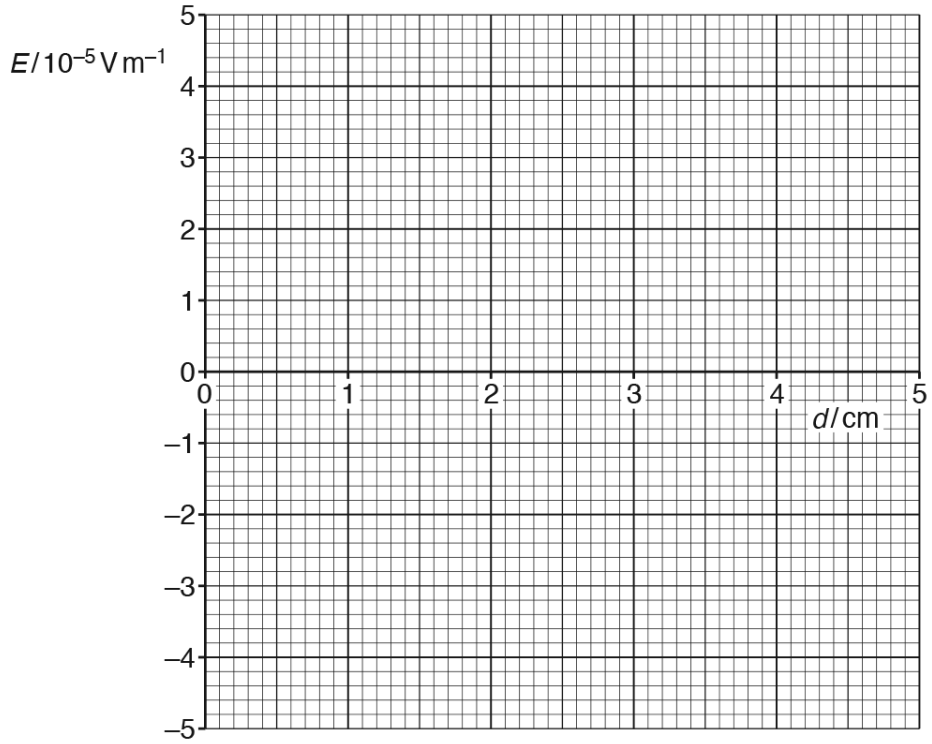


Fig. 6.2

[2]

(iii) A small positive charge is placed at A. The electric field causes this charge to move from rest along the line AB.

Describe the acceleration of the charge as it moves from A to B.

.....

.....

.....

.....[2]

[Total: 9]

184. 9702_s19_qp_42 Q: 6

(a) State what is meant by *electric potential* at a point.

.....

.....

.....[2]

(b) Two parallel metal plates A and B are held a distance *d* apart in a vacuum, as illustrated in Fig. 6.1.

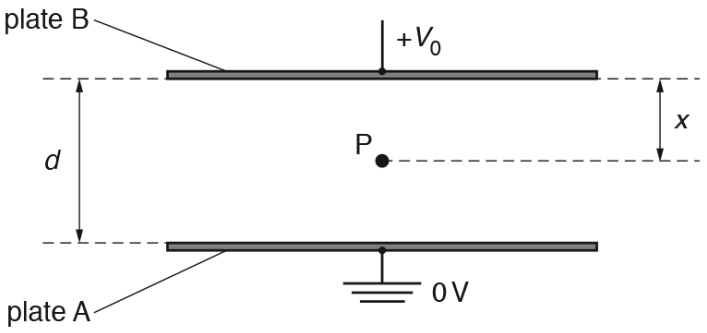


Fig. 6.1

Plate A is earthed and plate B is at a potential of $+V_0$.

Point P is situated in the centre region between the plates at a distance *x* from plate B. The potential at point P is *V*.

On Fig. 6.2, show the variation with *x* of the potential *V* for values of *x* from $x = 0$ to $x = d$.

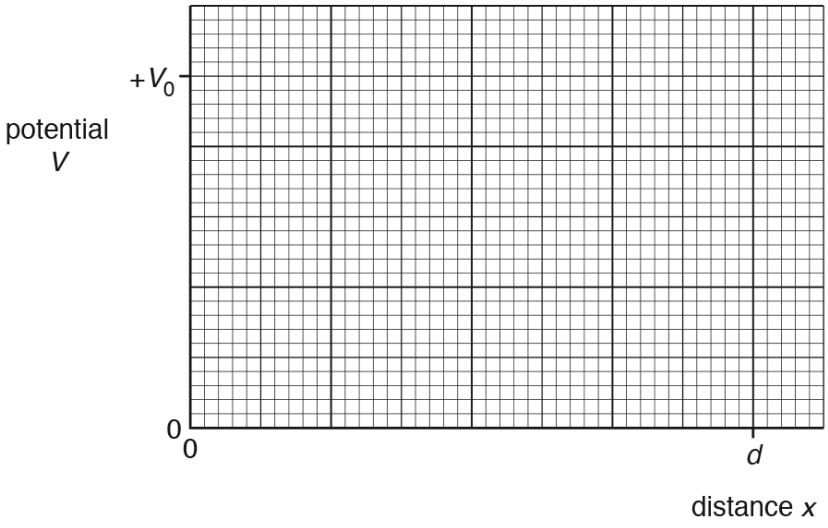


Fig. 6.2

[3]

(c) Two isolated solid metal spheres M and N, each of radius *R*, are situated in a vacuum. Their centres are a distance *D* apart, as illustrated in Fig. 6.3.

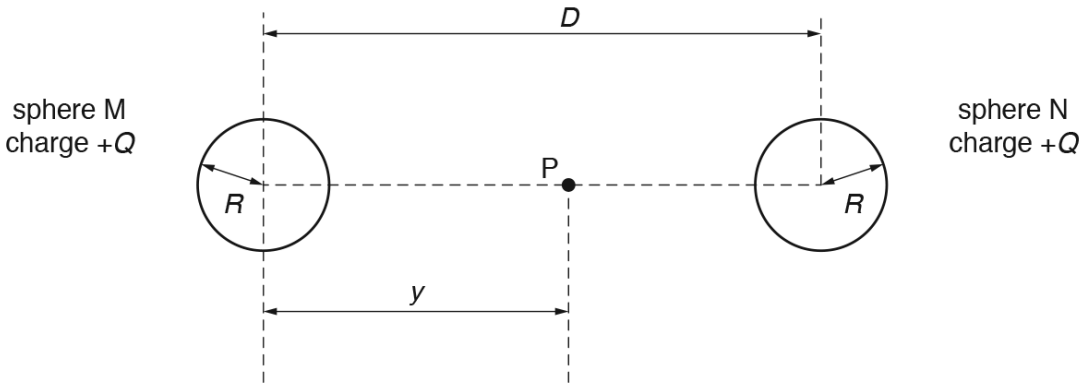


Fig. 6.3

Each sphere has charge +*Q*.

Point P lies on the line joining the centres of the two spheres, and is a distance *y* from the centre of sphere M.

On Fig. 6.4, show the variation with distance *y* of the electric potential at point P, for values of *y* from *y* = 0 to *y* = *D*.

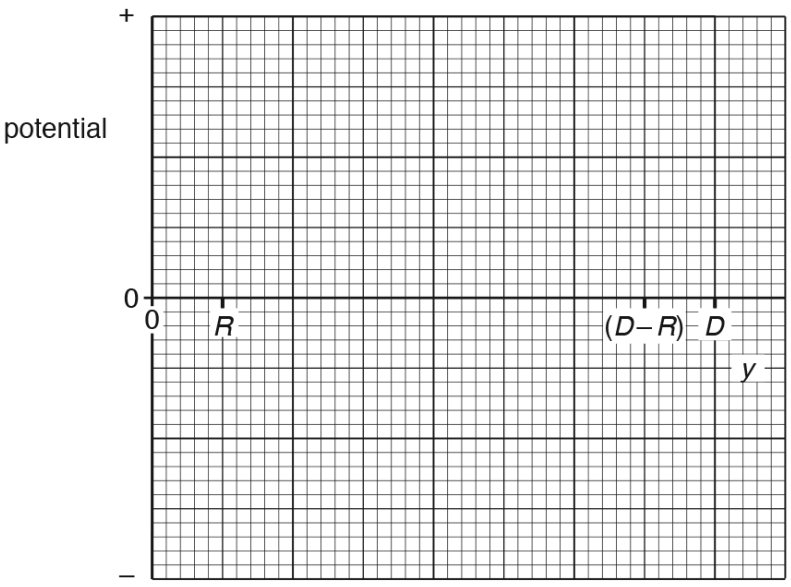


Fig. 6.4

[4]

[Total: 9]

185. 9702_w19_qp_42 Q: 9

(a) Define what is meant by *electric potential* at a point.

.....

.....

..... [2]

(b) In an α-particle scattering experiment, α-particles are directed towards a thin film of gold, as illustrated in Fig. 9.1.

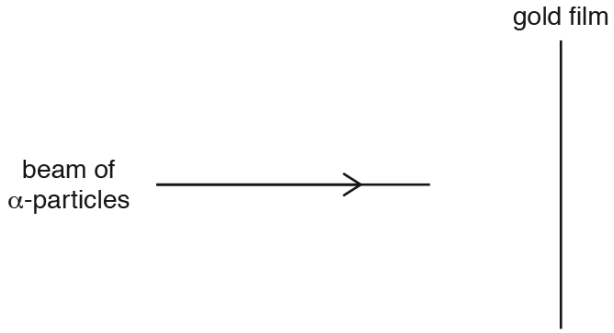


Fig. 9.1

The apparatus is in a vacuum.

The gold-197 ($^{197}_{79}$Au) nuclei in the film may be considered to be fixed point charges.

The α-particles emitted from the source each have an energy of 4.8 MeV.

Calculate:

(i) the initial kinetic energy E_K, in J, of an α-particle emitted from the source

E_K = ... J [1]

(ii) the distance d of closest approach of an α-particle to a gold nucleus.

d = ... m [4]

(c) Use your answer in **(b)(ii)** to comment on the possible diameter of a gold nucleus.

.....

..... [1]

[Total: 8]

186. 9702_m18_qp_42 Q: 7

(a) State what is meant by *electric potential* at a point.

.....

.....

.....[2]

(b) The centres of two charged metal spheres A and B are separated by a distance of 44.0 cm, as shown in Fig. 7.1.

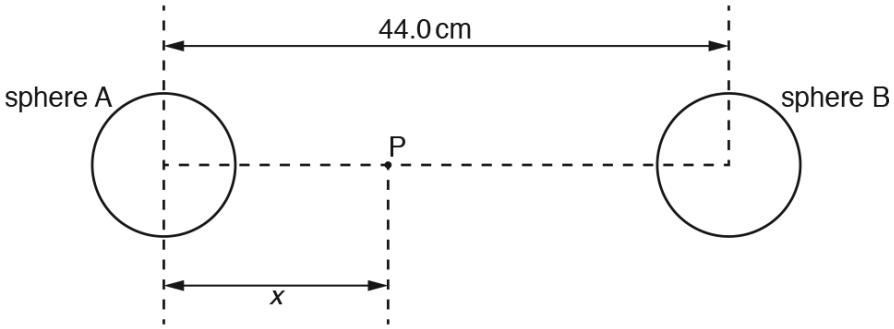


Fig. 7.1 (not to scale)

A moveable point P lies on the line joining the centres of the two spheres. Point P is a distance *x* from the centre of sphere A. The variation with distance *x* of the electric potential *V* at point P is shown in Fig. 7.2.

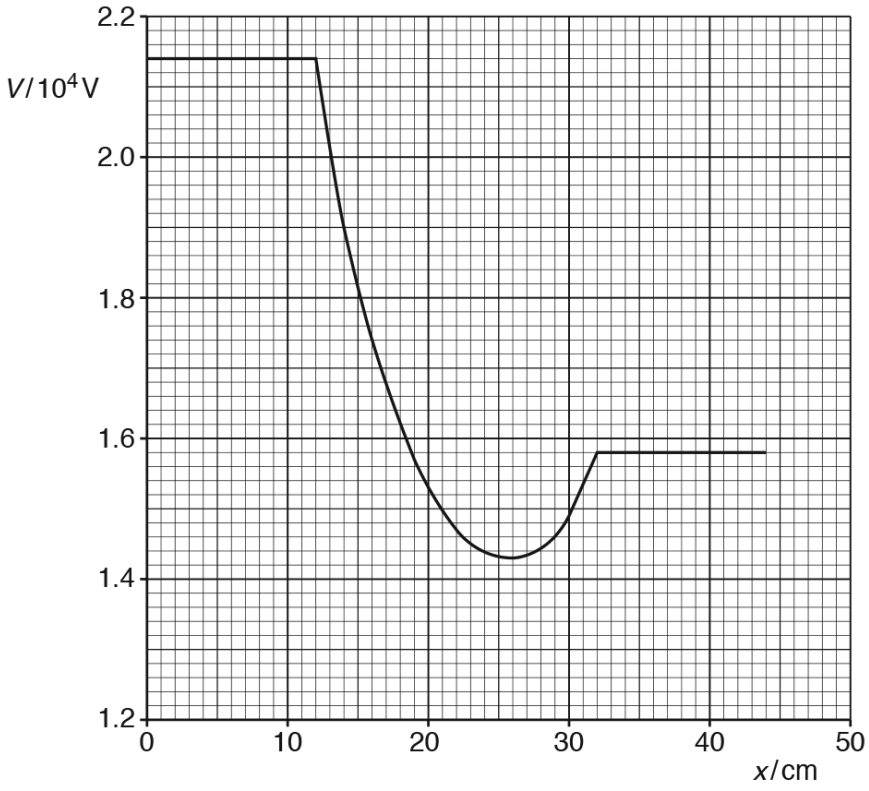


Fig. 7.2

(i) Use Fig. 7.2 to state and explain whether the two spheres have charges of the same, or opposite, sign.

.....

.....

.....[1]

(ii) A positively-charged particle is at rest on the surface of sphere A.

The particle moves freely from the surface of sphere A to the surface of sphere B.

1. Describe qualitatively the variation, if any, with distance x of the speed of the particle as it

moves from $x = 12\,\text{cm}$ to $x = 25\,\text{cm}$ .....

.....

passes through $x = 26\,\text{cm}$ .....

.....

moves from $x = 27\,\text{cm}$ to $x = 31\,\text{cm}$ .....

.....

reaches $x = 32\,\text{cm}$ .....

.....[4]

2. The particle has charge $3.2 \times 10^{-19}\,\text{C}$ and mass $6.6 \times 10^{-27}\,\text{kg}$.

Calculate the maximum speed of the particle.

speed = ... m s^{-1} [2]

[Total: 9]

187. 9702_w18_qp_41 Q: 6

(a) (i) Define *electric potential* at a point.

.....

.....

.....[2]

(ii) State the relationship between electric potential and electric field strength at a point.

.....

.....

.....[2]

(b) Two parallel metal plates A and B are situated a distance 1.2 cm apart in a vacuum, as shown in Fig. 6.1.

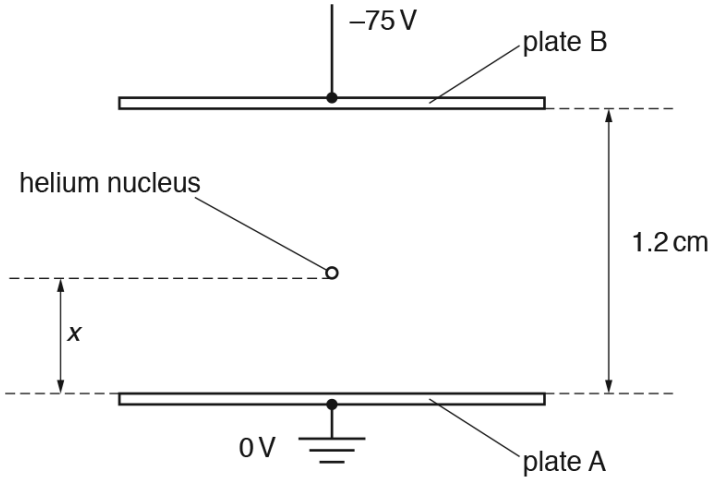


Fig. 6.1

Plate A is earthed and plate B is at a potential of –75 V.

A helium nucleus is situated between the plates, a distance x from plate A.

Initially, the helium nucleus is at rest on plate A where $x = 0$.

(i) The helium nucleus is free to move between the plates. By considering energy changes of the helium nucleus, explain why the speed at which it reaches plate B is independent of the separation of the plates.

.....

.....

.....

.....[2]

(ii) As the helium nucleus ($^4_2$He) moves from plate A towards plate B, its distance x from plate A increases.

Calculate the speed of the nucleus after it has moved a distance $x = 0.40\,\text{cm}$ from plate A.

speed = ... m s^{-1} [3]

[Total: 9]

188. 9702_w18_qp_42 Q: 6

(a) State

(i) what is meant by the *electric potential* at a point,

.....

.....

.....[2]

(ii) the relationship between electric potential at a point and electric field strength at the point.

.....

.....

.....[2]

(b) Two similar solid metal spheres A and B, each of radius *R*, are situated in a vacuum such that the separation of their centres is *D*, as shown in Fig. 6.1.

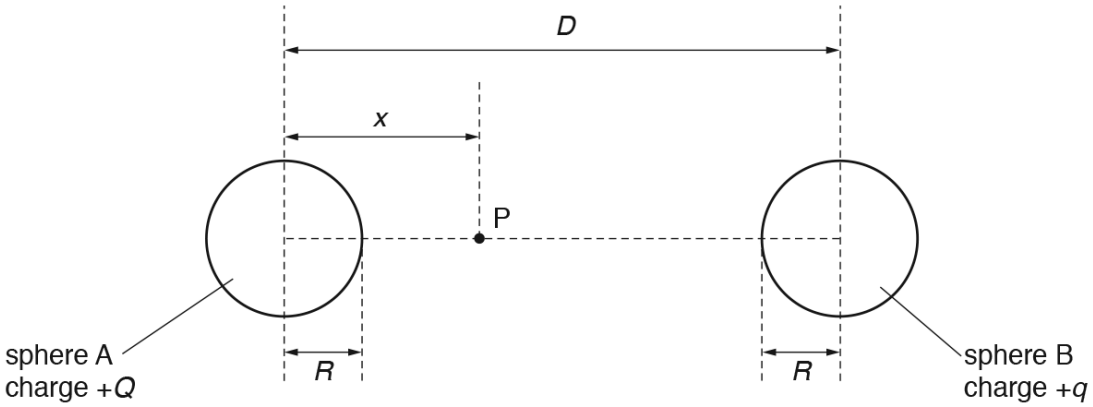


Fig. 6.1

The charge +*Q* on sphere A is larger than the charge +*q* on sphere B.

A movable point P is located on the line joining the centres of the two spheres.
The point P is a distance *x* from the centre of sphere A.

On Fig. 6.2, sketch a graph to show the variation with x of the electric potential V between the centres of the two spheres.

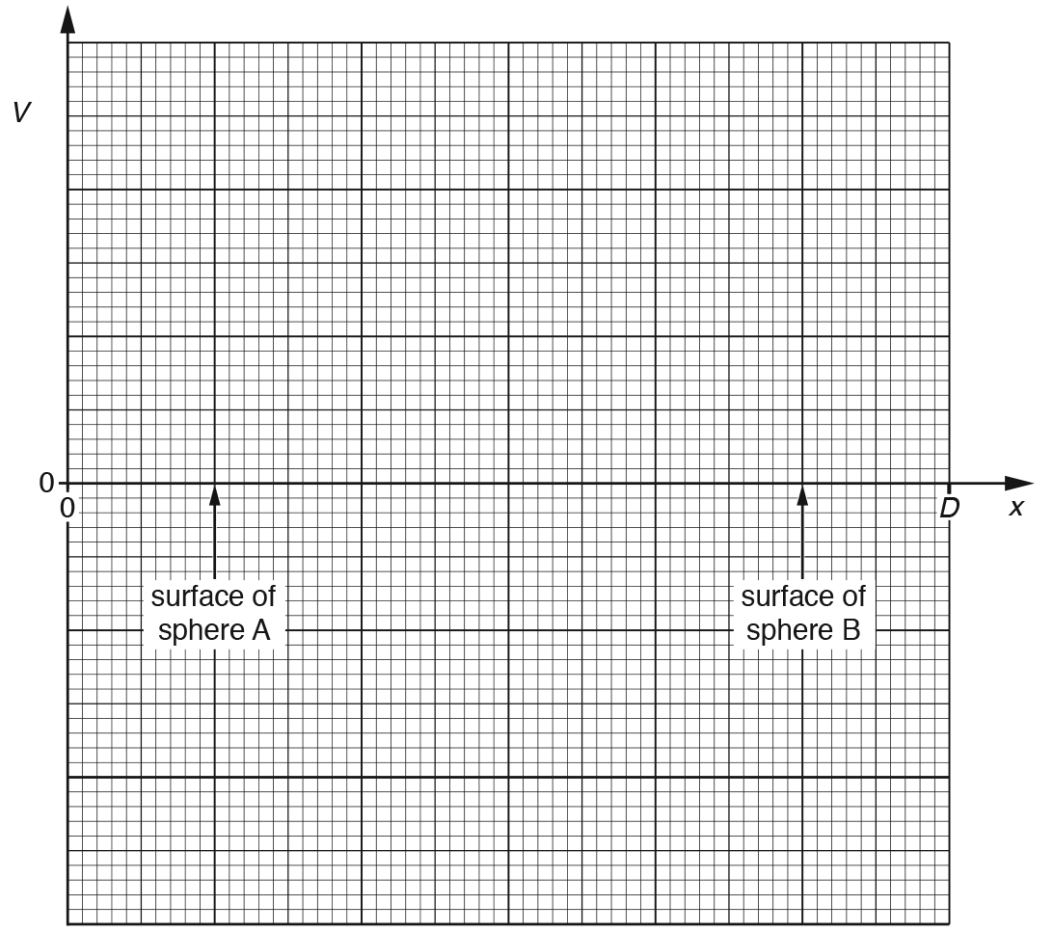


Fig. 6.2

[4]

[Total: 8]

189. 9702_w18_qp_43 Q: 6

(a) **(i)** Define *electric potential* at a point.

.....

.....

.....[2]

(ii) State the relationship between electric potential and electric field strength at a point.

.....

.....

.....[2]

(b) Two parallel metal plates A and B are situated a distance 1.2 cm apart in a vacuum, as shown in Fig. 6.1.

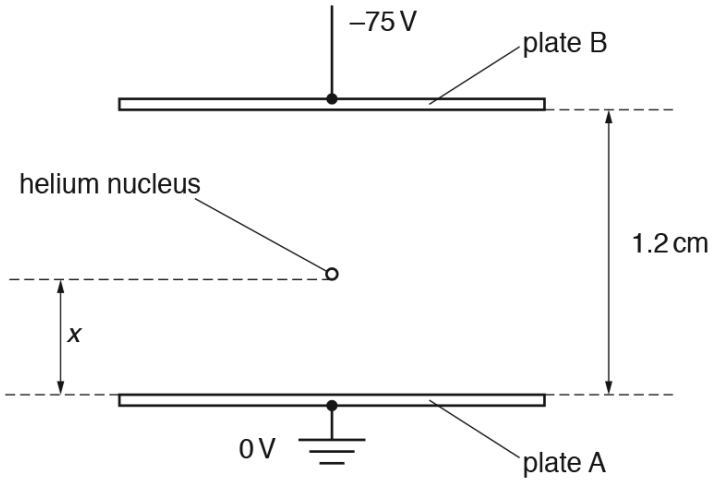


Fig. 6.1

Plate A is earthed and plate B is at a potential of –75 V.

A helium nucleus is situated between the plates, a distance x from plate A.

Initially, the helium nucleus is at rest on plate A where $x = 0$.

(i) The helium nucleus is free to move between the plates. By considering energy changes of the helium nucleus, explain why the speed at which it reaches plate B is independent of the separation of the plates.

.....

.....

.....

.....[2]

(ii) As the helium nucleus ($^4_2$He) moves from plate A towards plate B, its distance x from plate A increases.

Calculate the speed of the nucleus after it has moved a distance $x = 0.40\,\text{cm}$ from plate A.

speed = ... m s^{-1} [3]

[Total: 9]

190. 9702_s17_qp_42 Q: 6

(a) State Coulomb's law.

.....

.....

.....[2]

(b) Two charged metal spheres A and B are situated in a vacuum, as illustrated in Fig. 6.1.

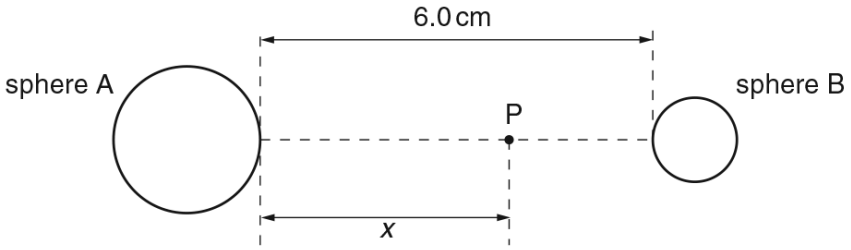


Fig. 6.1

The shortest distance between the surfaces of the spheres is 6.0 cm.

A movable point P lies along the line joining the centres of the two spheres, a distance x from the surface of sphere A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 6.2.

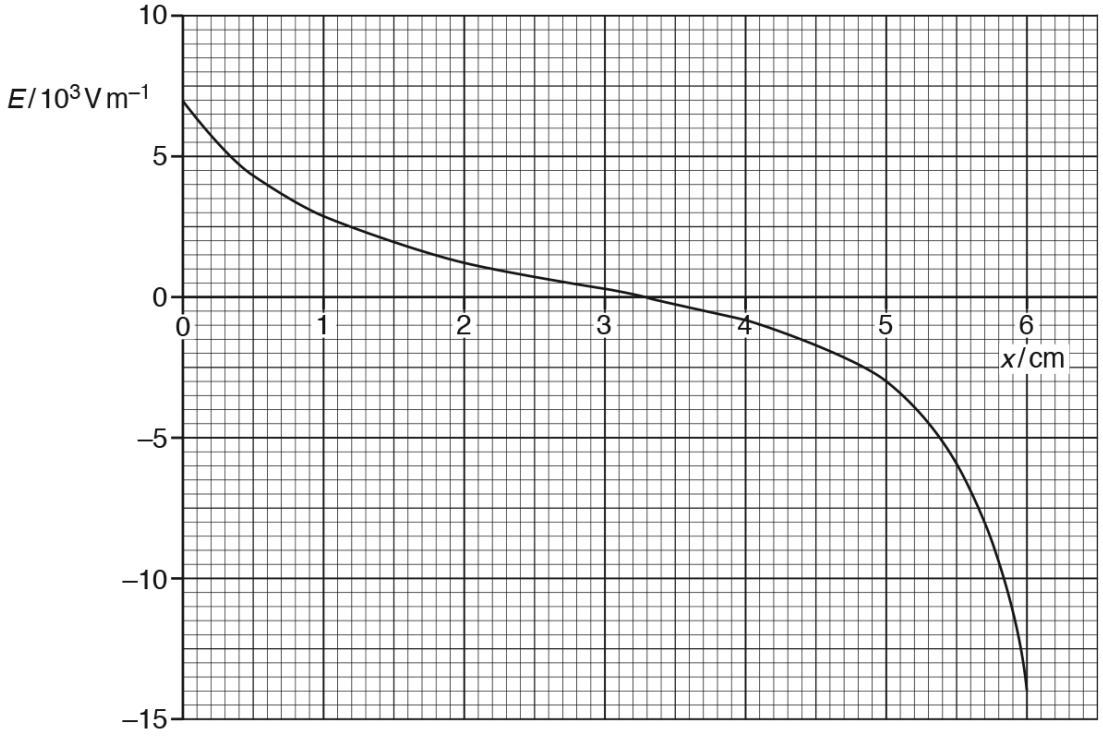


Fig. 6.2

(i) Use Fig. 6.2 to explain whether the two spheres have charges of the same, or opposite, sign.

.....

.....

.....

.....[2]

(ii) A proton is at point P where $x = 5.0\,\text{cm}$.
Use data from Fig. 6.2 to determine the acceleration of the proton.

acceleration = ... m s^{-2} [3]

(c) Use data from Fig. 6.2 to state the value of x at which the rate of change of electric potential is maximum. Give the reason for the value you have chosen.

.....

.....

.....[2]

[Total: 9]

191. 9702_s17_qp_43 Q: 5

An α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 5.1.



Fig. 5.1

The gold nucleus has charge $79e$.
The gold nucleus and the α-particle may be assumed to behave as point charges.
At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(a) The α-particle does not collide with the gold nucleus. Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m.

[3]

(b) Determine the acceleration of the α-particle for a separation of 4.7×10^{-14} m between the centres of the gold nucleus and of the α-particle.

acceleration = ... $m\,s^{-2}$ [3]

(c) In an α-particle scattering experiment, the beam of α-particles is incident on a very thin gold foil.
Suggest why the gold foil must be very thin.

.....

.....[1]

[Total: 7]

192. 9702_w17_qp_42 Q: 6

(a) For any point outside a spherical conductor, the charge on the sphere may be considered to act as a point charge at its centre. By reference to electric field lines, explain this.

.....

.....

.....

.....[2]

(b) An isolated spherical conductor has charge q, as shown in Fig. 6.1.

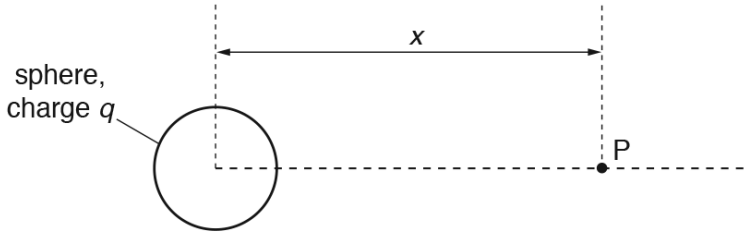


Fig. 6.1

Point P is a movable point that, at any one time, is a distance x from the centre of the sphere.

The variation with distance x of the electric potential V at point P due to the charge on the sphere is shown in Fig. 6.2.

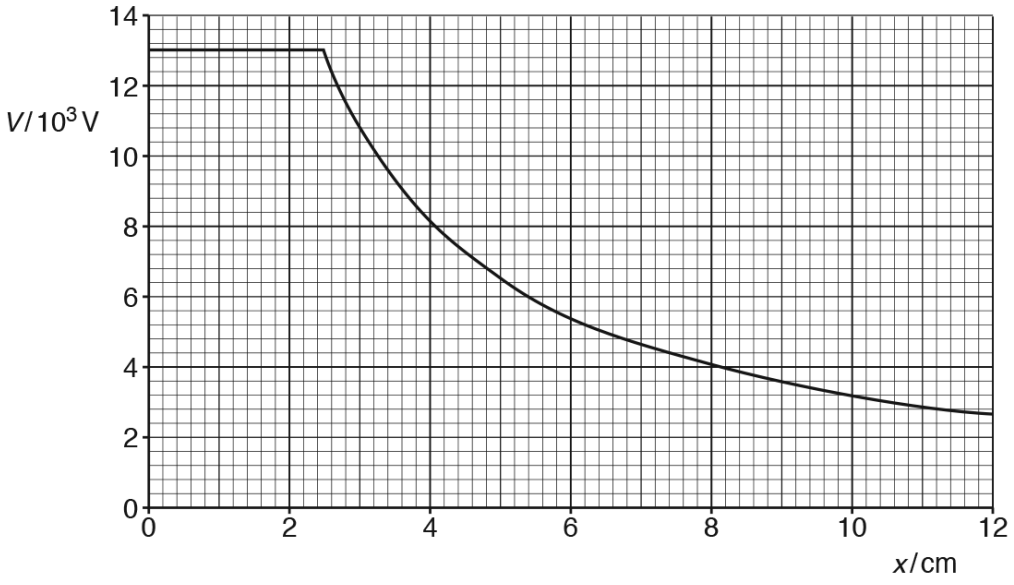


Fig. 6.2

Use Fig. 6.2 to determine

(i) the electric field strength E at point P where $x = 6.0\,\text{cm}$,

$E =$ ..... N C^{-1} [3]

(ii) the radius R of the sphere. Explain your answer.

$R =$ ..... cm [2]

[Total: 7]

---

193. 9702_w16_qp_41 Q: 5

Two small solid metal spheres A and B have equal radii and are in a vacuum. Their centres are 15 cm apart.
Sphere A has charge +3.0 pC and sphere B has charge +12 pC. The arrangement is illustrated in Fig. 5.1.

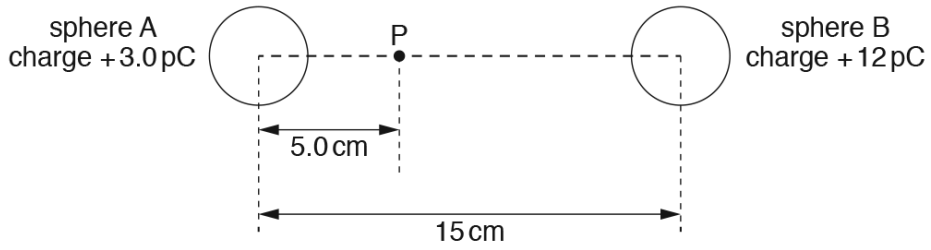


Fig. 5.1

Point P lies on the line joining the centres of the spheres and is a distance of 5.0 cm from the centre of sphere A.

(a) Suggest why the electric field strength in both spheres is zero.

.....

.....

..... [2]

(b) Show that the electric field strength is zero at point P. Explain your working.

[3]

(c) Calculate the electric potential at point P.

electric potential = ... V [2]

(d) A silver-107 nucleus ($^{107}_{47}$Ag) has speed v when it is a long distance from point P.

Use your answer in **(c)** to calculate the minimum value of speed v such that the nucleus can reach point P.

speed = ... $m\,s^{-1}$ [3]

[Total: 10]

---

194. 9702_w16_qp_42 Q: 6

Two solid metal spheres A and B, each of radius 1.5 cm, are situated in a vacuum. Their centres are separated by a distance of 20.0 cm, as shown in Fig. 6.1.

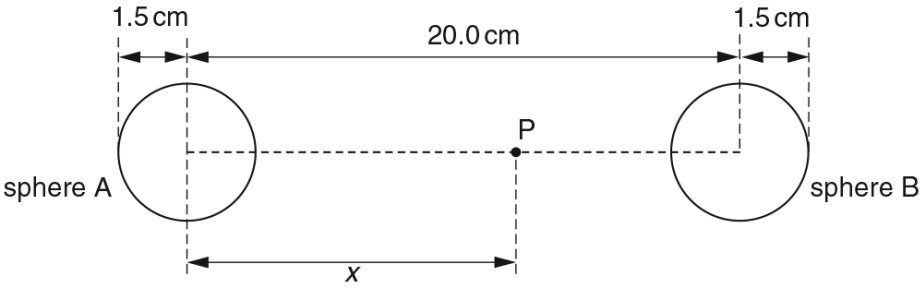


Fig. 6.1 (not to scale)

Both spheres are positively charged.

Point P lies on the line joining the centres of the two spheres, at a distance x from the centre of sphere A.

The variation with distance x of the electric field strength E at point P is shown in Fig. 6.2.

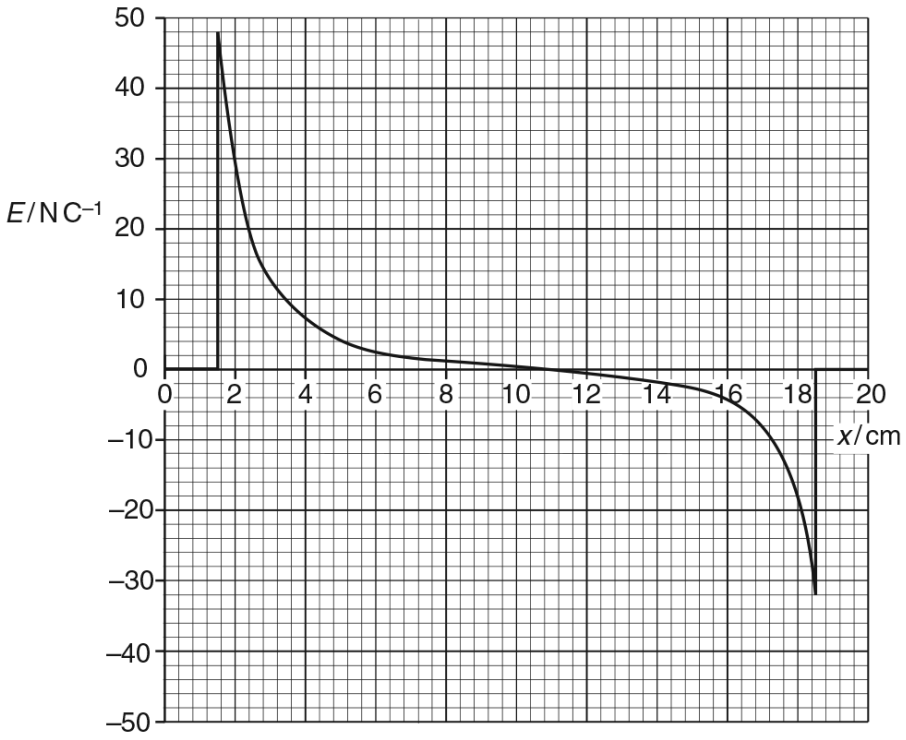


Fig. 6.2

(a) Use Fig. 6.2 to determine the ratio

$$\frac{\text{magnitude of charge on sphere A}}{\text{magnitude of charge on sphere B}}.$$

Explain your working.

ratio = ...[3]

(b) The variation with distance x of the electric potential V at point P is shown in Fig. 6.3.

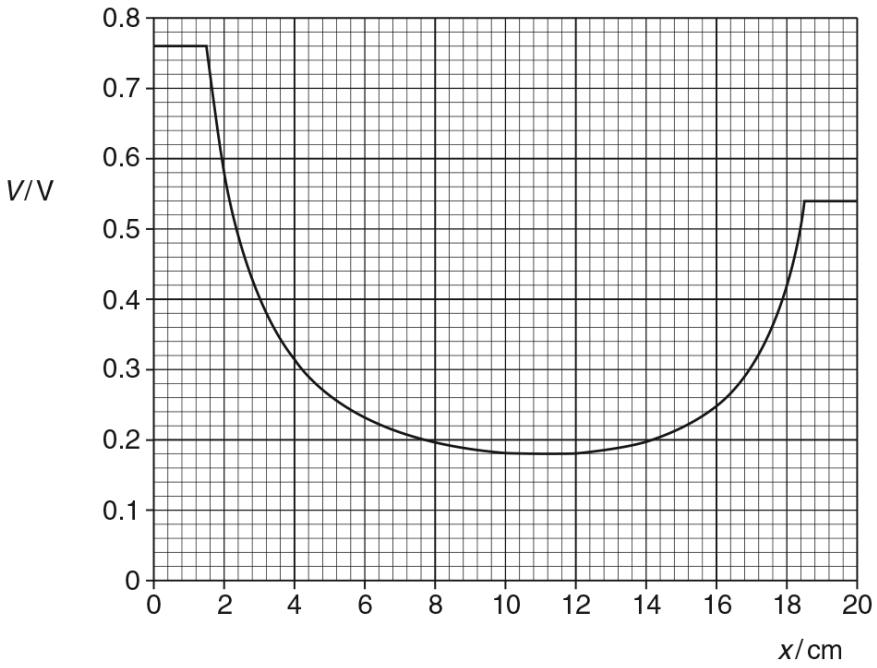


Fig. 6.3

An α-particle is initially at rest on the surface of sphere A.
The α-particle moves along the line joining the centres of the two spheres.

Determine, for the α-particle as it moves between the two spheres,

(i) its maximum speed,

maximum speed = ... $m\,s^{-1}$ [3]

(ii) its speed on reaching the surface of sphere B.

speed = ... $m\,s^{-1}$ [2]

[Total: 8]

195. 9702_w16_qp_43 Q: 5

Two small solid metal spheres A and B have equal radii and are in a vacuum. Their centres are 15 cm apart.
Sphere A has charge +3.0 pC and sphere B has charge +12 pC. The arrangement is illustrated in Fig. 5.1.

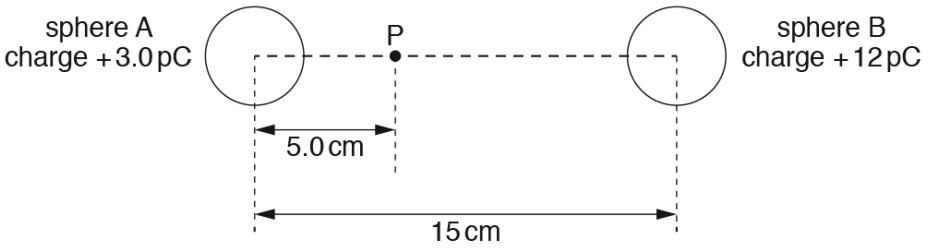


Fig. 5.1

Point P lies on the line joining the centres of the spheres and is a distance of 5.0 cm from the centre of sphere A.

(a) Suggest why the electric field strength in both spheres is zero.

.....

.....

..... [2]

(b) Show that the electric field strength is zero at point P. Explain your working.

[3]

(c) Calculate the electric potential at point P.

electric potential = ... V [2]

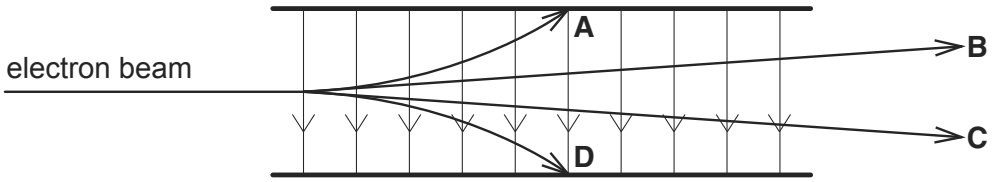
(d) A silver-107 nucleus ($^{107}_{47}Ag$) has speed v when it is a long distance from point P.

Use your answer in **(c)** to calculate the minimum value of speed v such that the nucleus can reach point P.

speed = ... $m\,s^{-1}$ [3]

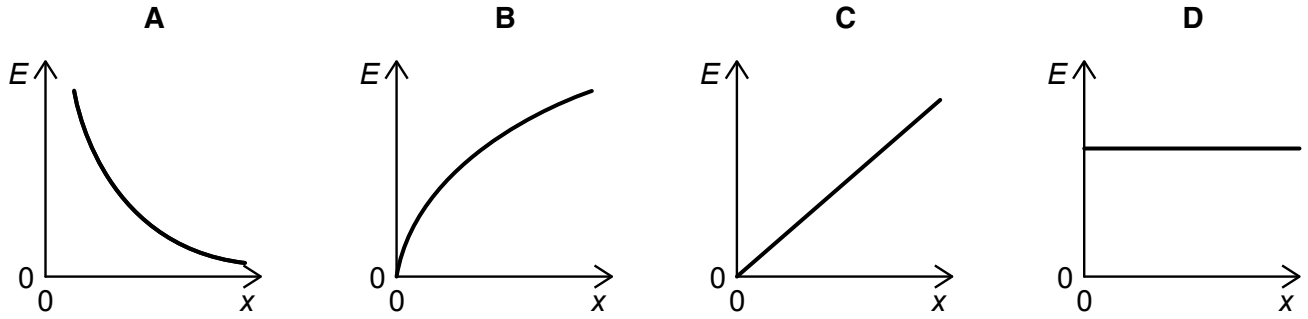
[Total: 10]

1 Which path shows a possible movement of an electron in the electric field shown? 9702/1/M/J/02/Q36

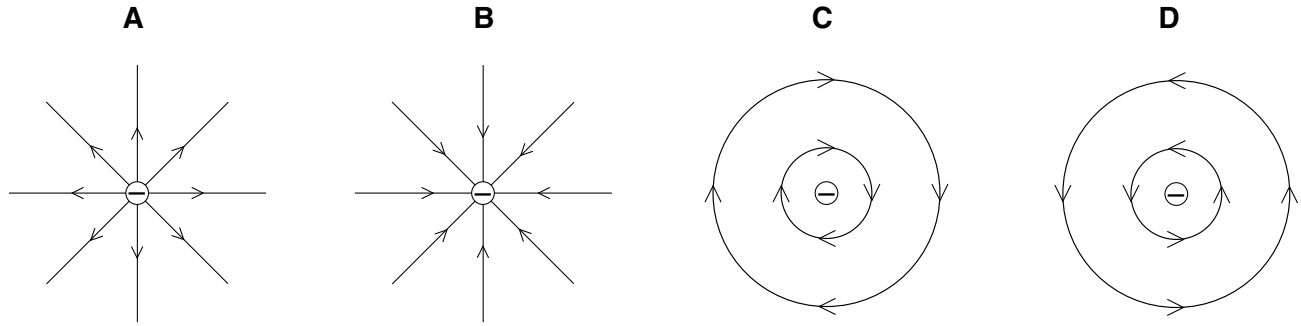


2 Two parallel conducting plates are connected to a battery, one plate to the positive terminal and the other plate to the negative. The plate separation is gradually increased, the plates remaining connected to the battery. 9702/1/M/J/02/Q37

Which graph shows how the electric field E between the plates depends on the plate separation x?

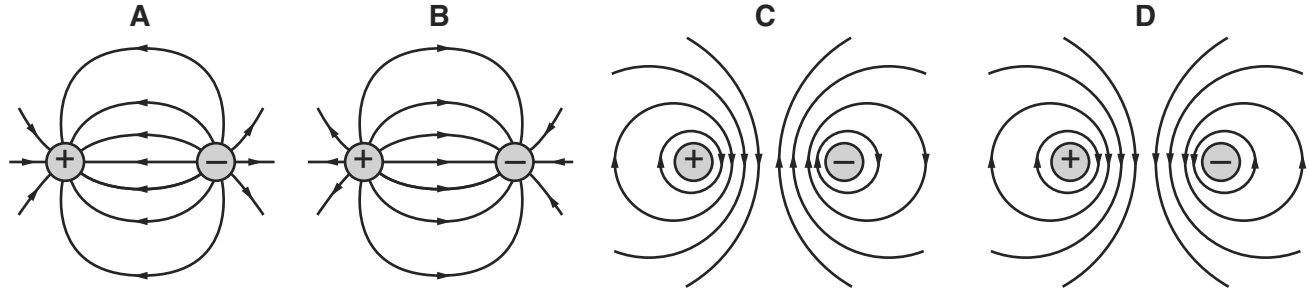


3 Which diagram shows the electric field pattern of an isolated negative point charge? 9702/1/O/N/02/Q37

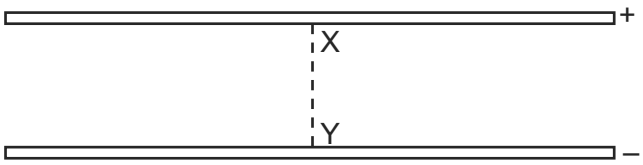


4 A positive charge and a negative charge of equal magnitude are placed a short distance apart. 9702/01/M/J/03/Q37

Which diagram best represents the associated electric field?

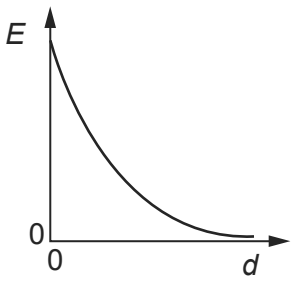


5 An electric field exists in the space between two charged metal plates. 9702/01/M/J/03/Q35

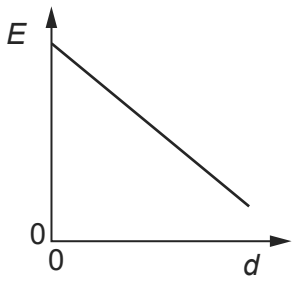


Which of the following graphs shows the variation of electric field strength *E* with distance *d* from X along the line XY?

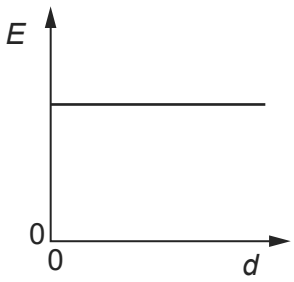
A



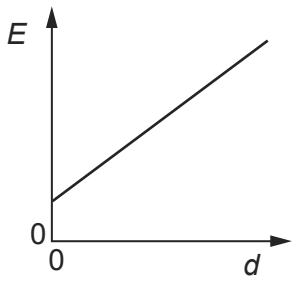
B



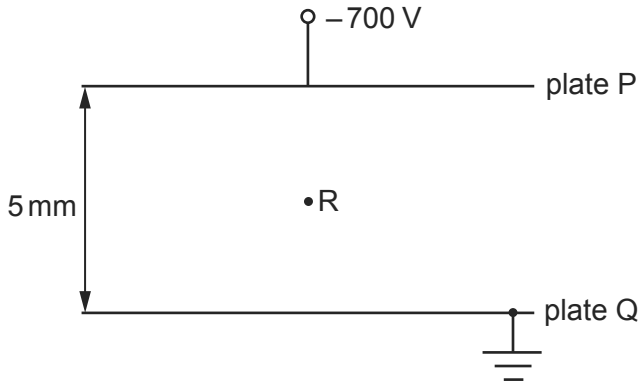
C



D



6 The diagram shows two metal plates P and Q between which there is a potential difference of 700 V. Plate Q is earthed. 9702/01/M/J/03/Q36



What is the magnitude and direction of the electric field at point R?

A $1.4 \times 10^2\,N\,C^{-1}$ from P towards Q

B $1.4 \times 10^2\,N\,C^{-1}$ from Q towards P

C $1.4 \times 10^5\,N\,C^{-1}$ from P towards Q

D $1.4 \times 10^5\,N\,C^{-1}$ from Q towards P

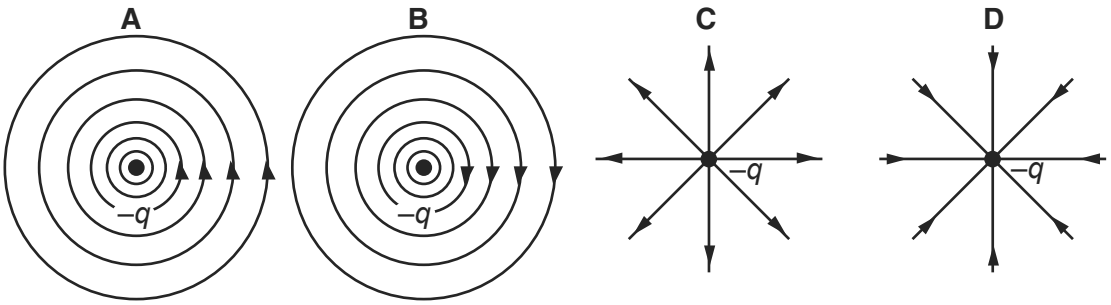
7 The electric field strength between a pair of parallel plates is *E*. The separation of the plates is doubled and the potential difference between the plates is increased by a factor of four.

9702/01/M/J/07/Q30

What is the new electric field strength?

A *E* **B** 2*E* **C** 4*E* **D** 8*E*

8 Which diagram represents the electric field of a negative point charge $-q$? 9702/01/O/N/03/Q35



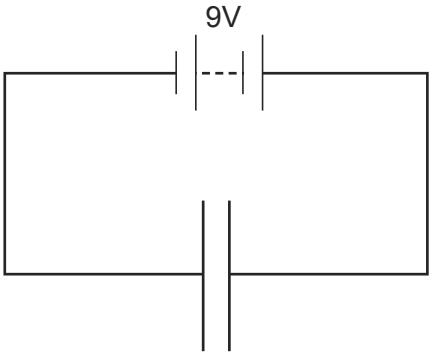
9 A potential difference V is applied between two parallel plates a small distance d apart, and produces an electric field of strength E between the plates. 9702/01/O/N/03/Q36



What is the electric field strength between the plates when both V and d are doubled?

A $E/4$ **B** E **C** $2E$ **D** $4E$

10 In the circuit below, the distance between the two parallel plates is 2.0×10^{-3} m. An electron is situated between the plates. 9702/01/O/N/03/3Q7



What is the force on the electron?

A 3.2×10^{-22} N

B 2.9×10^{-21} N

C 8.9×10^{-18} N

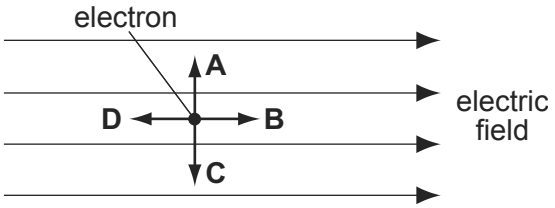
D 7.2×10^{-16} N

11 What is an equivalent unit to 1 volt? 9702/01/M/J/04/Q32

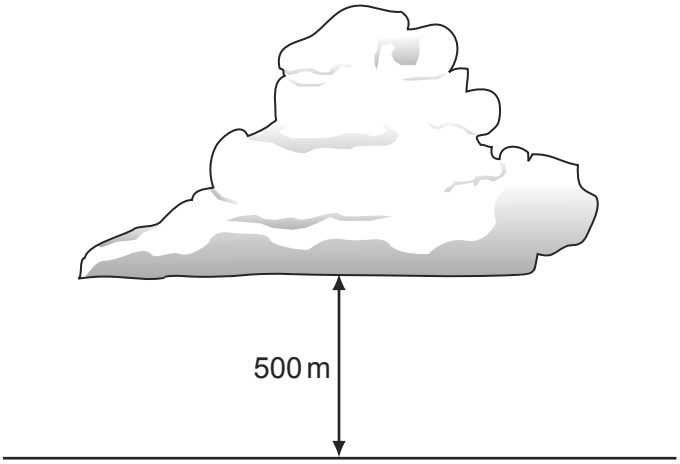
A $1\,JA^{-1}$ **B** $1\,JC^{-1}$ **C** $1\,WC^{-1}$ **D** $1\,Ws^{-1}$

12 The diagram shows an electron in a uniform electric field. 9702/01/M/J/04/Q29

In which direction will the field accelerate the electron?



13 The diagram shows a thundercloud whose base is 500 m above the ground. 9702/01/M/J/04/Q30



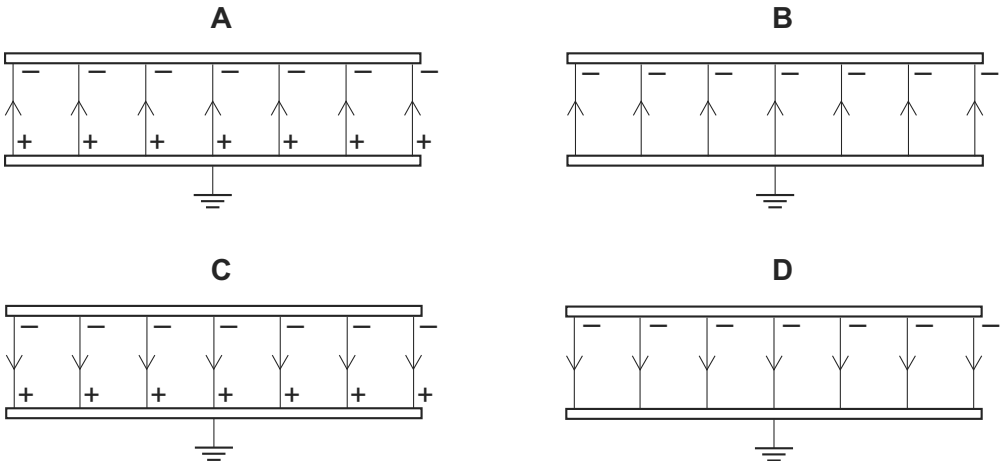
The potential difference between the base of the cloud and the ground is 200 MV. A raindrop with a charge of 4.0×10^{-12} C is in the region between the cloud and the ground.

What is the electrical force on the raindrop?

A 1.6×10^{-6} N **B** 8.0×10^{-4} N **C** 1.6×10^{-3} N **D** 0.40 N

14 Two parallel, conducting plates with air between them are placed close to one another. The top plate is given a negative charge and the bottom one is earthed. 9702/01/O/N/04/Q29

Which diagram best represents the distribution of charges and the field in this situation?



15 In a uniform electric field, which statement is correct? 9702/01/O/N/04/Q30

A All charged particles experience the same force.

B All charged particles move with the same velocity.

C All electric field lines are directed towards positive charges.

D All electric field lines are parallel.

16 Which of the following describes the electric potential difference between two points in a wire that carries a current? 9702/01/O/N/04/Q31

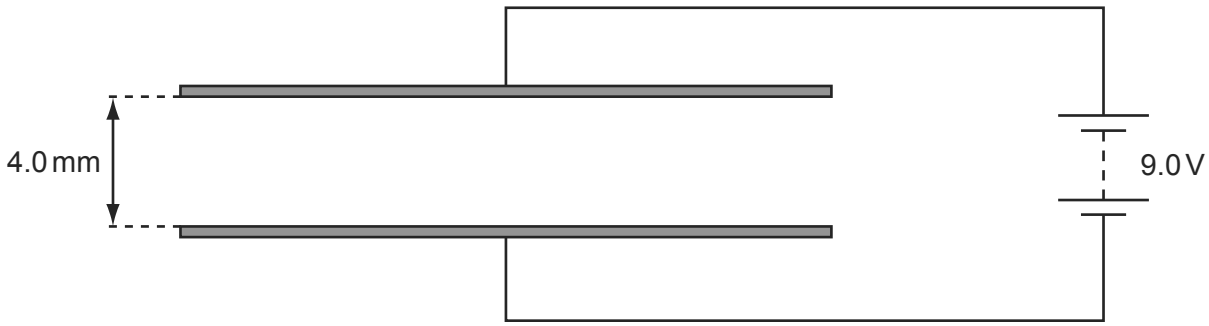
A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

17 The diagram shows a pair of metal plates 4.0 mm apart connected to a 9.0 V battery. 9702/01/M/J/05/Q30



What is the electric field between the plates?

A $4.4 \times 10^{-4}\,\mathrm{N\,C^{-1}}$

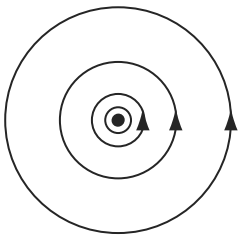
B $3.6 \times 10^{-2}\,\mathrm{N\,C^{-1}}$

C $36\,\mathrm{N\,C^{-1}}$

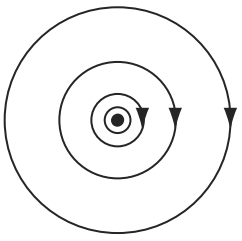
D $2.3 \times 10^{3}\,\mathrm{N\,C^{-1}}$

18 Which diagram represents the electric field of a negative point charge, shown by ● ? 9702/01/M/J/07/Q28

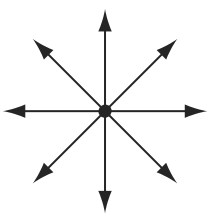
A



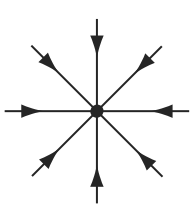
B



C



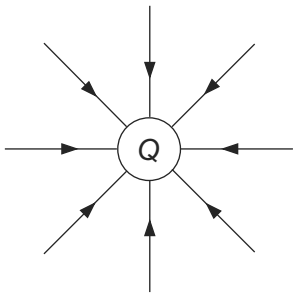
D



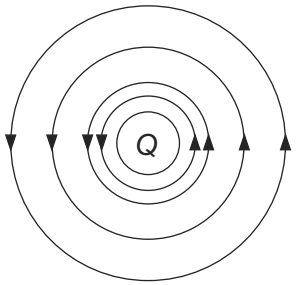
19 Which diagram represents the electric field in the vicinity of a positive electric charge of magnitude Q?

9702/01/M/J/05/Q31

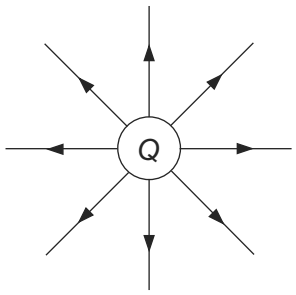
A



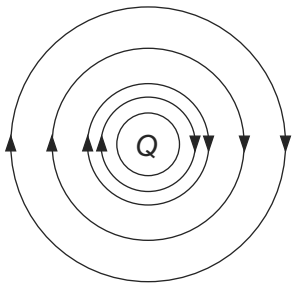
B



C



D

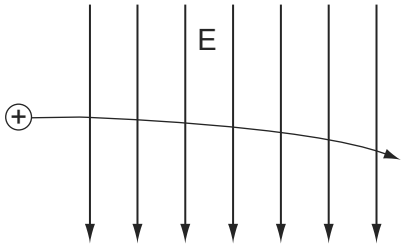


20 A positively charged particle is projected into a region of uniform electric field E. 9702/01/O/N/05/Q30

Which diagram represents the motion of the particle in the electric field?

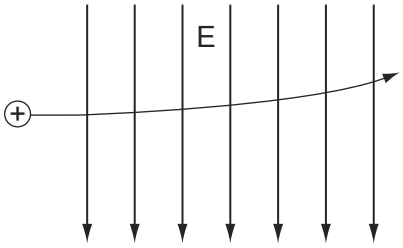
A

electric field in plane of the paper



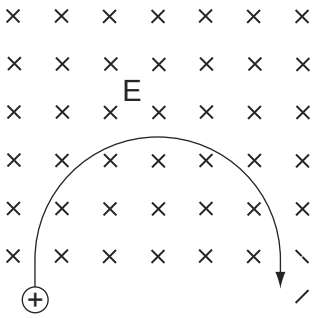
B

electric field in plane of the paper



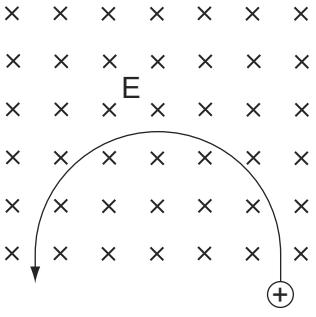
C

electric field into paper

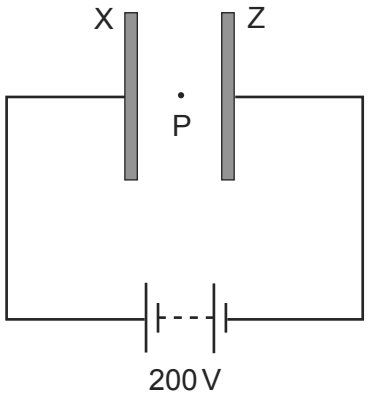


D

electric field into paper



21 Two large parallel plates X and Z are placed 5.0 mm apart and connected as shown to the terminals of a 200 volt d.c. supply. 9702/01/O/N/05/Q31



A small oil drop at P carries one excess electron.

What is the magnitude of the electrostatic force acting on the oil drop due to the electric field between the plates?

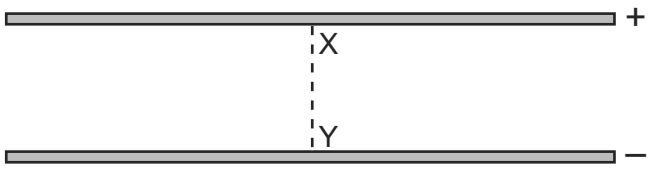
A 6.4×10^{-15} N

B 6.4×10^{-18} N

C 1.6×10^{-19} N

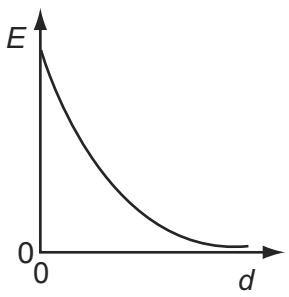
D 4.0×10^{-24} N

22 An electric field exists in the space between two charged metal plates. 9702/01/O/N/06/Q30

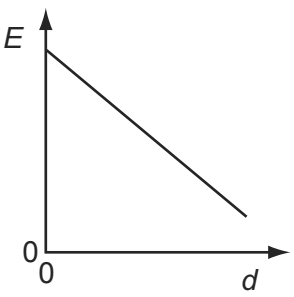


Which graph shows the variation of electric field strength *E* with distance *d* from X along the line XY?

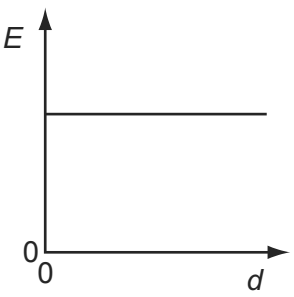
A



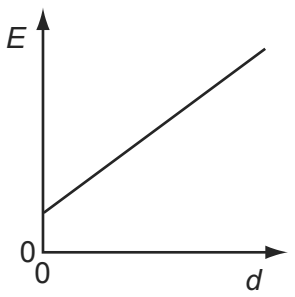
B



C



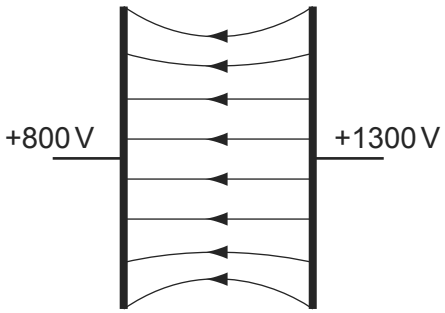
D



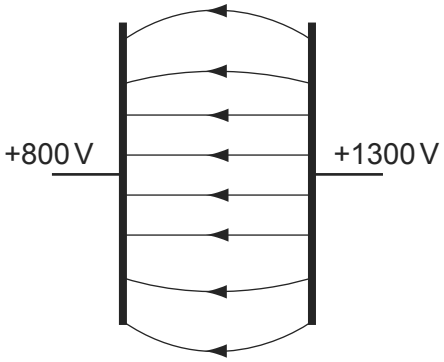
23 Two parallel metal plates are at potentials of +800 V and +1300 V. 9702/01/M/J/06/Q29

Which diagram best shows the electric field between the metal plates?

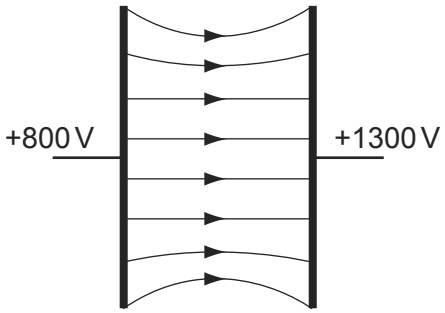
A



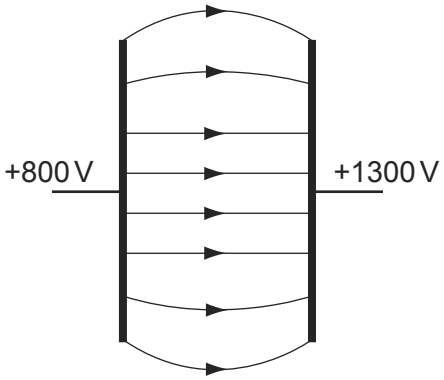
B



C

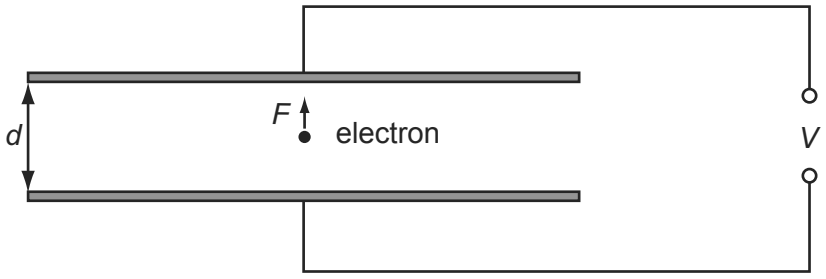


D



24 An electron of charge *e* is introduced between two metal plates a distance *d* apart. 9702/01/M/J/06/Q30

A potential difference *V* is applied to the plates as shown in the diagram.

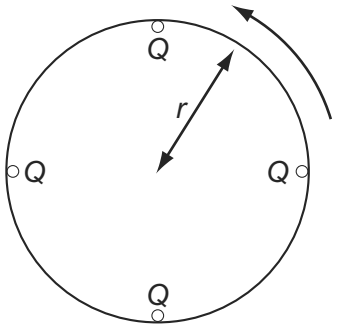


Which expression gives the electric force *F* on the electron?

A $\frac{eV}{d}$ **B** eVd **C** $\frac{V}{ed}$ **D** $\frac{dV}{e}$

25 Four point charges, each of charge Q, are placed on the edge of an insulating disc of radius r.

The frequency of rotation of the disc is f. 9702/01/O/N/06/Q31

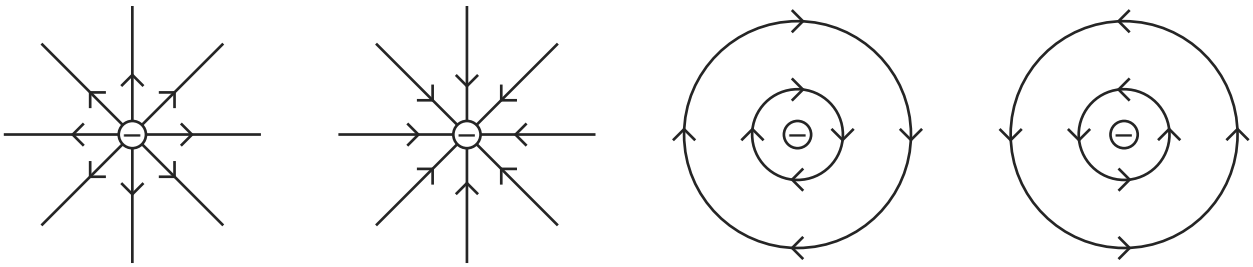


What is the equivalent electric current at the edge of the disc?

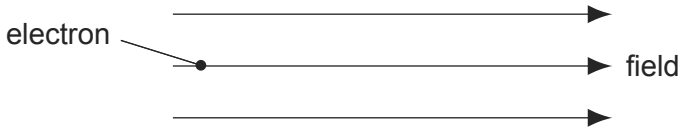
A $4Qf$ **B** $\frac{4Q}{f}$ **C** $8\pi rQf$ **D** $\frac{2Qf}{\pi r}$

26 Which diagram shows the electric field pattern of an isolated negative point charge? 9702/01/O/N/06/Q29

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



27 An electron is situated in a uniform electric field as shown in the diagram. 9702/01/O/N/07/Q26



What is the direction of the electric force acting on the electron?

A downwards into the paper

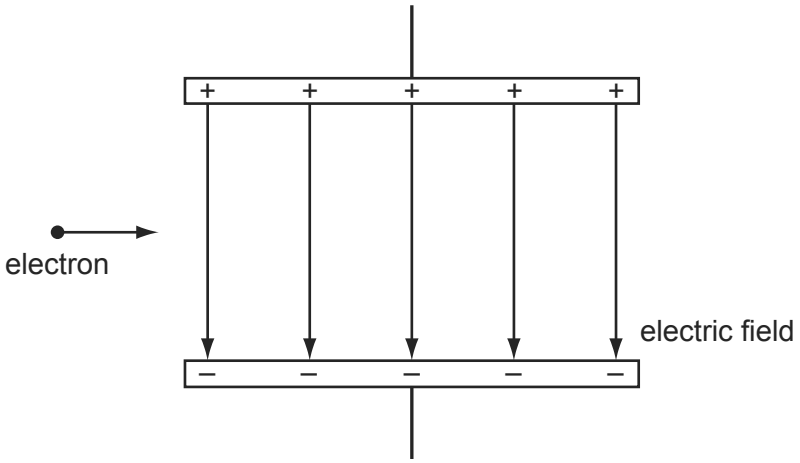
B upwards out of the paper

C to the left

D to the right

28 An electron, travelling horizontally at constant speed in a vacuum, enters a vertical electric field between two charged parallel plates as shown.

9702/01/M/J/07/Q29



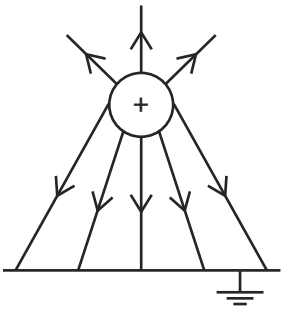
What are the horizontal and vertical components of the motion of this electron when it is in the field?

	horizontal component of motion	vertical component of motion
A	constant speed	acceleration upwards
B	constant speed	acceleration downwards
C	acceleration to the right	acceleration downwards
D	acceleration to the right	acceleration upwards

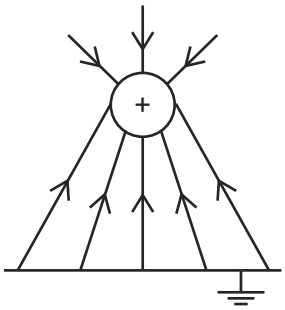
29 Which diagram shows the electric field between a positively charged metal sphere and an earthed metal plate?

9702/01/O/N/07/Q27

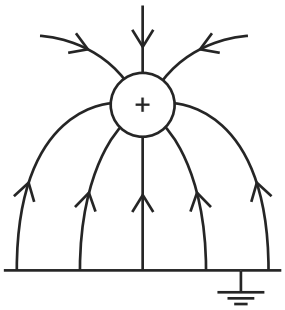
A



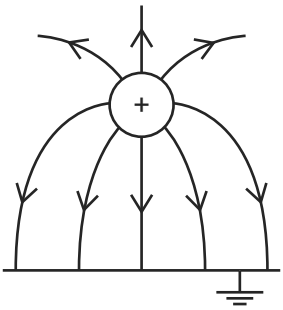
B



C

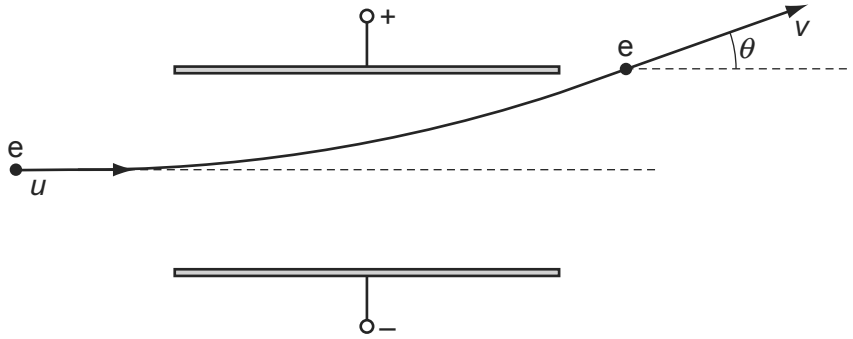


D



30 An electron enters the space between two parallel charged plates with an initial velocity u.

9702/01/M/J/08/Q30



While in the electric field, its direction changes by θ and it emerges with a velocity v.

What is the relation between v and u?

A $v = \frac{u}{\cos\theta}$ **B** $v = u\cos\theta$ **C** $v = \frac{u}{\sin\theta}$ **D** $v = u\sin\theta$

31 Which electrical quantity would be the result of a calculation in which energy transfer is divided by charge?

9702/01/O/N/07/Q28

A current

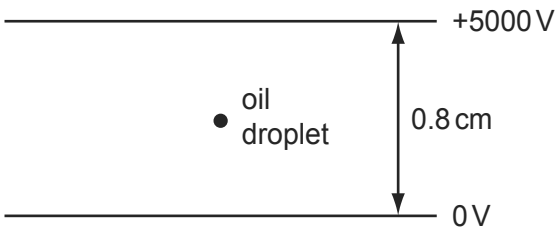
B potential difference

C power

D resistance

32 The diagram shows an oil droplet that has become charged by gaining five electrons. The droplet remains stationary between charged plates.

9702/01/M/J/08/Q31



What is the magnitude and direction of the electrostatic force on the oil droplet?

A 5.0×10^{-15} N upwards

B 5.0×10^{-15} N downwards

C 5.0×10^{-13} N upwards

D 5.0×10^{-13} N downwards

33 A particle has a charge of 4.8×10^{-19} C. The particle remains at rest between a pair of horizontal, parallel plates having a separation of 15 mm. The potential difference between the plates is 660 V. 9702/01/O/N/08/Q30

What is the weight of the particle?

A 2.1×10^{-14} N

B 2.1×10^{-15} N

C 2.1×10^{-17} N

D 1.1×10^{-23} N

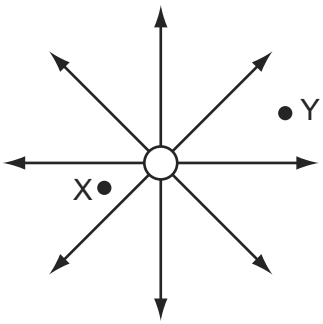
34 A small charge q is placed in the electric field of a large charge Q. 9702/11/O/N/09/Q27

Both charges experience a force F.

What is the electric field strength of the charge Q at the position of the charge q?

A $\frac{F}{Qq}$ **B** $\frac{F}{Q}$ **C** FqQ **D** $\frac{F}{q}$

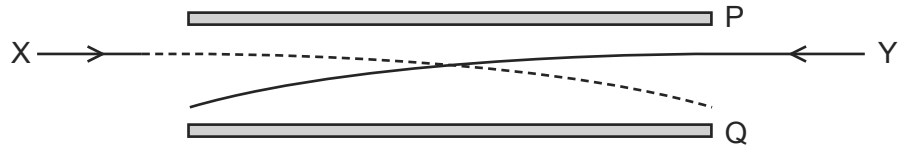
35 The diagram shows the electric field near a point charge and two electrons X and Y. 9702/01/O/N/08/Q29



Which row describes the forces acting on X and Y?

	direction of force	magnitude of force on X
A	radially inwards	less than force on Y
B	radially inwards	greater than force on Y
C	radially outwards	less than force on Y
D	radially outwards	greater than force on Y

36 The diagram shows the paths of two charged particles, X and Y, during their passage between a pair of oppositely charged metal plates, P and Q. 9702/01/M/J/09/Q27



The plates are charged such that the electric field between them is directed from Q to P.

Which charges on X and Y will produce the observed paths?

	X	Y
A	–	–
B	–	+
C	+	–
D	+	+

37 There is a potential difference between a pair of parallel plates. 9702/01/M/J/09/Q28

Which values of potential difference and separation of the plates will produce an electric field strength of the greatest value?

	potential difference	separation
A	$2V$	$2d$
B	$2V$	$\frac{d}{2}$
C	$\frac{V}{2}$	$2d$
D	$\frac{V}{2}$	$\frac{d}{2}$

38 The electric field at a certain distance from an isolated alpha particle is $3.0 \times 10^{7}\,\text{N C}^{-1}$. 9702/11/O/N/09/Q29

What is the force on an electron when at that distance from the alpha particle?

A $4.8 \times 10^{-12}\,\text{N}$

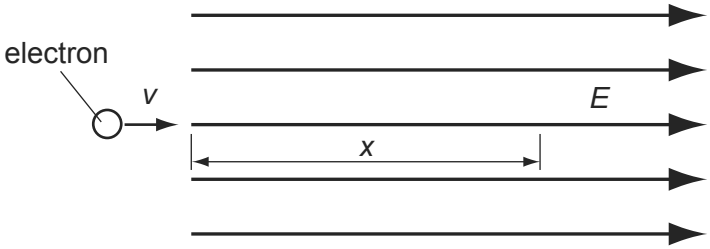
B $9.6 \times 10^{-12}\,\text{N}$

C $3.0 \times 10^{7}\,\text{N}$

D $6.0 \times 10^{7}\,\text{N}$

39 The diagram shows an electron, with charge e, mass m, and velocity v, entering a uniform electric field of strength E.

9702/01/M/J/09/Q29



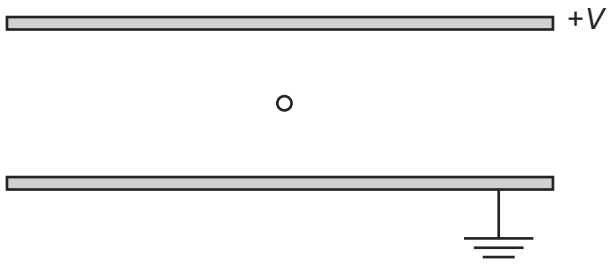
The direction of the field and the electron's motion are both horizontal and to the right.

Which expression gives the distance x through which the electron travels before it stops momentarily?

A $x = \frac{mv}{E}$ **B** $x = \frac{mv}{Ee}$ **C** $x = \frac{mv^2}{2E}$ **D** $x = \frac{mv^2}{2Ee}$

40 The diagram shows two parallel horizontal metal plates held at a potential difference V.

9702/11/O/N/09/Q28



A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

The acceleration of free fall is g and the electric field strength is E.

What is the ratio of the charge to mass of the drop, and the polarity of the charge on the drop?

	$\frac{\text{charge}}{\text{mass}}$	polarity
A	$\frac{g}{E}$	positive
B	$\frac{g}{E}$	negative
C	$\frac{E}{g}$	positive
D	$\frac{E}{g}$	negative

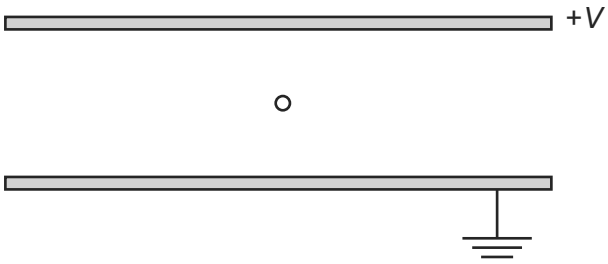
41 A small charge q is placed in the electric field of a large charge Q. 9702/12/O/N/09/Q26

Both charges experience a force F.

What is the electric field strength of the charge Q at the position of the charge q?

A $\frac{F}{Qq}$ **B** $\frac{F}{Q}$ **C** FqQ **D** $\frac{F}{q}$

42 The diagram shows two parallel horizontal metal plates held at a potential difference V. 9702/12/O/N/09/Q27



A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

The acceleration of free fall is g and the electric field strength is E.

What is the ratio of the charge to mass of the drop, and the polarity of the charge on the drop?

	$\frac{\text{charge}}{\text{mass}}$	polarity
A	$\frac{g}{E}$	positive
B	$\frac{g}{E}$	negative
C	$\frac{E}{g}$	positive
D	$\frac{E}{g}$	negative

43 The electric field at a certain distance from an isolated alpha particle is $3.0 \times 10^7\,\text{N C}^{-1}$.

What is the force on an electron when at that distance from the alpha particle? 9702/12/O/N/09/Q28

A $4.8 \times 10^{-12}\,\text{N}$

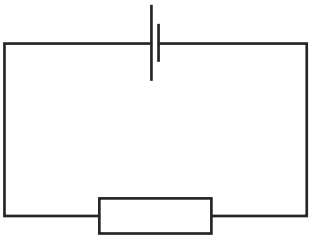
B $9.6 \times 10^{-12}\,\text{N}$

C $3.0 \times 10^7\,\text{N}$

D $6.0 \times 10^7\,\text{N}$

44 A cell is connected to a resistor. 9702/12/O/N/09/Q29

At any given moment, the potential difference across the cell is less than its electromotive force.



Which statement explains this?

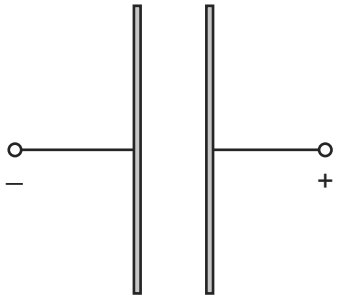
A The cell is continually discharging.

B The connecting wire has some resistance.

C Energy is needed to drive charge through the cell.

D Power is used when there is a current in the resistor.

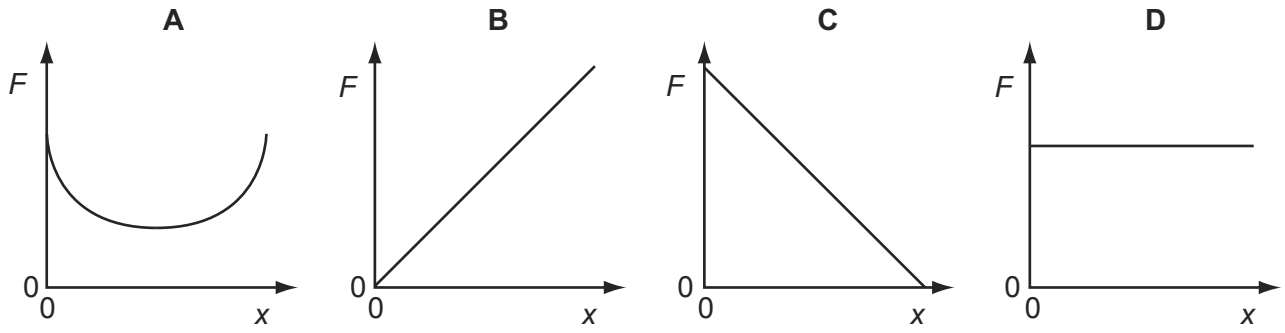
45 Two oppositely-charged parallel plates are arranged as shown. 9702/11/M/J/10/Q28



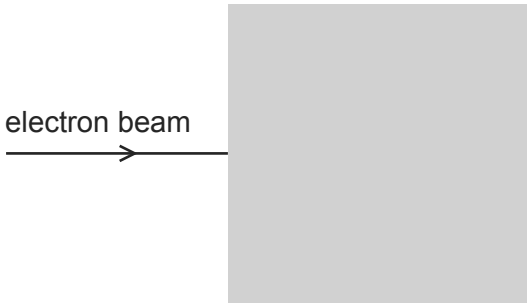
An electron is released from rest from the surface of the negatively-charged plate.

The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



46 In the diagram, the shaded area represents a uniform electric field directed away from the observer (at right-angles into the plane of the paper). 9702/11/M/J/10/Q29



A horizontal beam of electrons enters the field, travelling from left to right.

In which direction is this beam deflected by the field?

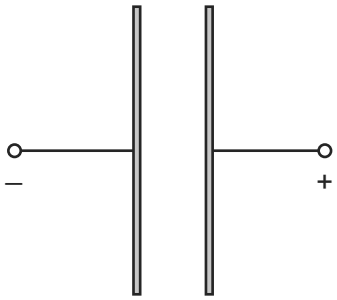
A upwards (in the plane of the paper)

B downwards (in the plane of the paper)

C away from the observer

D towards the observer

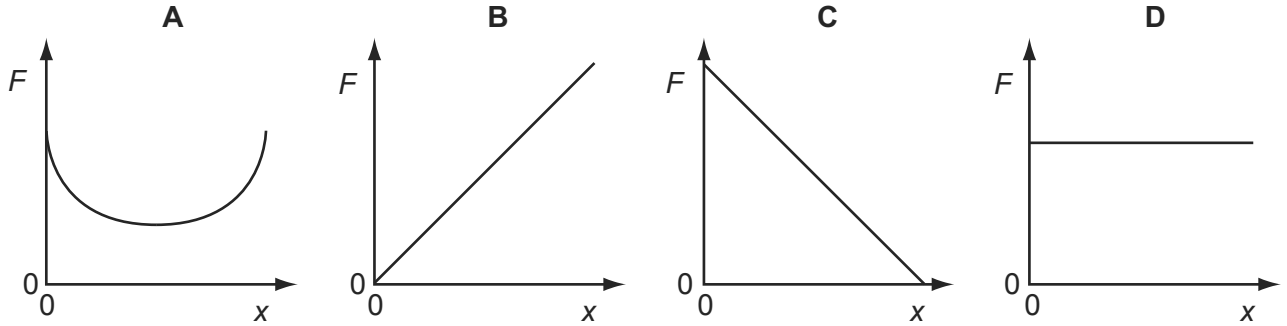
47 Two oppositely-charged parallel plates are arranged as shown. 9702/12/M/J/10/Q26



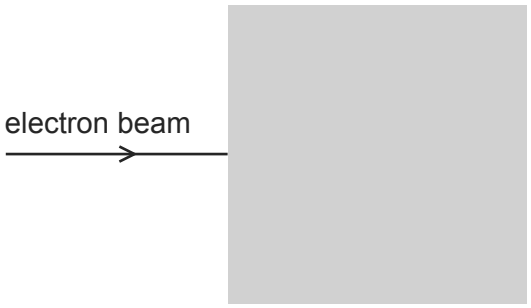
An electron is released from rest from the surface of the negatively-charged plate.

The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



48 In the diagram, the shaded area represents a uniform electric field directed away from the observer (at right-angles into the plane of the paper). 9702/12/M/J/10/Q27



A horizontal beam of electrons enters the field, travelling from left to right.

In which direction is this beam deflected by the field?

A upwards (in the plane of the paper)

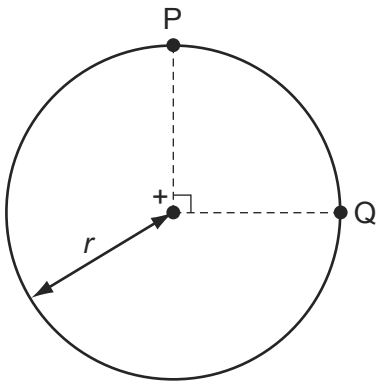
B downwards (in the plane of the paper)

C away from the observer

D towards the observer

49 The diagram shows two points P and Q which lie, 90° apart, on a circle of radius *r*. 9702/12/M/J/10/Q28

A positive point charge at the centre of the circle creates an electric field of magnitude *E* at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

50 When will 1 C of charge pass a point in an electrical circuit? 9702/12/M/J/12/Q32

A when 1 A moves through a potential difference of 1 V

B when a power of 1 W is used for 1 s

C when the current is 5 mA for 200 s

D when the current is 10 A for 10 s

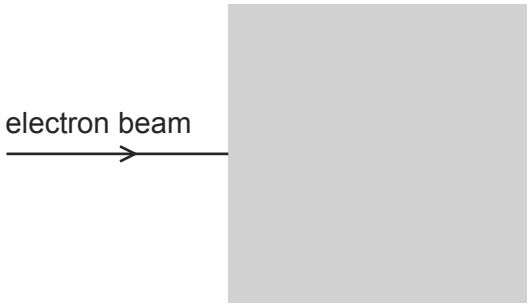
51 Which row describes the circumstances under which forces act on a charged particle in a uniform electric field?

9702/12/M/J/10/Q29

	charged particle	direction of force
A	moving charges only	parallel to the field
B	stationary charges only	perpendicular to the field
C	stationary and moving charges	parallel to the field
D	stationary and moving charges	perpendicular to the field

52 In the diagram, the shaded area represents a uniform electric field directed away from the observer (at right-angles into the plane of the paper).

9702/13/M/J/10/Q26



A horizontal beam of electrons enters the field, travelling from left to right.

In which direction is this beam deflected by the field?

A upwards (in the plane of the paper)

B downwards (in the plane of the paper)

C away from the observer

D towards the observer

53 An electron is in an electric field of strength 5×10^4 V m^{-1}. The field is the only influence on the electron.

9702/11/O/N/10/Q28

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

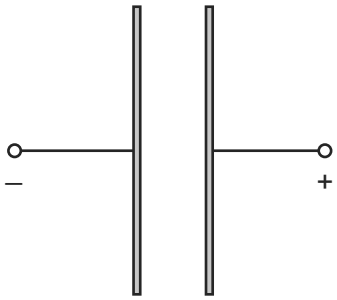
A the force on the electron

B the momentum of the electron

C the kinetic energy of the electron

D the speed of the electron

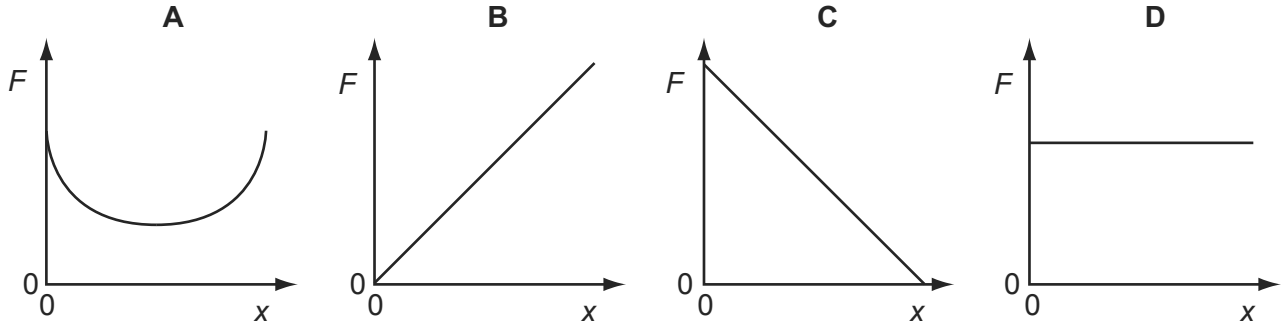
54 Two oppositely-charged parallel plates are arranged as shown. 9702/13/M/J/10/Q27



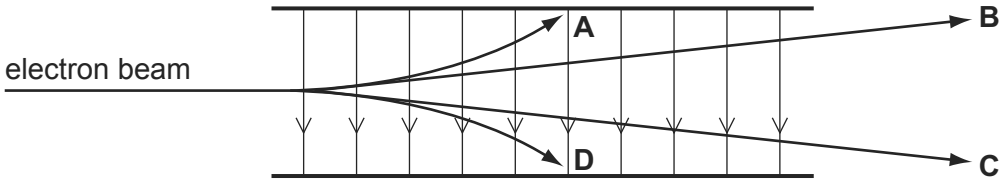
An electron is released from rest from the surface of the negatively-charged plate.

The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



55 Which path shows a possible movement of an electron in the electric field shown? 9702/12/O/N/11/Q30

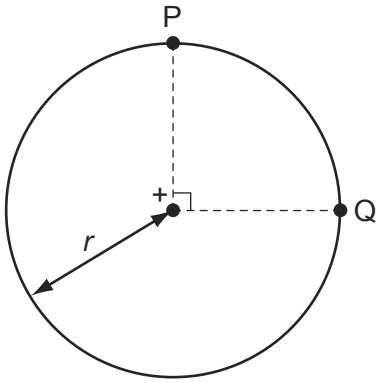


56 Which row describes the circumstances under which forces act on a charged particle in a uniform electric field? 9702/13/M/J/10/Q28

	charged particle	direction of force
A	moving charges only	parallel to the field
B	stationary charges only	perpendicular to the field
C	stationary and moving charges	parallel to the field
D	stationary and moving charges	perpendicular to the field

57 The diagram shows two points P and Q which lie, 90° apart, on a circle of radius *r*. 9702/13/M/J/10/Q29

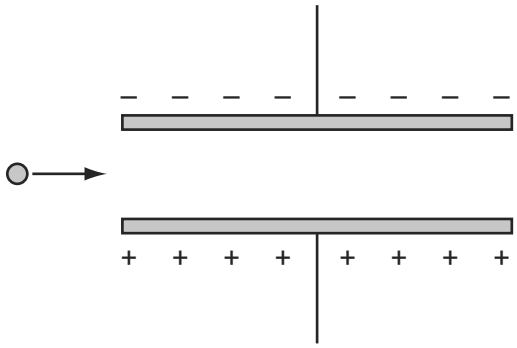
A positive point charge at the centre of the circle creates an electric field of magnitude *E* at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

58 The diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum. 9702/13/M/J/11/Q30

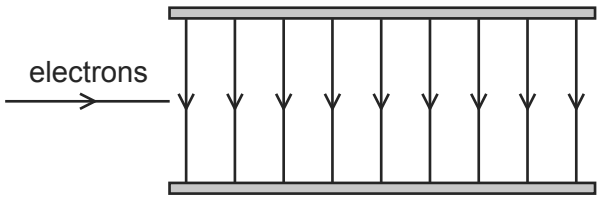


Which row describes the horizontal and vertical components of its motion as it travels between the plates?

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

59 Electrons are accelerated and then directed into the uniform electric field between two parallel plates in a vacuum.

9702/11/O/N/10/Q29



What best describes the shape of the path followed by the electrons in the field?

A a downwards curve along a line that is part of a circle

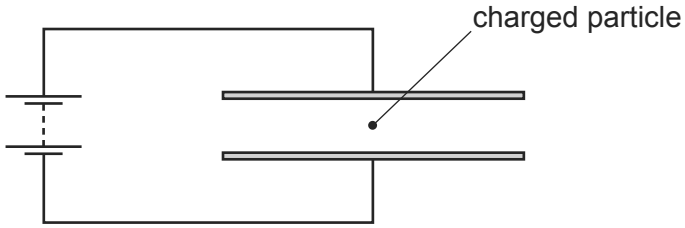
B a downwards curve along a line that is **not** part of a circle

C an upwards curve along a line that is part of a circle

D an upwards curve along a line that is **not** part of a circle

60 A charged particle is in the electric field between two horizontal metal plates connected to a source of constant potential difference, as shown. There is a force F on the particle due to the electric field.

9702/11/O/N/10/Q30



The separation of the plates is doubled.

What will be the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

61 What describes the electric potential difference between two points in a wire that carries a current?

9702/12/M/J/11/Q32

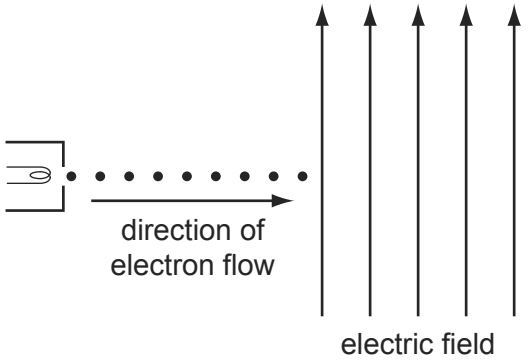
A the force required to move a unit positive charge between the points

B the ratio of the energy dissipated between the points to the current

C the ratio of the power dissipated between the points to the current

D the ratio of the power dissipated between the points to the charge moved

62 The diagram shows a vertical uniform electric field in a vacuum. 9702/12/O/N/10/Q28

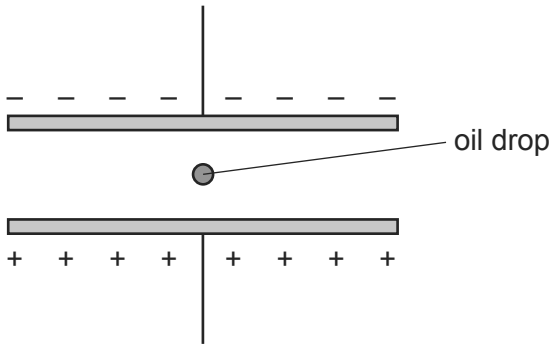


An electron gun injects a beam of electrons horizontally into the field.

Which changes, if any, have occurred to the path and speed of the electrons by the time the beam leaves the field?

	path of electrons	speed of electrons
A	deflected downwards	increased
B	deflected downwards	unchanged
C	deflected upwards	increased
D	deflected upwards	unchanged

63 A very small oil drop of mass m carries a charge $+q$. 9702/12/O/N/10/Q29



The potential difference across the plates is V and the separation is d.

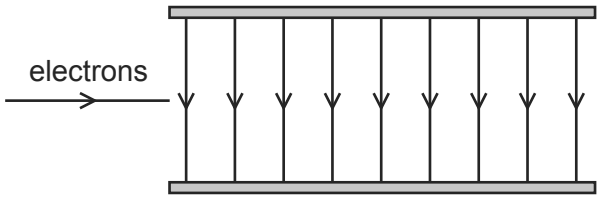
The weight of the drop is balanced by the electric force. (Buoyancy forces may be considered to be negligible.)

Which formula gives the charge on the drop?

A $q = \frac{mgd}{V}$ **B** $q = \frac{mgV}{d}$ **C** $q = \frac{Vd}{mg}$ **D** $q = \frac{V}{mgd}$

64 Electrons are accelerated and then directed into the uniform electric field between two parallel plates in a vacuum.

9702/13/O/N/10/Q28



What best describes the shape of the path followed by the electrons in the field?

A a downwards curve along a line that is part of a circle

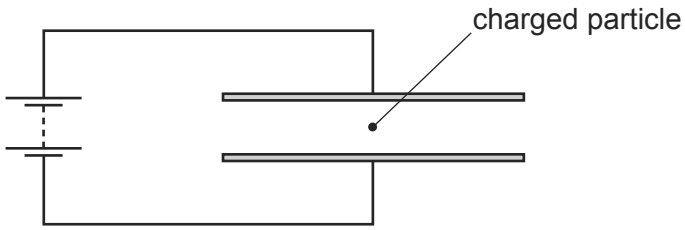
B a downwards curve along a line that is **not** part of a circle

C an upwards curve along a line that is part of a circle

D an upwards curve along a line that is **not** part of a circle

65 A charged particle is in the electric field between two horizontal metal plates connected to a source of constant potential difference, as shown. There is a force F on the particle due to the electric field.

9702/13/O/N/10/Q29



The separation of the plates is doubled.

What will be the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

66 An electron is in an electric field of strength 5×10^4 V m^{-1}. The field is the only influence on the electron.

9702/13/O/N/10/Q30

The mass and charge of an electron are known.

Which quantity can be calculated without any more information?

A the force on the electron

B the momentum of the electron

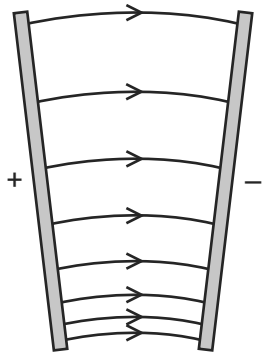
C the kinetic energy of the electron

D the speed of the electron

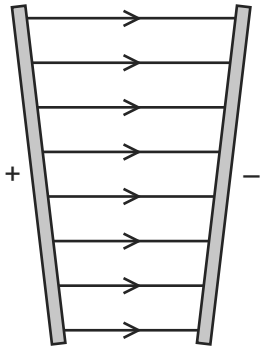
67 A potential difference is applied between two metal plates that are **not** parallel. 9702/11/M/J/11/Q28

Which diagram shows the electric field between the plates?

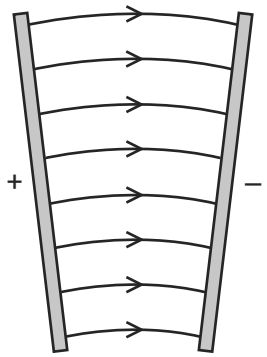
A



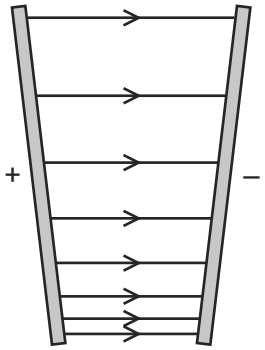
B



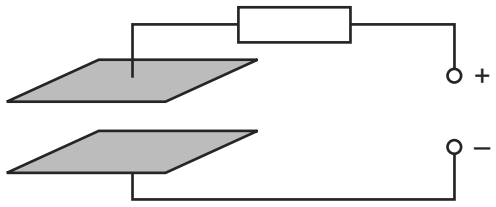
C



D



68 The diagram shows two parallel metal plates connected to a d.c. power supply through a resistor. 9702/12/M/J/11/Q30



There is a uniform electric field in the region between the plates.

Which change would cause a **decrease** in the strength of the electric field?

A a small increase in the distance between the plates

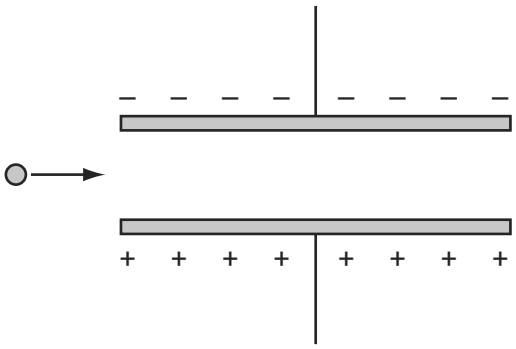
B a small increase in the potential difference between the plates

C a small increase in the value of the resistor

D a small increase to the area of both plates

69 The diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

9702/11/M/J/11/Q29



Which row describes the horizontal and vertical components of its motion as it travels between the plates?

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

70 Two parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV.

9702/11/M/J/11/Q30

What is the force on an electron when it is in the uniform electric field between the plates?

A 4.8×10^{-20} N

B 7.7×10^{-20} N

C 4.8×10^{-17} N

D 7.7×10^{-14} N

71 A battery is marked 9.0 V.

9702/13/M/J/11/Q31

What does this mean?

A Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

B The battery supplies 9.0 J to an external circuit for each coulomb of charge.

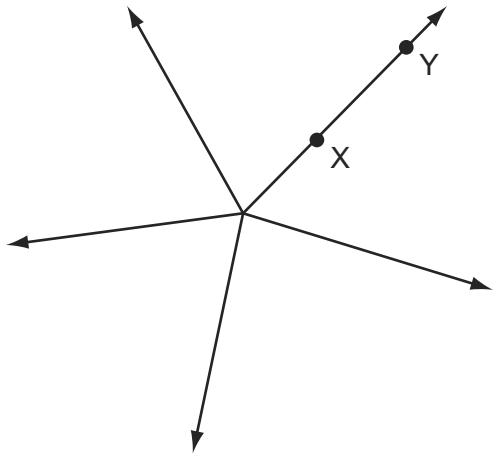
C The potential difference across any component connected to the battery will be 9.0 V.

D There will always be 9.0 V across the battery terminals.

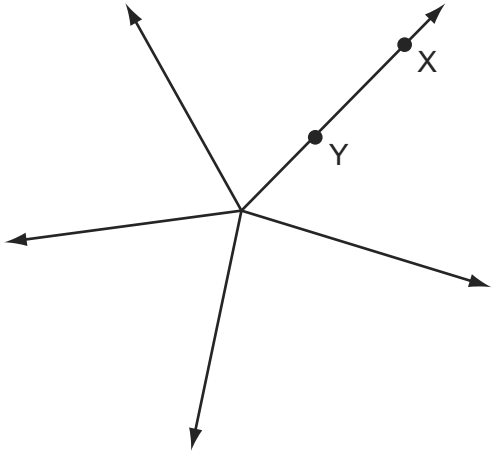
72 In each electric field diagram, a positively charged particle is moved from X to Y. 9702/12/M/J/11/Q31

In which diagram would the particle experience an increasing repulsive force?

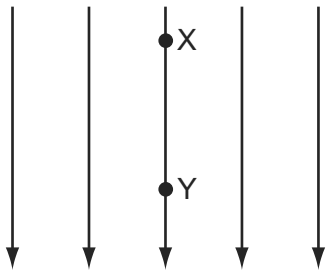
A



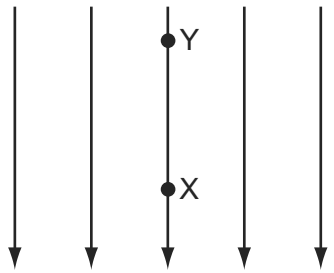
B



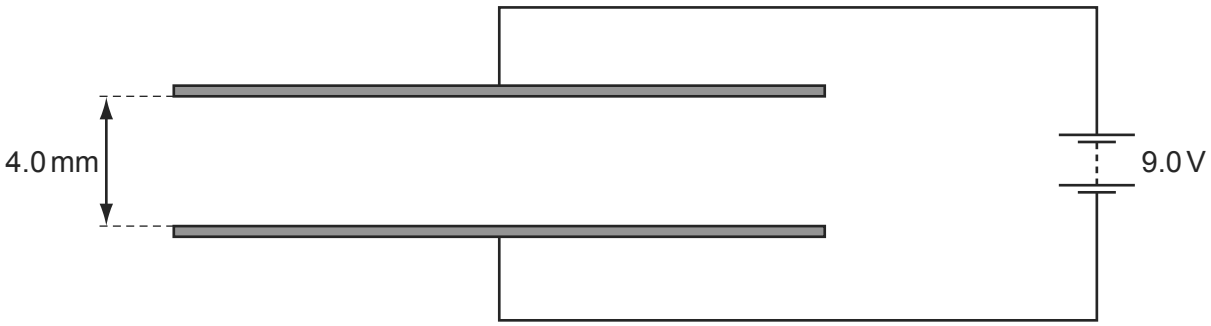
C



D



73 The diagram shows a pair of parallel metal plates 4.0 mm apart connected to a 9.0 V battery. 9702/12/O/N/11/Q29



What is the electric field strength between the plates?

A $4.4 \times 10^{-4}\,\text{N C}^{-1}$

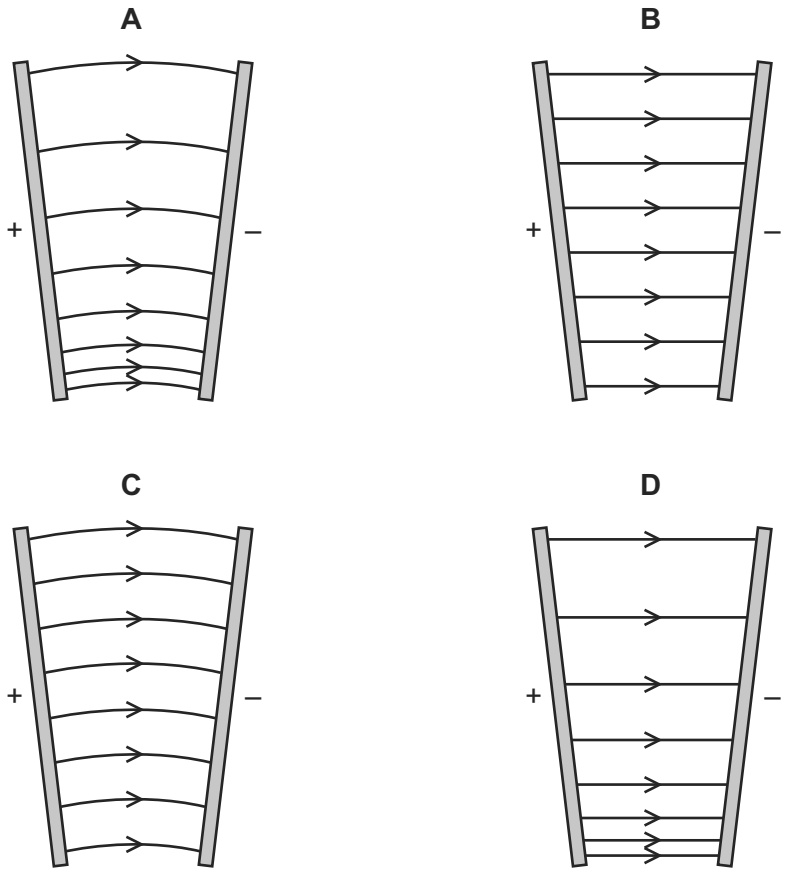
B $3.6 \times 10^{-2}\,\text{N C}^{-1}$

C $36\,\text{N C}^{-1}$

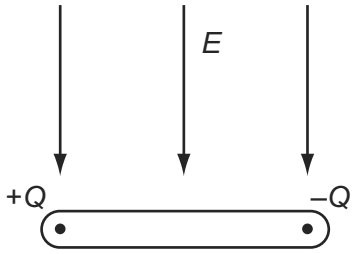
D $2.3 \times 10^{3}\,\text{N C}^{-1}$

74 A potential difference is applied between two metal plates that are **not** parallel. 9702/13/M/J/11/Q29

Which diagram shows the electric field between the plates?



75 The diagram shows an insulating rod with equal and opposite point charges at each end. An electric field of strength *E* acts on the rod in a downwards direction. 9702/11/O/N/11/Q32



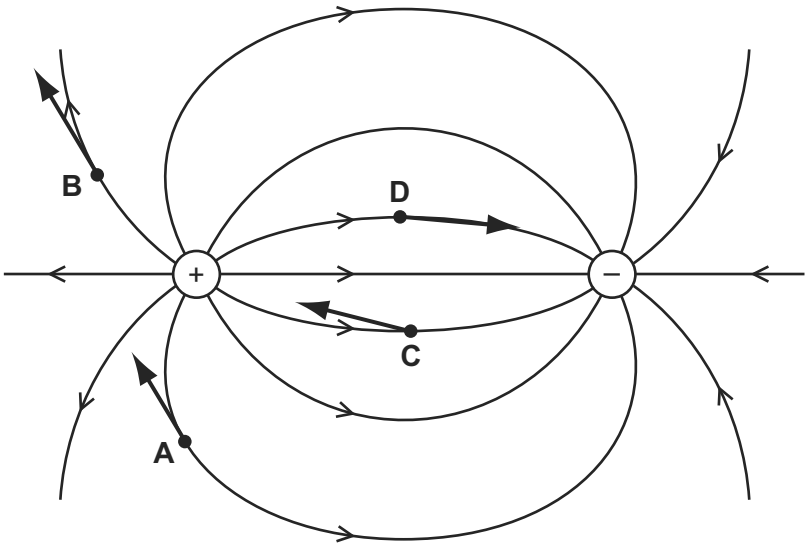
Which row is correct?

	resultant force	resultant torque
A	zero	clockwise
B	downwards	clockwise
C	zero	anti-clockwise
D	downwards	anti-clockwise

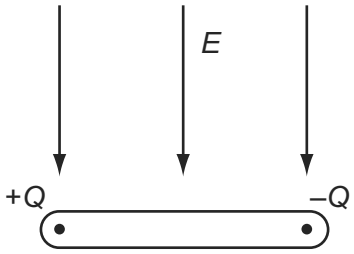
76 The diagram shows a non-uniform electric field near a positively charged and a negatively charged sphere. 9702/12/O/N/11/Q31

Four electrons, **A**, **B**, **C** and **D**, are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?



77 The diagram shows an insulating rod with equal and opposite point charges at each end. An electric field of strength *E* acts on the rod in a downwards direction. 9702/13/O/N/11/Q31

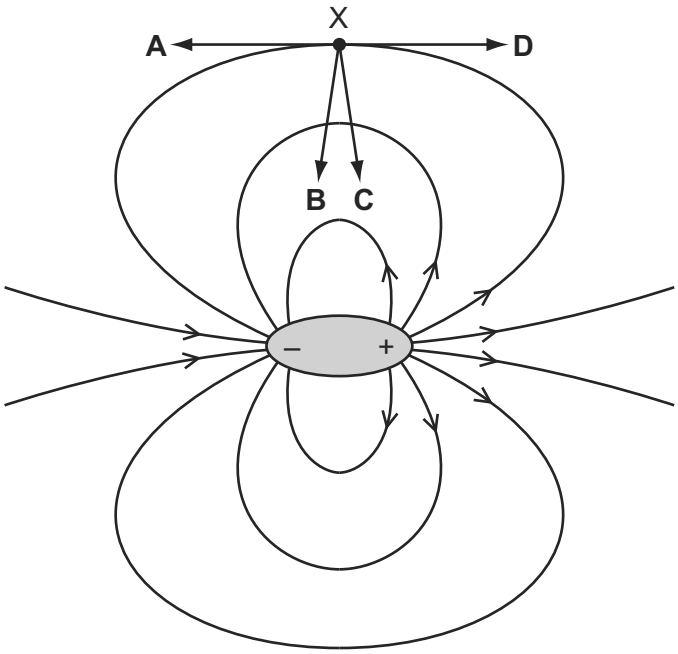


Which row is correct?

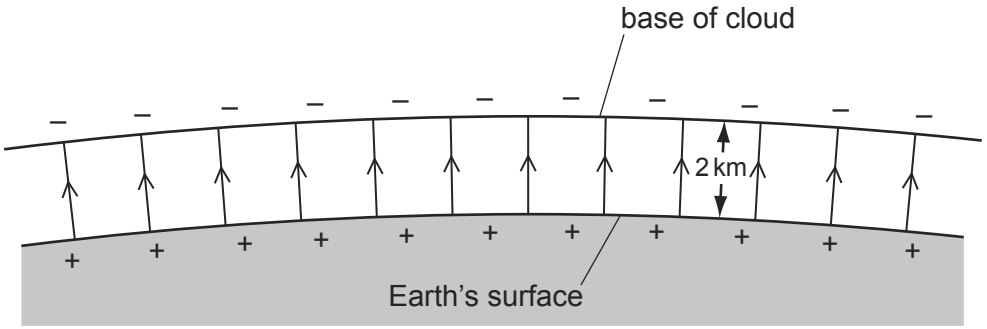
	resultant force	resultant torque
A	zero	clockwise
B	downwards	clockwise
C	zero	anti-clockwise
D	downwards	anti-clockwise

78 A dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of a dipole is shown below. 9702/11/M/J/12/Q31

In which direction does the force act on an electron when at point X?



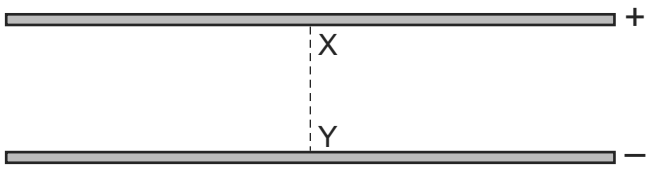
79 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kN C^{-1}. The diagram shows the electric field between the base of a cloud and the Earth's surface. 9702/11/M/J/12/Q32



What is the minimum potential difference between the Earth and the base of a cloud, 2 km high, for lightning to occur?

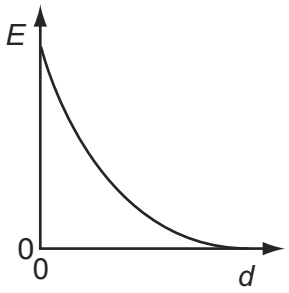
A 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV

80 An electric field exists in the space between two charged metal plates. 9702/12/M/J/12/Q31

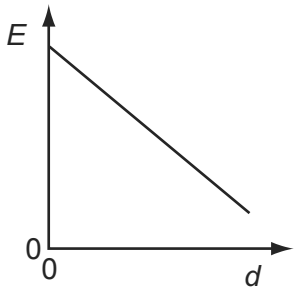


Which graph shows the variation of electric field strength E with distance d from X along the line XY?

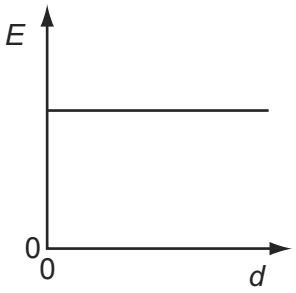
A



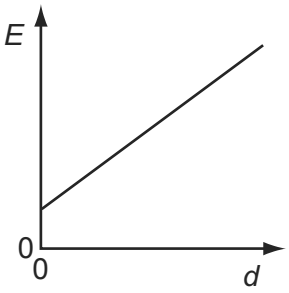
B



C



D



81 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V. 9702/13/O/N/11/Q32

What is the electric field strength E at a point midway between the plates?

A $1.0 \times 10^4\,\text{V m}^{-1}$ downwards

B $1.0 \times 10^4\,\text{V m}^{-1}$ upwards

C $2.0 \times 10^4\,\text{V m}^{-1}$ downwards

D $2.0 \times 10^4\,\text{V m}^{-1}$ upwards

82 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V. 9702/11/O/N/11/Q31

What is the electric field strength E at a point midway between the plates?

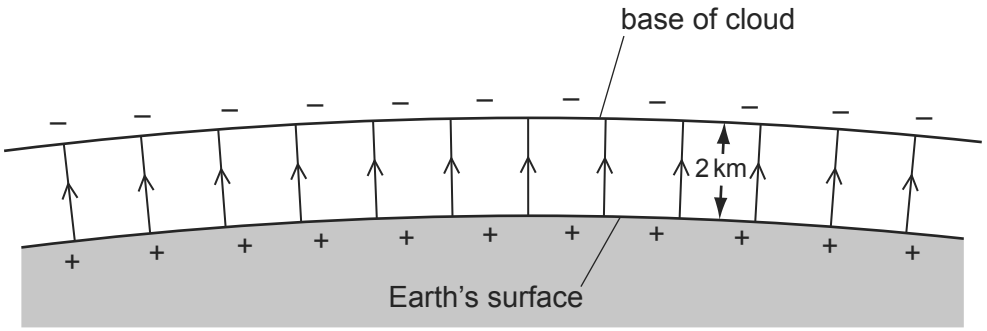
A $1.0 \times 10^4\,\text{V m}^{-1}$ downwards

B $1.0 \times 10^4\,\text{V m}^{-1}$ upwards

C $2.0 \times 10^4\,\text{V m}^{-1}$ downwards

D $2.0 \times 10^4\,\text{V m}^{-1}$ upwards

83 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kN C^{-1}. The diagram shows the electric field between the base of a cloud and the Earth's surface. 9702/13/M/J/12/Q33

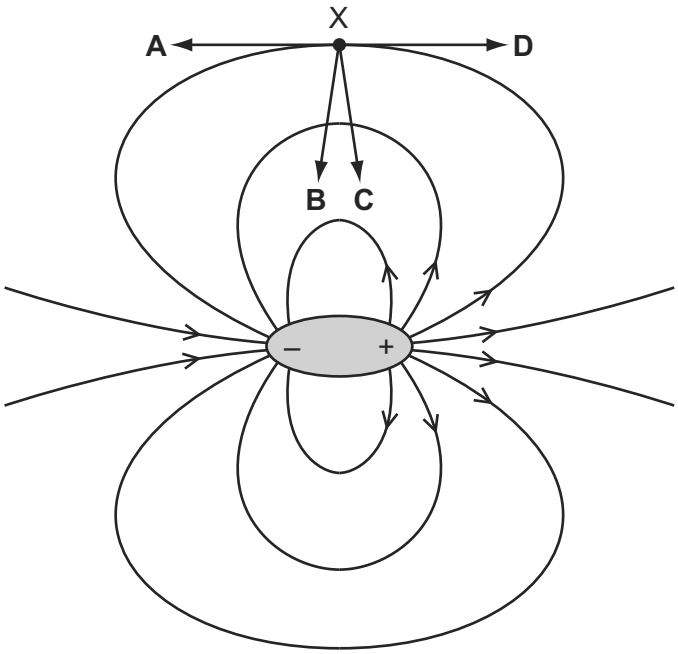


What is the minimum potential difference between the Earth and the base of a cloud, 2 km high, for lightning to occur?

A 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV

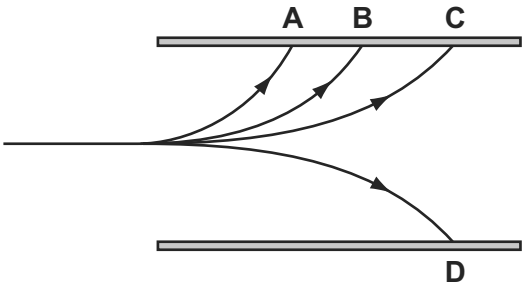
84 A dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of a dipole is shown below. 9702/13/M/J/12/Q31

In which direction does the force act on an electron when at point X?



85 A single proton travelling with a constant horizontal velocity enters a uniform electric field between two parallel charged plates. In the diagram, **B** shows the path taken by the proton.

Which path is taken by a helium nucleus that enters the electric field at the same point and with the same velocity as the proton? 9702/12/O/N/12/Q33



86 A charged particle moves in a uniform electric field between two parallel metal plates.

To calculate the force acting on the particle due to the electric field, which quantity is **not** required? 9702/12/O/N/12/Q32

A particle charge

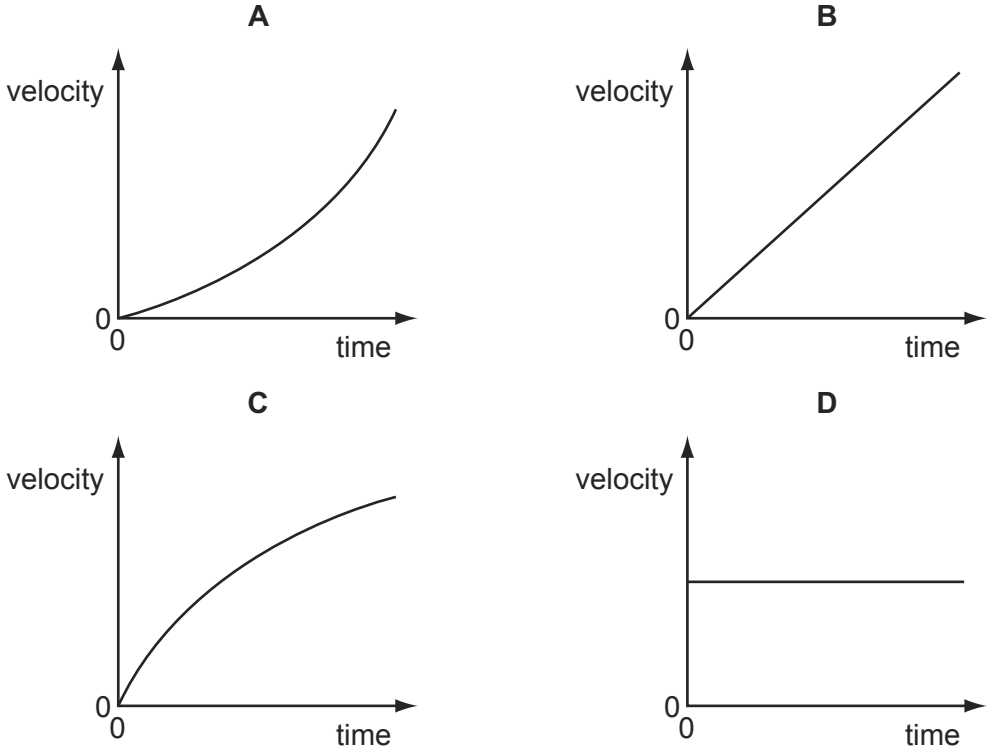
B particle speed

C plate separation

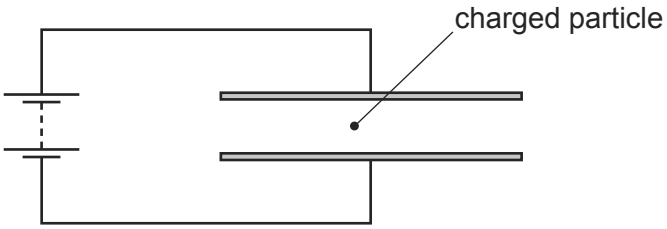
D potential difference between the plates

87 An electron is initially at rest in a uniform electric field. 9702/11/O/N/12/Q30

Which graph shows the variation with time of the velocity of the electron?



88 A charged particle is in the electric field between two horizontal metal plates connected to a source of constant potential difference, as shown. 9702/11/O/N/12/Q31



There is a force F on the particle due to the electric field.

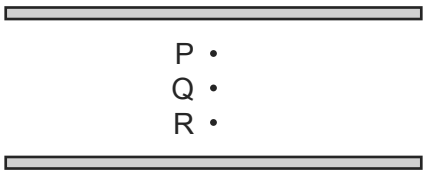
The separation of the plates is doubled.

What will be the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

89 The diagram shows two parallel plates. 9702/13/O/N/12/Q30

The plates are charged so that there is an electric field between them. P, Q and R are points which are $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of the distance from the top plate to the bottom plate.



What is the electric field strength at point P?

A the same as that at point Q

B twice that at point R

C half that at point R

D one third that at point Q

90 A positive charge of 2.6×10^{-8} C is in an electric field of constant field strength 300 000 V m^{-1}.

How much work must be done on the charge in order to move it a distance of 4.0 mm in the opposite direction to the direction of the field? 9702/13/O/N/12/Q31

A 3.1×10^{-5} J

B 2.0×10^{-3} J

C 3.1×10^{-2} J

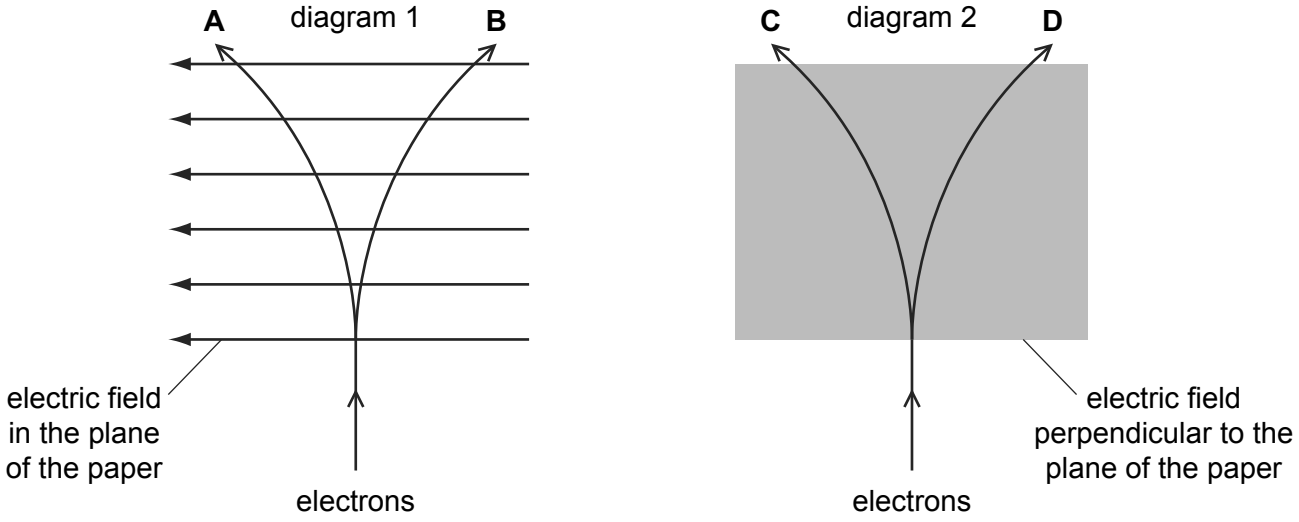
D 2.0 J

91 A beam of electrons is directed into an electric field and is deflected by it. 9702/11/M/J/13/Q30

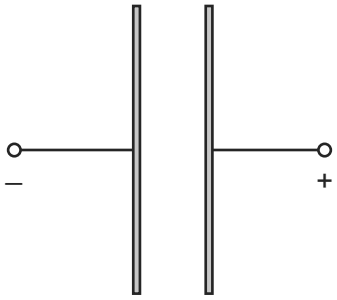
Diagram 1 represents an electric field in the plane of the paper.
Diagram 2 represents an electric field directed perpendicular to the plane of the paper.

The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of the electrons inside the field?



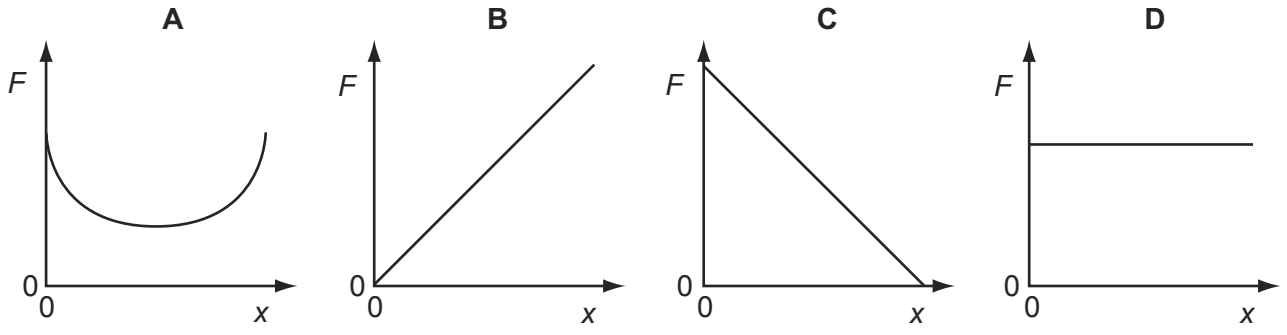
92 Two oppositely-charged parallel plates are arranged as shown. 9702/11/M/J/13/Q31



An electron is released from rest from the surface of the negatively-charged plate.

The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force *F* on the electron varies with its distance *x* from the negative plate?



93 Two conducting layers of a liquid crystal display of a calculator are 8 μm apart. A 1.5 V cell is connected across the conducting layers when the calculator is switched on. 9702/12/M/J/13/Q30

What is the electric field strength between the layers?

A $1.2 \times 10^{-5}\,V\,m^{-1}$

B $0.19\,V\,m^{-1}$

C $12\,V\,m^{-1}$

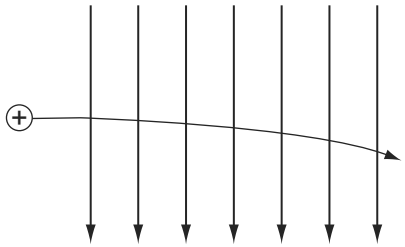
D $1.9 \times 10^{5}\,V\,m^{-1}$

94 A positively-charged particle is projected into a uniform electric field. 9702/12/M/J/13/Q31

Which diagram represents the path of the particle in the electric field?

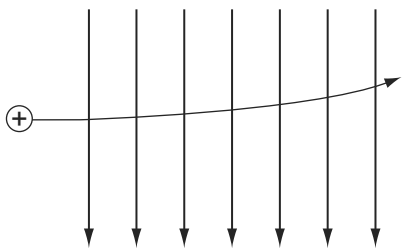
A

electric field in plane of the paper



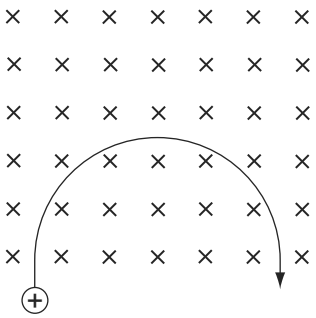
B

electric field in plane of the paper



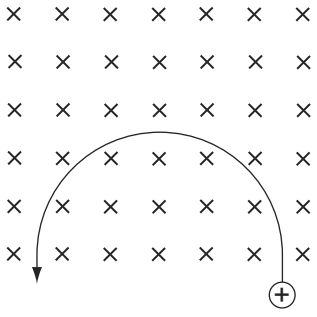
C

electric field into paper

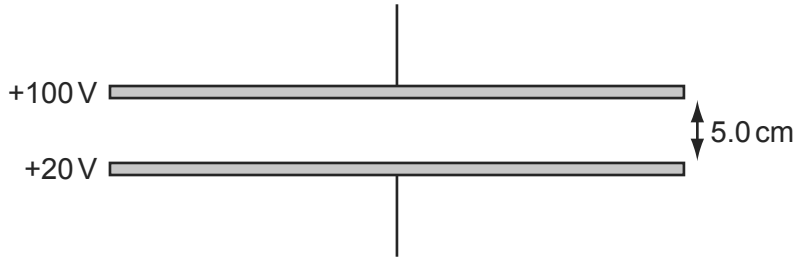


D

electric field into paper



95 Two metal plates are held horizontal and parallel, 5.0 cm apart. The plates are at potentials of +100 V and +20 V. 9702/13/M/J/13/Q29



What is the force experienced by an electron in the electric field between the plates?

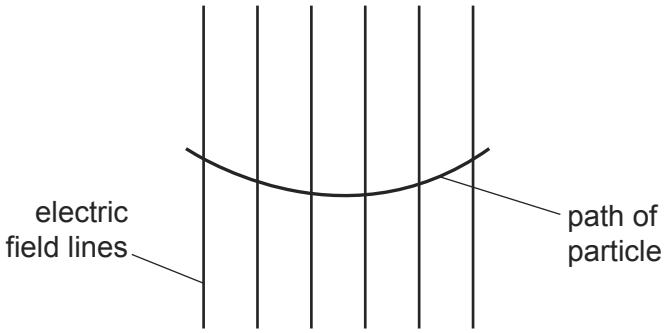
A 2.6×10^{-18} N

B 3.8×10^{-18} N

C 2.6×10^{-16} N

D 3.8×10^{-16} N

96 The diagram shows the path of a charged particle through a uniform electric field, having vertical field lines. 9702/13/M/J/13/Q30



What could give a path of this shape?

A a positive charge travelling left to right in a field directed downwards

B a positive charge travelling right to left in a field directed downwards

C a negative charge travelling right to left in a field directed upwards

D a negative charge travelling left to right in a field directed downwards

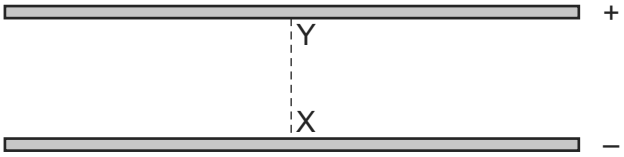
97 A small charge q is placed in the electric field of a large charge Q. 9702/13/O/N/13/Q31

Both charges experience a force F.

What is the electric field strength of the charge Q at the position of the charge q?

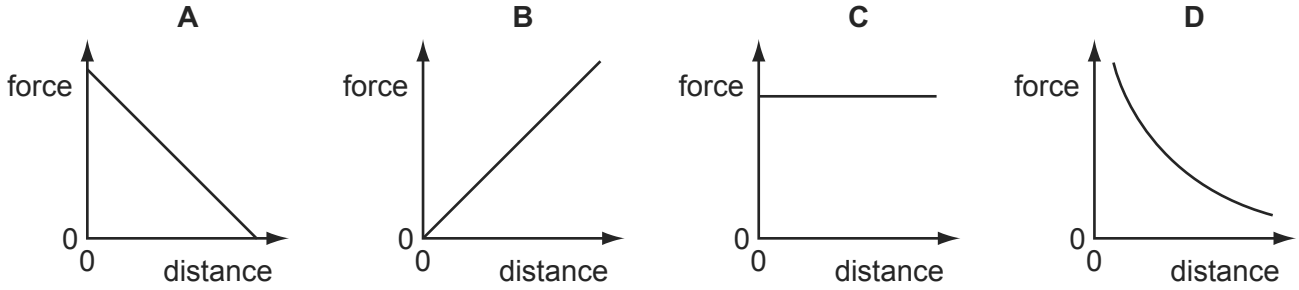
A $\frac{F}{Qq}$ **B** $\frac{F}{Q}$ **C** FqQ **D** $\frac{F}{q}$

98 Two charged parallel metal plates produce an electric field. 9702/13/O/N/13/Q30

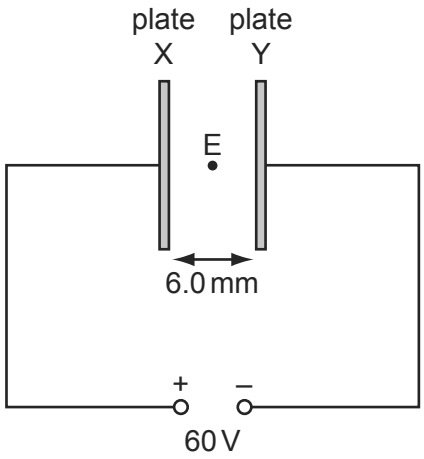


A charged particle moves from X to Y.

Which graph shows the variation of the force on the particle with distance from X along the line XY?



99 Two vertical conducting plates X and Y are positioned so that they are separated by a distance of 6.0 mm in air. A 60 V d.c. supply is connected as shown. 9702/11/O/N/13/Q31



What is the electric field strength at E, a point midway between the plates?

A $1.0 \times 10^4\,V\,m^{-1}$ towards X

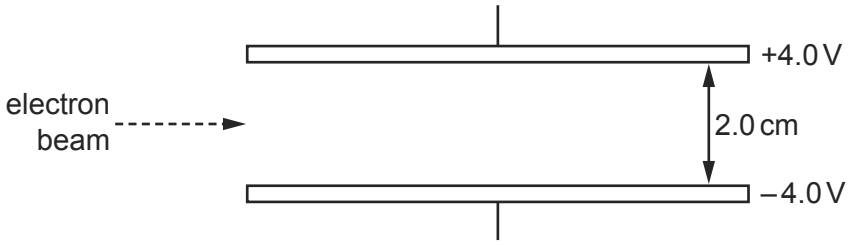
B $1.0 \times 10^4\,V\,m^{-1}$ towards Y

C $2.0 \times 10^4\,V\,m^{-1}$ towards X

D $2.0 \times 10^4\,V\,m^{-1}$ towards Y

100 A horizontal beam of electrons is passed between two horizontal parallel plates, 2.0 cm apart, as shown.

9702/11/M/J/14/Q28



The upper plate has an electrical potential of +4.0 V, and the lower plate has an electrical potential of –4.0 V.

What is the force on each electron when between the plates?

A 3.2×10^{-17} N downwards

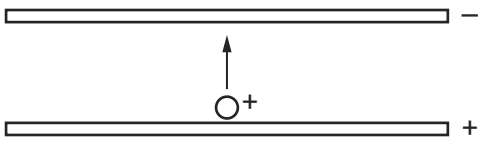
B 3.2×10^{-19} N upwards

C 6.4×10^{-19} N downwards

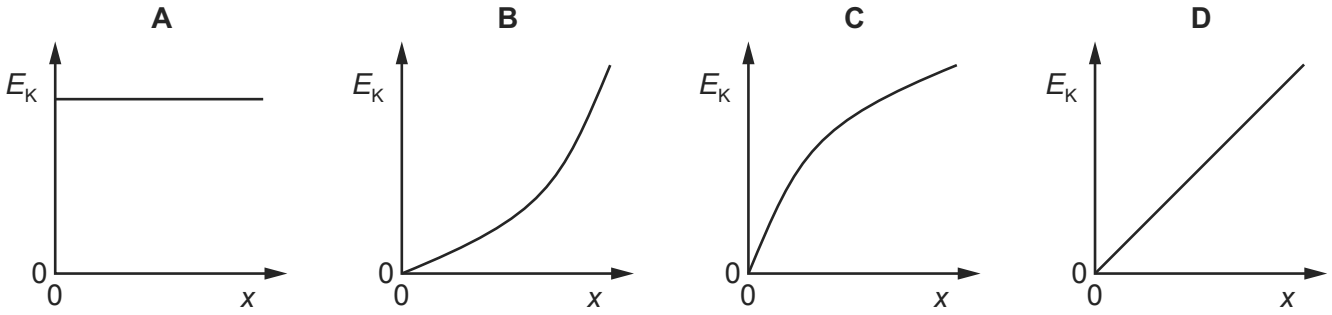
D 6.4×10^{-17} N upwards

101 Two oppositely-charged horizontal metal plates are placed in a vacuum. A positively-charged particle starts from rest and moves from one plate to the other plate, as shown.

9702/12/M/J/14/Q29

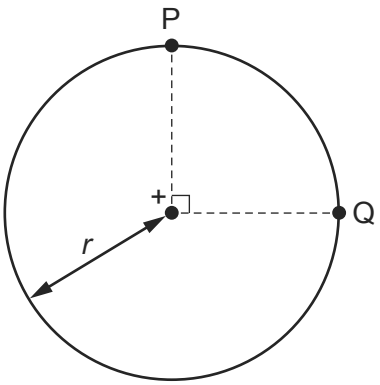


Which graph shows how the kinetic energy E_K of the particle varies with the distance x moved from the positive plate?



102 The diagram shows two points P and Q which lie 90° apart on a circle of radius *r*. 9702/11/M/J/14/Q29

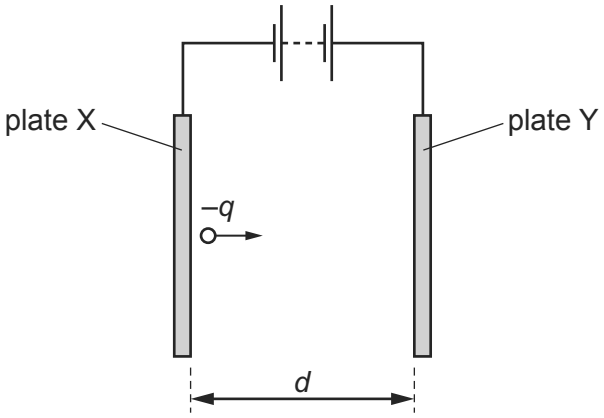
A positive point charge at the centre of the circle creates an electric field of magnitude *E* at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

103 Two parallel plates X and Y are separated by a distance *d* in a vacuum. There is a potential difference between the plates so that a uniform electric field is produced. 9702/13/M/J/14/Q32



A charge –*q* moves from rest from the surface of plate X and travels towards plate Y.

When the charge reaches plate Y it has kinetic energy *K*.

Which expression gives the electric field strength between the plates?

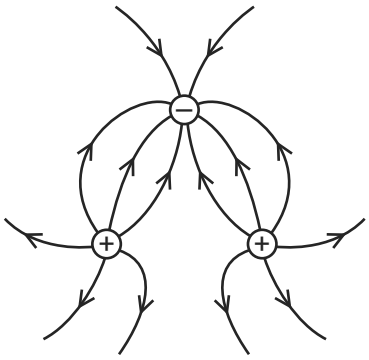
A $\frac{q}{Kd}$ **B** $\frac{qd}{K}$ **C** $\frac{K}{qd}$ **D** $\frac{Kd}{q}$

104 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

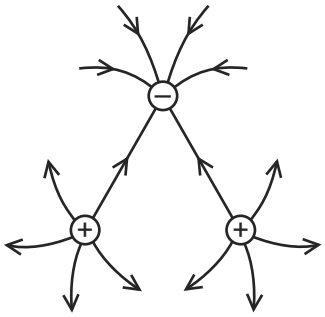
9702/12/M/J/14/Q28

Which diagram best represents the electric field surrounding the charges?

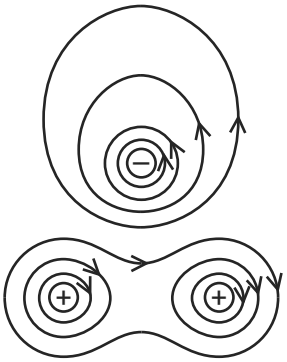
A



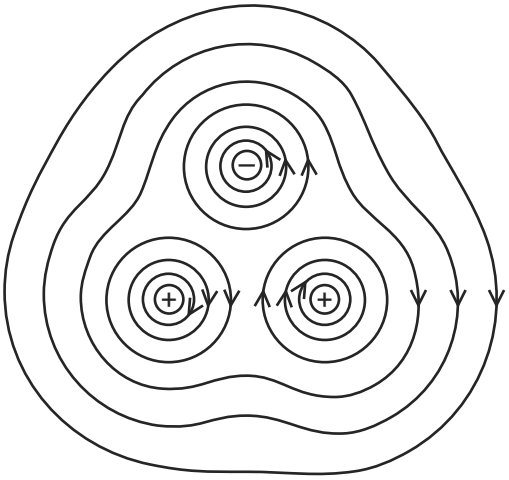
B



C



D



105 A particle is in a uniform field. The particle experiences a force in the opposite direction to the field.

9702/11/O/N/13/Q13

Which field is the particle in, and on which property of the particle is the field acting?

	field	property of particle on which the field acts
A	electric	charge
B	electric	current
C	gravitational	mass
D	gravitational	weight

106 Two parallel metal plates have a potential difference between them of 12 V. The distance between the plates is 1.0 mm.

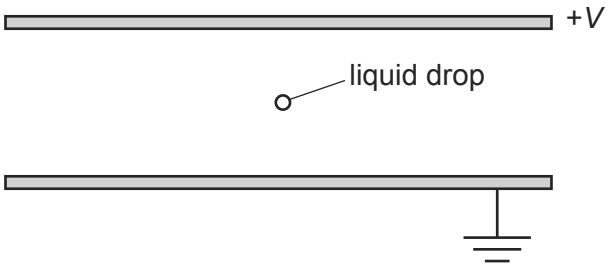
9702/11/O/N/13/Q32

What are the electric field strength between the plates and the work done on a charge of +3.9 μC to move the charge from the negative plate to the positive plate?

	electric field strength / N C^{-1}	work done / J
A	12	4.7×10^{-5}
B	12	47
C	12 000	4.7×10^{-5}
D	12 000	47

107 The diagram shows two parallel horizontal metal plates. There is a potential difference *V* between the plates.

9702/11/O/N/14/Q28



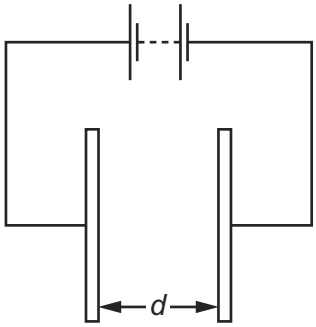
A small charged liquid drop, midway between the plates, is held in equilibrium by the combination of its weight and the electric force acting on it.

The acceleration of free fall is *g* and the electric field strength is *E*.

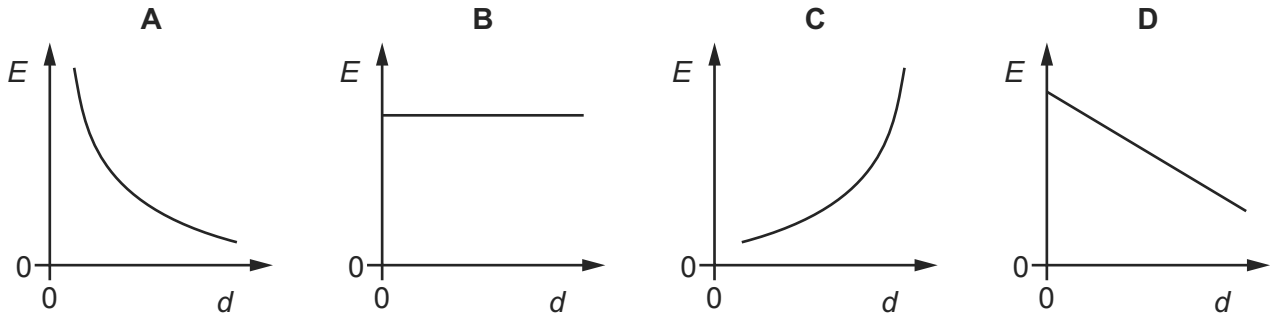
What is the polarity of the charge on the drop, and the ratio of charge to mass of the drop?

	polarity	$\frac{\text{charge}}{\text{mass}}$
A	negative	$\frac{E}{g}$
B	negative	$\frac{g}{E}$
C	positive	$\frac{E}{g}$
D	positive	$\frac{g}{E}$

108 The diagram shows two metal plates connected to a constant high voltage. 9702/11/O/N/14/Q29

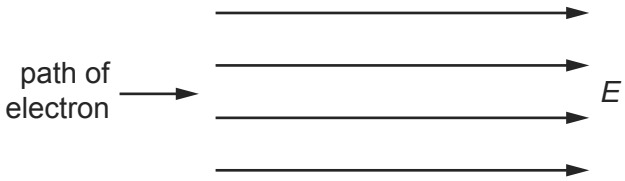


Which graph shows the variation of the electric field strength E midway between the two plates as the distance d between the two plates is increased?



109 An electron enters a region of space where there is a uniform electric field E as shown.

9702/13/M/J/14/Q31



Initially, the electron is moving parallel to, and in the direction of, the electric field.

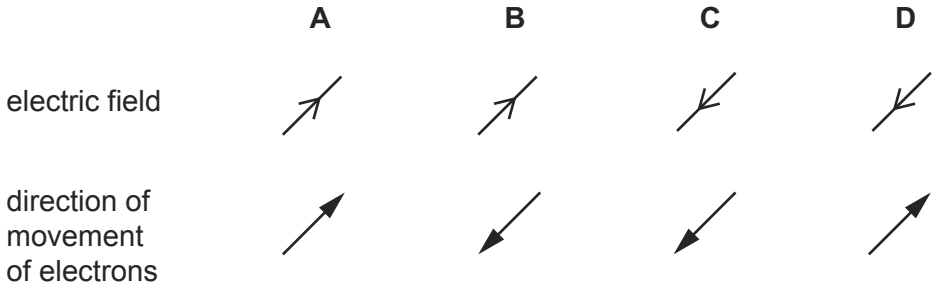
What is the subsequent path and change of speed of the electron?

	path of electron	speed of electron
A	linear	decreases
B	linear	increases
C	parabolic	decreases
D	parabolic	increases

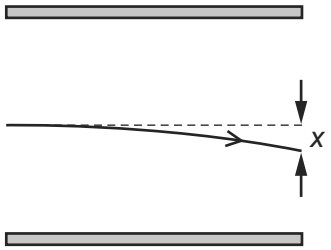
110 Regions of unbalanced charge are produced inside a cloud as shown. 9702/13/O/N/14/Q31



For the region X, which diagram correctly represents the direction of the electric field and the initial direction in which electrons would move?



111 The path of an electron with initial speed v in the uniform electric field between two parallel plates is shown. 9702/13/O/N/14/Q32



The vertical deflection x is measured at the right-hand edge of the plates.

The distance between the plates is halved. The potential difference between the plates remains the same.

What will be the new deflection of the electron with the same initial speed v?

A x **B** $\sqrt{2}x$ **C** $2x$ **D** $4x$

112 Which unit is **not** used in either the definition of the coulomb or the definition of the volt? 9702/12/M/J/15/Q31

A ampere

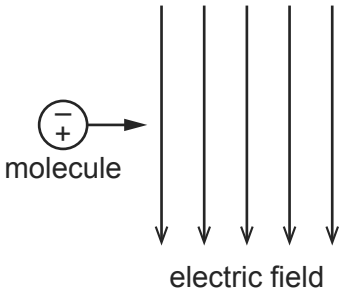
B joule

C ohm

D second

113 A molecule behaves as an electric dipole consisting of two equal point charges, of opposite sign, separated by a fixed distance. The molecule moves with constant horizontal velocity as it enters a vertical uniform electric field, as shown.

9702/13/M/J/15/Q30



The positive and negative charges of the molecule enter the field at the same time.

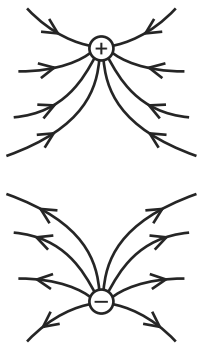
Which row describes the velocity of the molecule in the field?

	horizontal component of velocity	vertical component of velocity
A	constant	increases
B	constant	zero
C	increases	increases
D	increases	zero

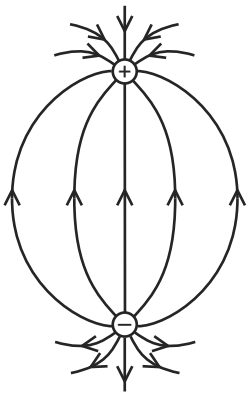
114 Which diagram best represents the electric field between two point charges of equal magnitude and opposite sign?

9702/13/M/J/15/Q31

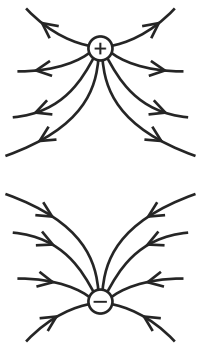
A



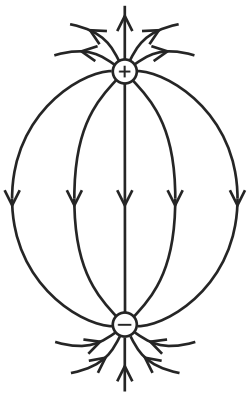
B



C



D



115 Two parallel metal plates, a distance of 2 mm apart, have a potential difference of 1000 V across them.

9702/11/M/J/15/Q31

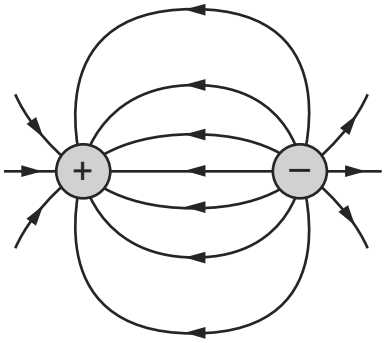
What is the electric field strength between the plates?

A $500\,V\,m^{-1}$ **B** $50\,000\,V\,m^{-1}$ **C** $50\,000\,N\,C^{-1}$ **D** $500\,000\,N\,C^{-1}$

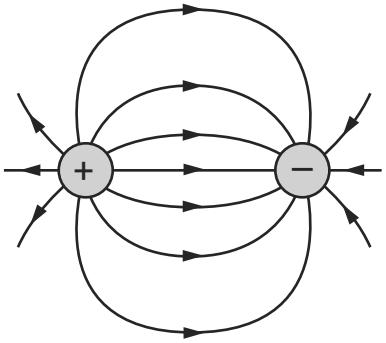
116 A positive charge and a negative charge of equal magnitude are placed a short distance apart.

Which diagram best represents the associated electric field? 9702/12/M/J/15/Q29

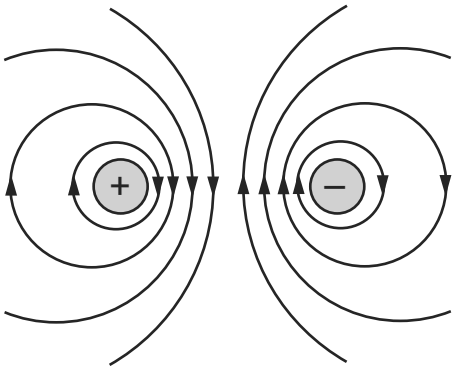
A



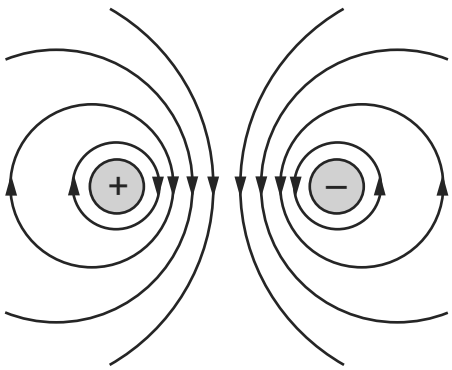
B



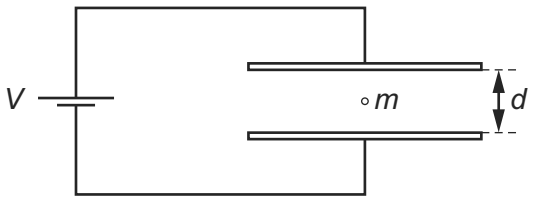
C



D



117 A charged oil drop of mass m, with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d. 9702/12/M/J/15/Q30



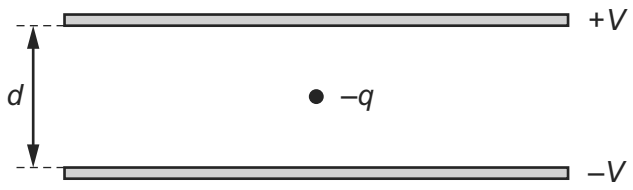
The voltage between the plates is V, the elementary charge is e and the acceleration of free fall is g.

What is the value of n?

A $\frac{eV}{mgd}$ **B** $\frac{mgd}{eV}$ **C** $\frac{meV}{gd}$ **D** $\frac{gd}{meV}$

118 An oil droplet has charge $-q$ and is situated between two horizontal metal plates as shown in the diagram.

9702/11/M/J/15/Q32



The separation of the plates is d. The droplet is observed to be stationary when the upper plate is at potential $+V$ and the lower plate is at potential $-V$.

For this to occur, what is the weight of the droplet?

A $\frac{Vq}{d}$ **B** $\frac{2Vq}{d}$ **C** $\frac{Vd}{q}$ **D** $\frac{2Vd}{q}$

Q1.

Use

4 In a particular experiment, a high voltage is created by charging an isolated metal sphere, as illustrated in Fig. 4.1.

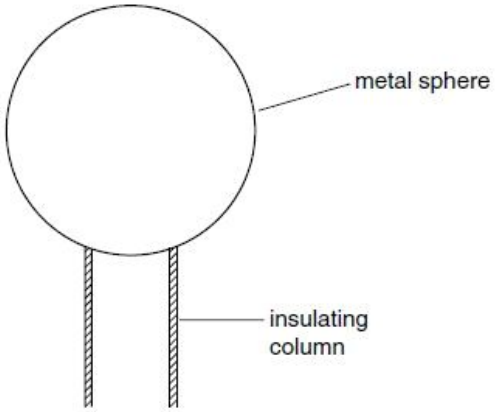


Fig. 4.1

The sphere has diameter 42 cm and any charge on its surface may be considered as if it were concentrated at its centre.

The air surrounding the sphere loses its insulating properties, causing a spark, when the electric field exceeds 20 kV cm^{-1}.

(a) By reference to an atom in the air, suggest the mechanism by which the electric field causes the air to become conducting.

.....

.....

.....

..... [3]

(b) Calculate, for the charged sphere when a spark is about to occur,

(i) the charge on the sphere,

charge = ... C [3]

(ii) its potential.

potential = ... V [2]

(c) Under certain conditions, a spark sometimes occurs before the potential reaches that calculated in **(b)(ii)**. Suggest a reason for this.

.....

..... [1]

Q2.

1 **(a)** State the significance of the Millikan experiment.

.....

..... [1]

(b) In the Millikan experiment, oil droplets were found to have the following charges.

1.56×10^{-19} C
4.88×10^{-19} C
1.64×10^{-19} C
3.14×10^{-19} C
4.76×10^{-19} C

Use these data to determine a value for the elementary charge. Explain your working.

.....

.....

elementary charge = ... C [2]

Q3.

5 An isolated conducting sphere of radius r is given a charge $+Q$. This charge may be assumed to act as a point charge situated at the centre of the sphere, as shown in Fig. 5.1.

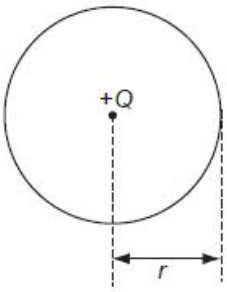


Fig. 5.1

Fig. 5.2. shows the variation with distance x from the centre of the sphere of the potential V due to the charge $+Q$.

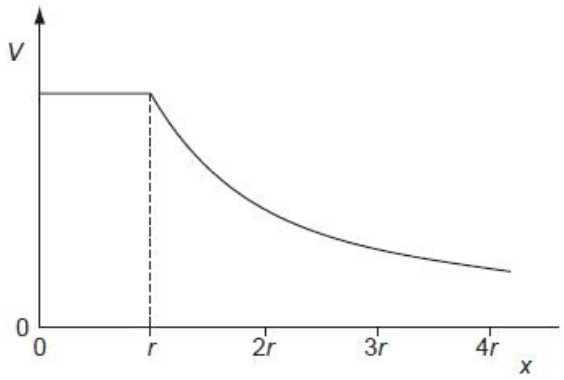


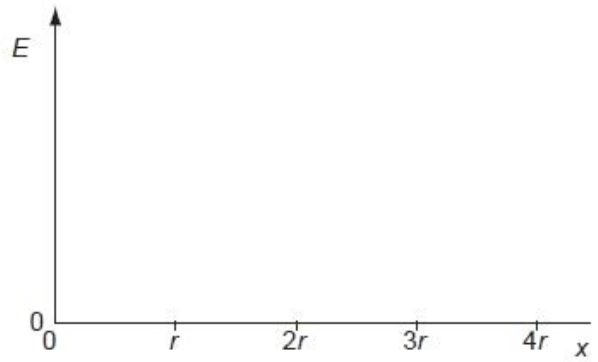
Fig. 5.2

(a) State the relation between electric field and potential.

.....[1]

(b) Using the relation in **(a)**, on Fig. 5.3 sketch a graph to show the variation with distance x of the electric field E due to the charge $+Q$.

U



[3]

Fig. 5.3

Q4.

Us

5 An isolated conducting sphere of radius r is placed in air. It is given a charge $+Q$. This charge may be assumed to act as a point charge situated at the centre of the sphere.

(a) **(i)** Define *electric field strength*.

.....

..... [1]

(ii) State a formula for the electric field strength E at the surface of the sphere. Also, state the meaning of any other symbols used.

.....

.....

..... [2]

(b) The maximum field strength at the surface of the sphere before electrical breakdown (sparking) occurs is 2.0×10^6 V m^{-1}. The sphere has a radius r of 0.35 m.

Calculate the maximum values of

(i) the charge that can be stored on the sphere,

charge = ... C [2]

(ii) the potential at the surface of the sphere.

potential = ... V [2]

(c) Suggest the effect of the electric field on a single atom near the sphere's surface as electrical breakdown of the air occurs.

.....

.....

..... [2]

Q5.

3 Two charged points A and B are separated by a distance of 6.0 cm, as shown in Fig. 3.1.

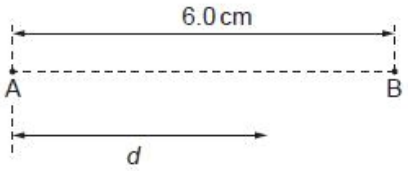


Fig. 3.1

The variation with distance *d* from A of the electric field strength *E* along the line AB is shown in Fig. 3.2.

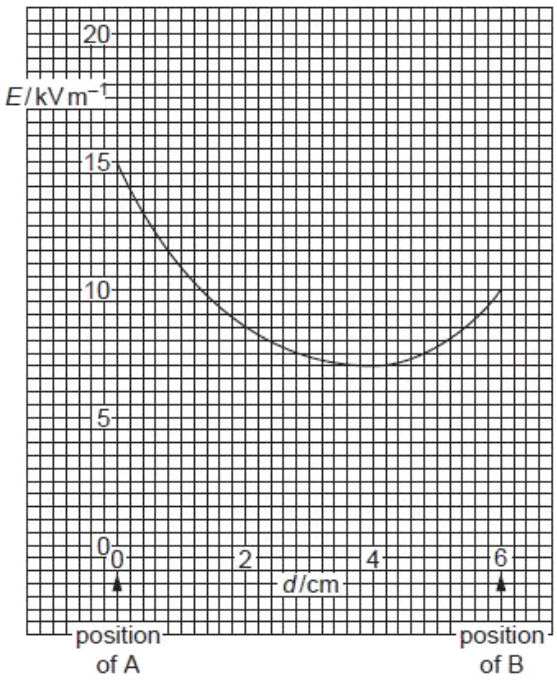


Fig. 3.2

An electron is emitted with negligible speed from A and travels along AB.

(a) State the relation between electric field strength *E* and potential *V*.

.....

..... [2]

(b) The area below the line of the graph of Fig. 3.2 represents the potential difference between A and B.

Use Fig. 3.2 to determine the potential difference between A and B.

potential difference = ... V [4]

(c) Use your answer to **(b)** to calculate the speed of the electron as it reaches point B.

speed = ... $m\,s^{-1}$ [2]

(d) **(i)** Use Fig. 3.2 to determine the value of d at which the electron has maximum acceleration.

d = ... cm [1]

(ii) Without any further calculation, describe the variation with distance d of the acceleration of the electron.

.....

.....

..... [2]

Q6.

4 **(a)** Define *electric potential* at a point.

For Examiner's Use

.....

.....

.....[2]

(b) Two isolated point charges A and B are separated by a distance of 30.0 cm, as shown in Fig. 4.1.

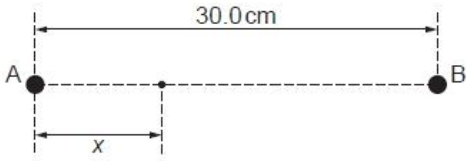


Fig. 4.1

The charge at A is + 3.6 × 10^{-9} C.
The variation with distance x from A along AB of the potential V is shown in Fig. 4.2.

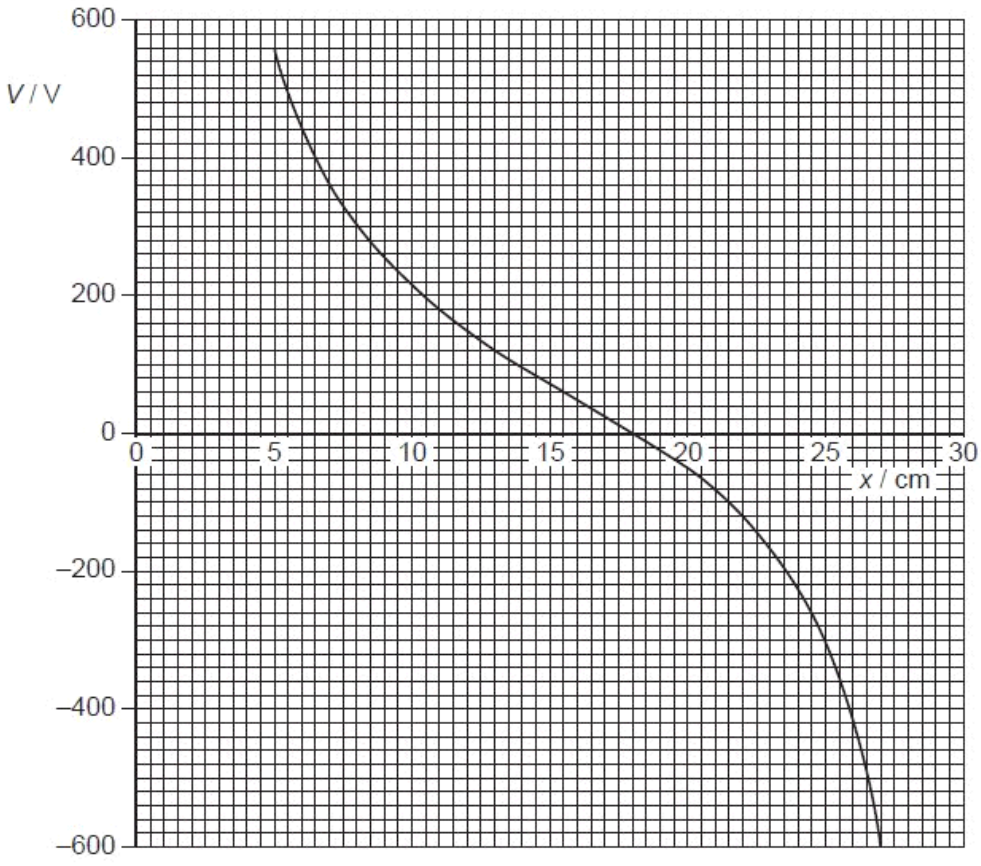


Fig. 4.2

(i) State the value of x at which the potential is zero.

x = ... cm [1]

(ii) Use your answer in **(i)** to determine the charge at B.

charge = ... C [3]

(c) A small test charge is now moved along the line AB in **(b)** from $x = 5.0\,\text{cm}$ to $x = 27\,\text{cm}$. State and explain the value of x at which the force on the test charge will be maximum.

.....

.....

.....

.....[3]

Q7.

4 **(a)** Explain what is meant by the *potential energy* of a body.

For Examiner Use

.....

.....

.....[2]

(b) Two deuterium ($^2_1$H) nuclei each have initial kinetic energy E_K and are initially separated by a large distance.
The nuclei may be considered to be spheres of diameter 3.8×10^{-15} m with their masses and charges concentrated at their centres.
The nuclei move from their initial positions to their final position of just touching, as illustrated in Fig. 4.1.

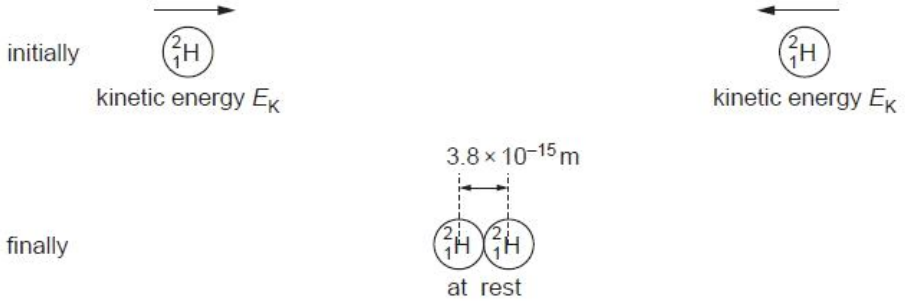


Fig. 4.1

(i) For the two nuclei approaching each other, calculate the total change in

1. gravitational potential energy,

energy = ... J [3]

2. electric potential energy.

energy = ... J [3]

(ii) Use your answers in **(i)** to show that the initial kinetic energy E_K of each nucleus is 0.19 MeV.

[2]

(iii) The two nuclei may rebound from each other. Suggest one other effect that could happen to the two nuclei if the initial kinetic energy of each nucleus is greater than that calculated in **(ii)**.

.....

.....[1]

Q8.

4 Two point charges A and B each have a charge of $+6.4 \times 10^{-19}$ C. They are separated in a vacuum by a distance of 12.0 μm, as shown in Fig. 4.1.

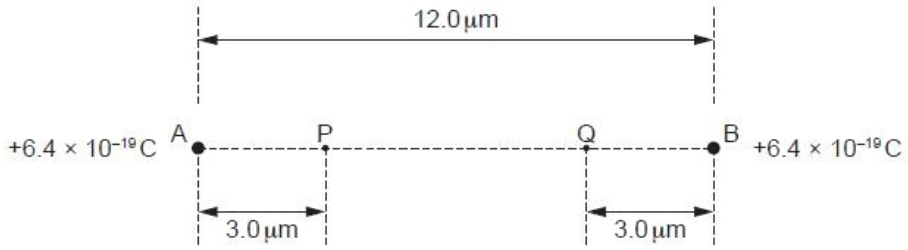


Fig. 4.1

Points P and Q are situated on the line AB. Point P is 3.0 μm from charge A and point Q is 3.0 μm from charge B.

(a) Calculate the force of repulsion between the charges A and B.

force = ... N [3]

(b) Explain why, without any calculation, when a small test charge is moved from point P to point Q, the net work done is zero.

.....

.....

..... [2]

(c) Calculate the work done by an electron in moving from the midpoint of line AB to point P.

work done = ... J [4]

Q9.

4 **(a)** Define *electric potential* at a point.

.....

.....

.....[2]

(b) Two small spherical charged particles P and Q may be assumed to be point charges located at their centres. The particles are in a vacuum.

Particle P is fixed in position. Particle Q is moved along the line joining the two charges, as illustrated in Fig. 4.1.

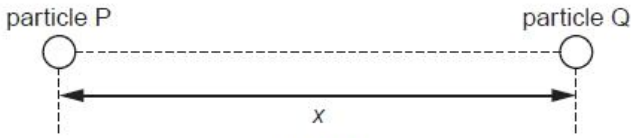


Fig. 4.1

The variation with separation x of the electric potential energy E_P of particle Q is shown in Fig. 4.2.

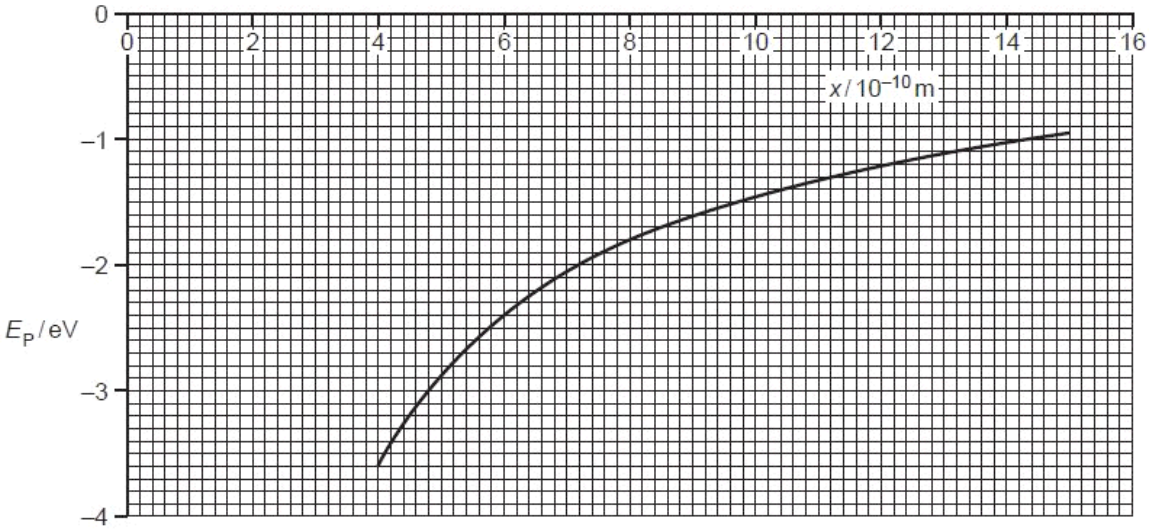


Fig. 4.2

(i) State how the magnitude of the electric field strength is related to potential gradient.

.....

.....[1]

(ii) Use your answer in **(i)** to show that the force on particle Q is proportional to the gradient of the curve of Fig. 4.2.

.....

.....

.....[2]

(c) The magnitude of the charge on each of the particles P and Q is 1.6×10^{-19} C.
Calculate the separation of the particles at the point where particle Q has electric potential energy equal to –5.1 eV.

separation = ... m [4]

(d) By reference to Fig. 4.2, state and explain

(i) whether the two charges have the same, or opposite, sign,

.....

.....

.....[2]

(ii) the effect, if any, on the shape of the graph of doubling the charge on particle P.

.....

.....

.....[2]

Q10.

5 **(a)** Define *electric field strength*.

.....

.....[1]

(b) An isolated metal sphere is to be used to store charge at high potential. The charge stored may be assumed to be a point charge at the centre of the sphere. The sphere has a radius of 25 cm. Electrical breakdown (a spark) occurs in the air surrounding the sphere when the electric field strength at the surface of the sphere exceeds $1.8 \times 10^4\,\text{V cm}^{-1}$.

(i) Show that the maximum charge that can be stored on the sphere is 12.5 μC.

[2]

(ii) Calculate the potential of the sphere for this maximum charge.

potential = ... V [2]

Q11.

4 A charged point mass is situated in a vacuum. A proton travels directly towards the mass, as illustrated in Fig. 4.1.

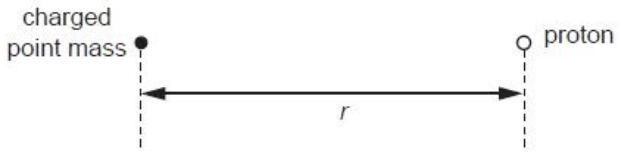


Fig. 4.1

When the separation of the mass and the proton is r, the electric potential energy of the system is U_P.

The variation with r of the potential energy U_P is shown in Fig. 4.2.

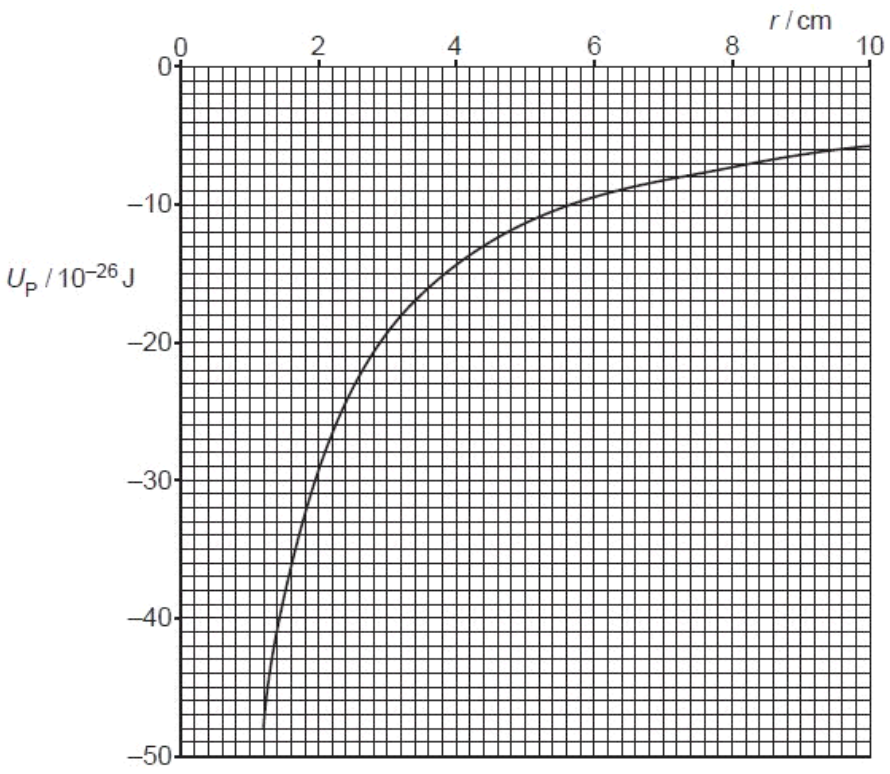


Fig. 4.2

(a) (i) Use Fig. 4.2 to state and explain whether the mass is charged positively or negatively.

.....

.....

.....[2]

(ii) The gradient at a point on the graph of Fig. 4.2 is G.
Show that the electric field strength E at this point due to the charged point mass is given by the expression

$$Eq = G$$

where q is the charge at this point.

.....

.....

.....[2]

(b) Use the expression in **(a)(ii)** and Fig. 4.2 to determine the electric field strength at a distance of 4.0 cm from the charged point mass.

field strength = ... $V\,m^{-1}$ [4]

Q12.

4 **(a)** Define *electric potential* at a point.

F
Exam
U

.....

.....

.....[2]

(b) A charged particle is accelerated from rest in a vacuum through a potential difference V. Show that the final speed v of the particle is given by the expression

$$v = \sqrt{\left(\frac{2Vq}{m}\right)}$$

where $\frac{q}{m}$ is the ratio of the charge to the mass (the specific charge) of the particle.

[2]

(c) A particle with specific charge $+9.58 \times 10^7\,C\,kg^{-1}$ is moving in a vacuum towards a fixed metal sphere, as illustrated in Fig. 4.1.



Fig. 4.1

The initial speed of the particle is $2.5 \times 10^5\,m\,s^{-1}$ when it is a long distance from the sphere.
The sphere is positively charged and has a potential of +470 V.

Use the expression in **(b)** to determine whether the particle will reach the surface of the sphere.

[3]

Q13.

4 **(a)** An insulated metal sphere of radius R is situated in a vacuum. The charge q on the sphere may be considered to be a point charge at the centre of the sphere.

For Examiner Use

(i) State a formula, in terms of R and q, for the potential V on the surface of the sphere.

..... [1]

(ii) Define capacitance and hence show that the capacitance C of the sphere is given by the expression

$$C = 4\pi\varepsilon_0 R.$$

[1]

(b) An isolated metal sphere has radius 45 cm.

(i) Use the expression in **(a)(ii)** to calculate the capacitance, in picofarad, of the sphere.

capacitance = ... pF [2]

(ii) The sphere is charged to a potential of 9.0×10^5 V.
A spark occurs, partially discharging the sphere so that its potential is reduced to 3.6×10^5 V.

Determine the energy of the spark.

energy = ... J [3]

Q14.

Use

2 An α-particle ($^{4}_{2}$He) is moving directly towards a stationary gold nucleus ($^{197}_{79}$Au).

The α-particle and the gold nucleus may be considered to be solid spheres with the charge and mass concentrated at the centre of each sphere.

When the two spheres are just touching, the separation of their centres is 9.6×10^{-15} m.

(a) The α-particle and the gold nucleus may be assumed to be an isolated system. Calculate, for the α-particle just in contact with the gold nucleus,

(i) its gravitational potential energy,

gravitational potential energy = ... J [3]

(ii) its electric potential energy.

electric potential energy = ... J [3]

(b) Using your answers in **(a)**, suggest why, when making calculations based on an α-particle scattering experiment, gravitational effects are not considered.

.....

.....[1]

(c) In the α-particle scattering experiment conducted in 1913, the maximum kinetic energy of the available α-particles was about 6 MeV. Suggest why, in this experiment, the radius of the target nucleus could not be determined.

.....

.....

.....[2]

Q15.

Use

4 A small charged metal sphere is situated in an earthed metal box. Fig. 4.1 illustrates the electric field between the sphere and the metal box.

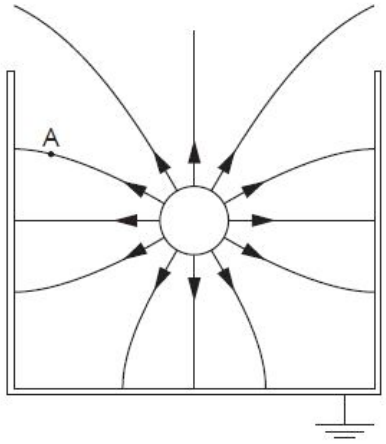


Fig. 4.1

(a) By reference to Fig. 4.1, state and explain

(i) whether the sphere is positively or negatively charged,

.....

.....

.....[2]

(ii) why it appears as if the charge on the sphere is concentrated at the centre of the sphere.

.....

.....[1]

(b) On Fig. 4.1, draw an arrow to show the direction of the force on a stationary electron situated at point A. [2]

(c) The radius r of the sphere is 2.4 cm. The magnitude of the charge q on the sphere is 0.76 nC.

(i) Use the expression

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

to calculate a value for the magnitude of the potential V at the surface of the sphere.

V = ...V [2]

(ii) State the sign of the charge induced on the inside of the metal box. Hence explain whether the actual magnitude of the potential will be greater or smaller than the value calculated in **(i)**.

.....

.....

.....

.....[3]

(d) A lead sphere is placed in a lead box in free space, in a similar arrangement to that shown in Fig. 4.1. Explain why it is **not** possible for the gravitational field to have a similar shape to that of the electric field.

.....

.....

.....[1]

Q16.

5 **(a)** Define *electric potential* at a point.

For Examiner's Use

.....

.....

..... [2]

(b) An α-particle is emitted from a radioactive source with kinetic energy of 4.8 MeV.

The α-particle travels in a vacuum directly towards a gold ($^{197}_{79}$Au) nucleus, as illustrated in Fig. 5.1.



Fig. 5.1

The α-particle and the gold nucleus may be considered to be point charges in an isolated system.

(i) Explain why, as the α-particle approaches the gold nucleus, it comes to rest.

.....

.....

..... [2]

(ii) For the closest approach of the α-particle to the gold nucleus determine

1. their separation,

separation = ... m [3]

2. the magnitude of the force on the α-particle.

force = ... N [2]

For Examiner's Use

Q17.

4 Two small charged metal spheres A and B are situated in a vacuum. The distance between the centres of the spheres is 12.0 cm, as shown in Fig. 4.1.

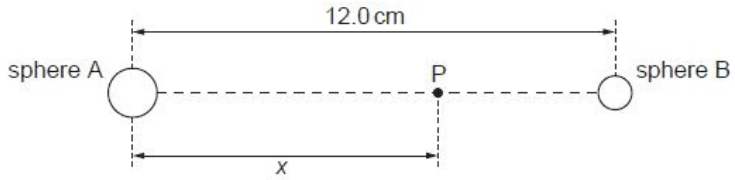
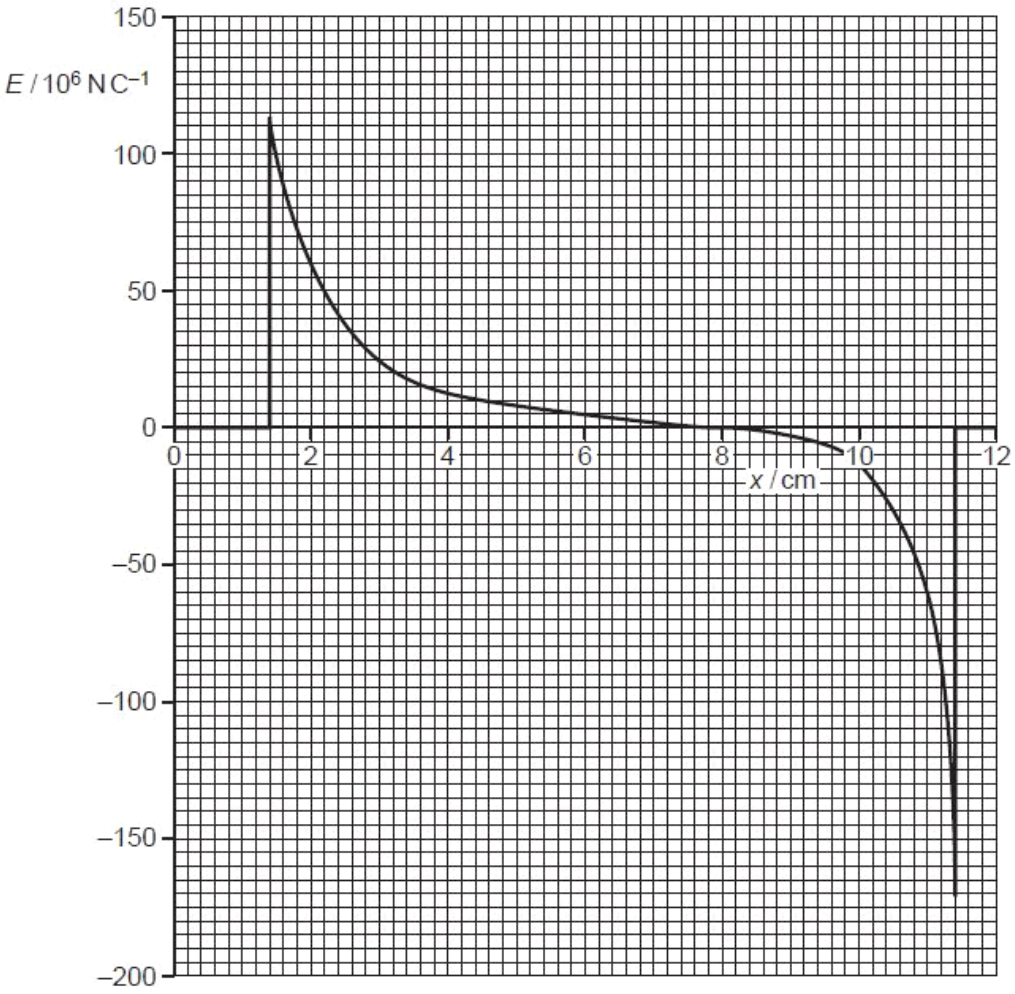


Fig. 4.1 (not to scale)

The charge on each sphere may be assumed to be a point charge at the centre of the sphere.
Point P is a movable point that lies on the line joining the centres of the spheres and is distance x from the centre of sphere A.
The variation with distance x of the electric field strength E at point P is shown in Fig. 4.2.

For Examiner's Use



(a) State the evidence provided by Fig. 4.2 for the statements that

(i) the spheres are conductors,

.....

.....[1]

(ii) the charges on the spheres are either both positive or both negative.

.....

.....

.....[2]

(b) **(i)** State the relation between electric field strength E and potential gradient at a point.

.....

.....[1]

(ii) Use Fig. 4.2 to state and explain the distance x at which the rate of change of potential with distance is

1. maximum,

.....

.....

.....[2]

2. minimum.

.....

.....

.....[2]

Q18.

3 **(a)** State what is meant by a line of force in

For Examiner's Use

(i) a gravitational field,

.....

.....[1]

(ii) an electric field.

.....

.....[2]

(b) A charged metal sphere is isolated in space.
State one similarity and one difference between the gravitational force field and the electric force field around the sphere.

similarity: .....

.....

difference: .....

.....

.....

[3]

(c) Two horizontal metal plates are separated by a distance of 1.8 cm in a vacuum.
A potential difference of 270 V is maintained between the plates, as shown in Fig. 3.1.

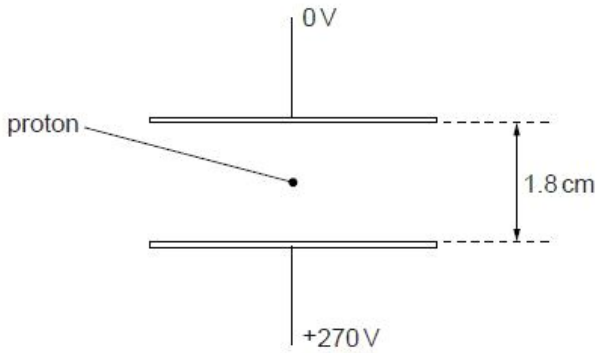


Fig. 3.1

A proton is in the space between the plates.
Explain quantitatively why, when predicting the motion of the proton between the plates, the gravitational field is not taken into consideration.

[4]

Q19.

4 An α-particle and a proton are at rest a distance 20 μm apart in a vacuum, as illustrated in Fig. 4.1.

For Examiner's Use

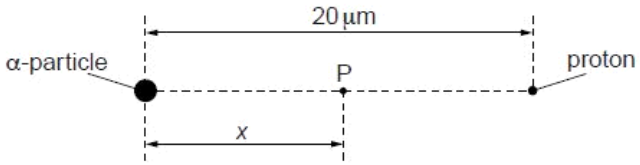


Fig. 4.1

(a) (i) State Coulomb's law.

.....

.....

.....[2]

(ii) The α-particle and the proton may be considered to be point charges. Calculate the electric force between the α-particle and the proton.

force = ... N [2]

(b) (i) Define *electric field strength*.

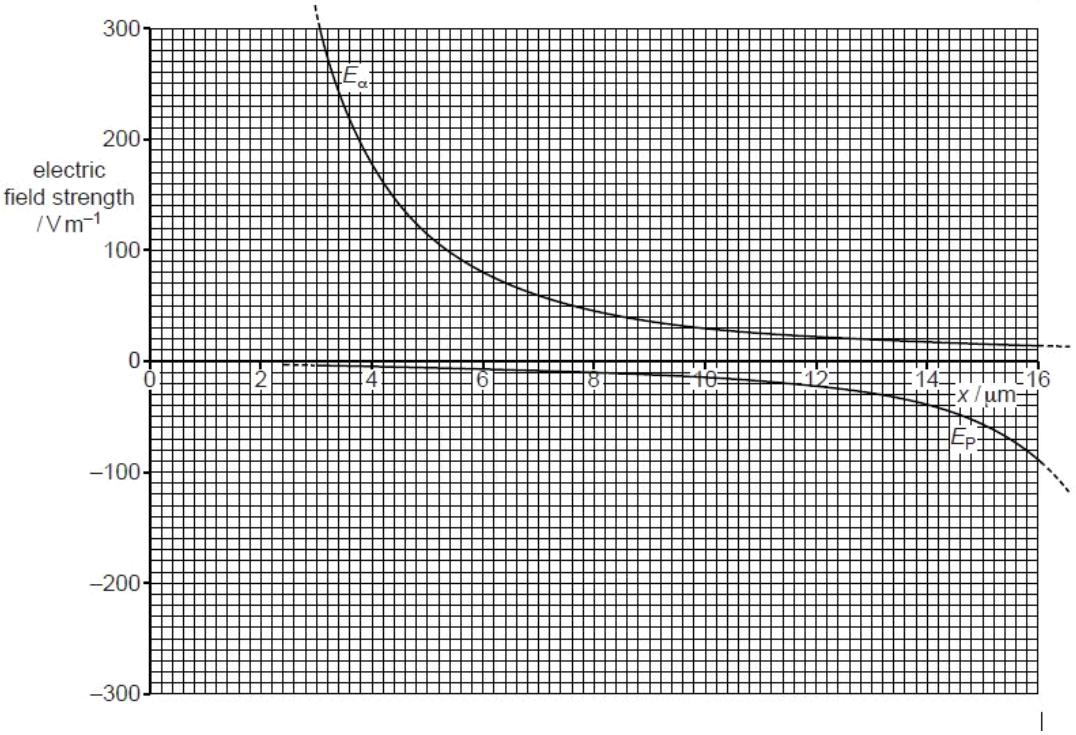
.....

.....

.....[2]

(ii) A point P is distance *x* from the α-particle along the line joining the α-particle to the proton (see Fig. 4.1). The variation with distance *x* of the electric field strength E_α due to the α-particle alone is shown in Fig. 4.2.

For Examiner's Use



The variation with distance x of the electric field strength E_P due to the proton alone is also shown in Fig. 4.2.

1. Explain why the two separate electric fields have opposite signs.

.....

.....

.....[2]

2. On Fig. 4.2, sketch the variation with x of the combined electric field due to the α-particle and the proton for values of x from 4 μm to 16 μm. [3]

Q20.

3 **(a)** Define *electric potential* at a point.

For Examiner's Use

.....

.....

.....[2]

(b) Two point charges A and B are separated by a distance of 20 nm in a vacuum, as illustrated in Fig. 3.1.

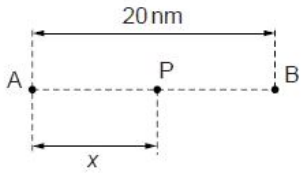


Fig. 3.1

A point P is a distance x from A along the line AB.
The variation with distance x of the electric potential V_A due to charge A alone is shown in Fig. 3.2.

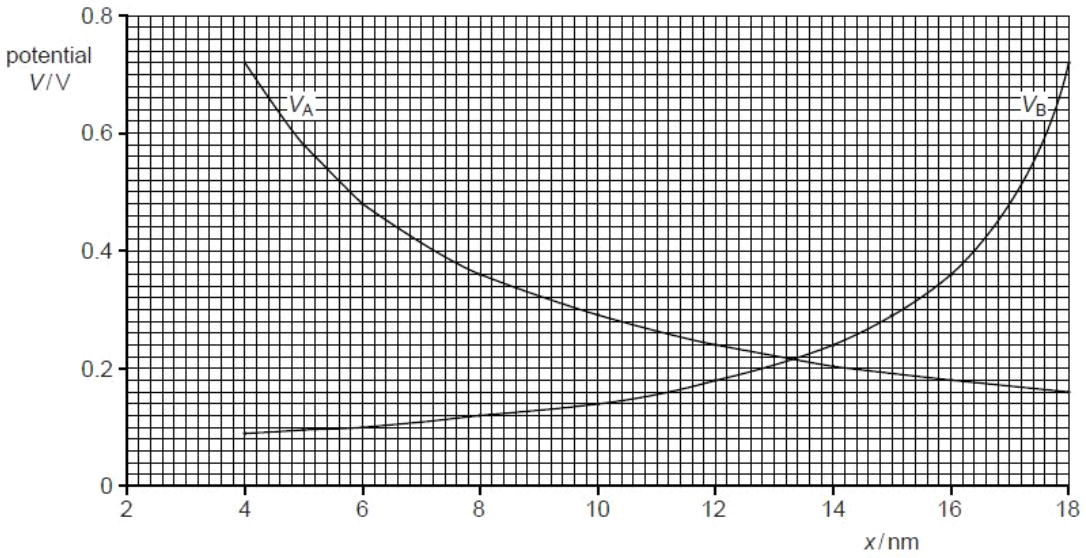


Fig. 3.2

The variation with distance x of the electric potential V_B due to charge B alone is also shown in Fig. 3.2.

For Examiner's Use

(i) State and explain whether the charges A and B are of the same, or opposite, sign.

.....

.....

.....[2]

(ii) By reference to Fig. 3.2, state how the combined electric potential due to both charges may be determined.

.....

.....[1]

(iii) Without any calculation, use Fig. 3.2 to estimate the distance x at which the combined electric potential of the two charges is a minimum.

x = ... nm [1]

(iv) The point P is a distance $x = 10\,\text{nm}$ from A.
An α-particle has kinetic energy E_K when at infinity.

Use Fig. 3.2 to determine the minimum value of E_K such that the α-particle may travel from infinity to point P.

E_K = ... J [3]

Q21.

5 An isolated solid metal sphere of radius r is given a positive charge. The distance from the centre of the sphere is x.

(a) The electric potential at the surface of the sphere is V_0.

On the axes of Fig. 5.1, sketch a graph to show the variation with distance x of the electric potential due to the charged sphere, for values of x from $x = 0$ to $x = 4r$.

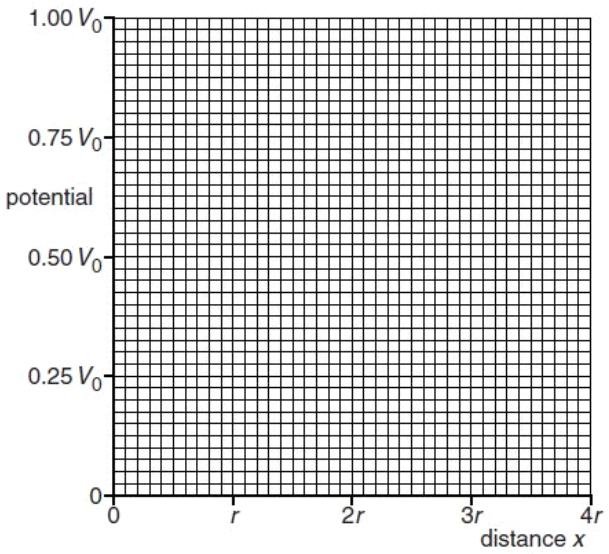


Fig. 5.1

[3]

(b) The electric field strength at the surface of the sphere is E_0.

On the axes of Fig. 5.2, sketch a graph to show the variation with distance x of the electric field strength due to the charged sphere, for values of x from $x = 0$ to $x = 4r$.

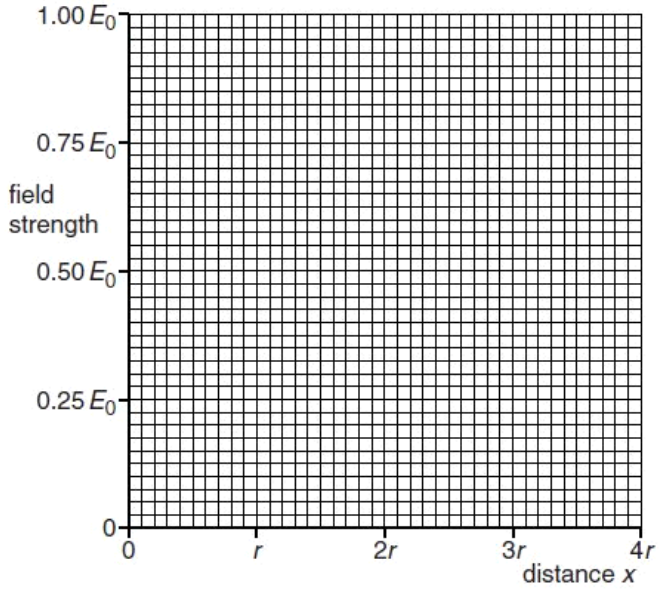


Fig. 5.2

[3]

Q22.

4 A helium nucleus contains two protons.

In a model of the helium nucleus, each proton is considered to be a charged point mass. The separation of these point masses is assumed to be 2.0×10^{-15} m.

(a) For the two protons in this model, calculate

(i) the electrostatic force,

electrostatic force = ... N [2]

(ii) the gravitational force.

gravitational force = ... N [2]

(b) Using your answers in (a), suggest why

(i) there must be some other force between the protons in the nucleus,

.....

.....

.....

..... [3]

(ii) this additional force must have a short range.

.....

.....

..... [2]

Q23.

5 (a) Define *electric potential* at a point.

.....

.....

..... [2]

(b) An isolated solid metal sphere is positively charged.

The variation of the potential V with distance x from the centre of the sphere is shown in Fig. 5.1.

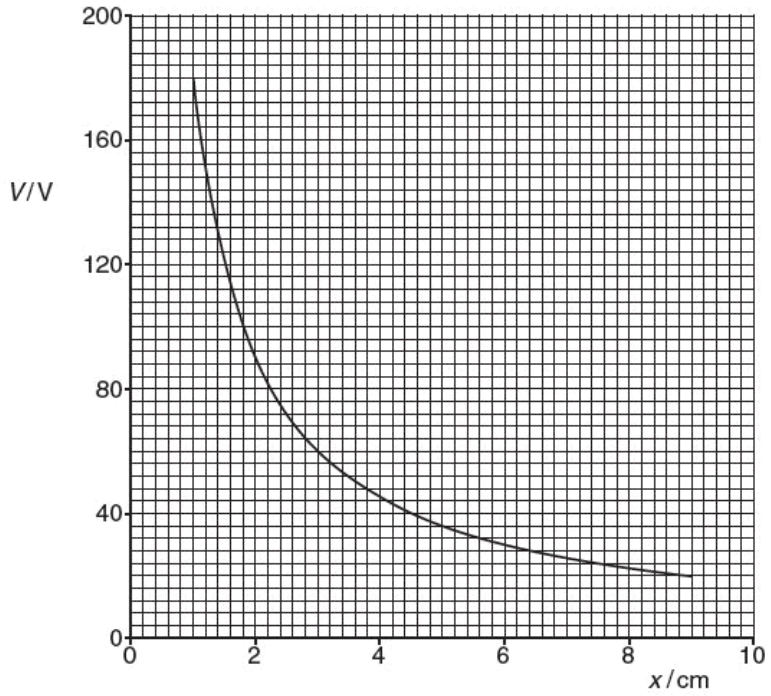


Fig. 5.1

Use Fig. 5.1 to suggest

(i) why the radius of the sphere cannot be greater than 1.0 cm,

.....

..... [1]

(ii) that the charge on the sphere behaves as if it were a point charge.

[3]

(c) Assuming that the charge on the sphere does behave as a point charge, use data from Fig. 5.1 to determine the charge on the sphere.

charge = ... C [2]

Q24.

5 **(a)** Define *electric potential* at a point.

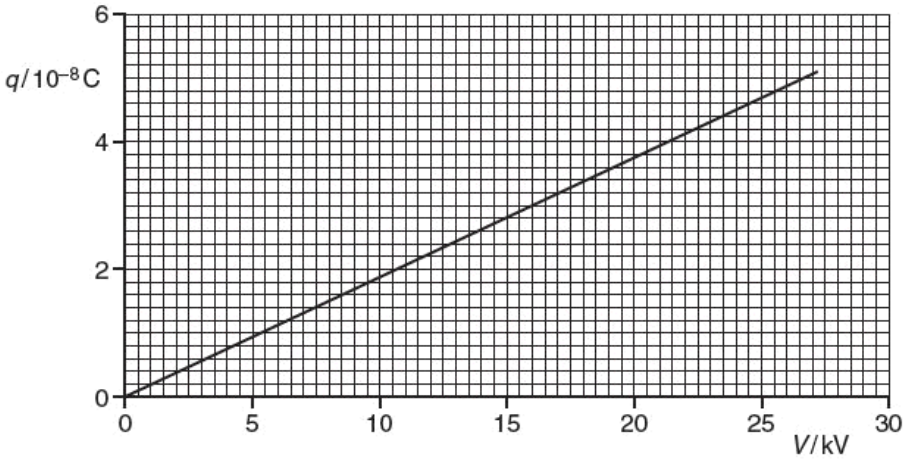
.....

.....

..... [2]

(b) An isolated metal sphere is charged to a potential V. The charge on the sphere is q.
The charge on the sphere may be considered to act as a point charge at the centre of the sphere.

The variation with potential V of the charge q on the sphere is shown in Fig. 5.1.



Use Fig. 5.1 to determine

(i) the radius of the sphere,

radius = ... m [2]

(ii) the energy required to increase the potential of the sphere from zero to 24 kV.

energy = ... J [3]

(c) The sphere in **(b)** discharges by causing sparks when the electric field strength at the surface of the sphere is greater than $2.0 \times 10^6\,V\,m^{-1}$.

Use your answer in **(b)(i)** to calculate the maximum potential to which the sphere can be charged.

potential = ... V [3]

Electric Fields – 2020 A2

1. Nov/2020/Paper_41/No.5

(a) Define *electric potential* at a point.

.....

.....

..... [2]

(b) Two point charges A and B are separated by a distance of 12.0 cm in a vacuum, as illustrated in Fig. 5.1.

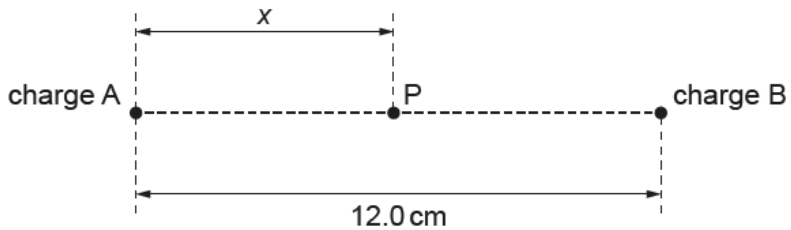


Fig. 5.1

The charge of A is $+2.0 \times 10^{-9}$ C.

A point P lies on the line joining charges A and B. Its distance from charge A is x.

The variation with distance x of the electric potential V at point P is shown in Fig. 5.2.

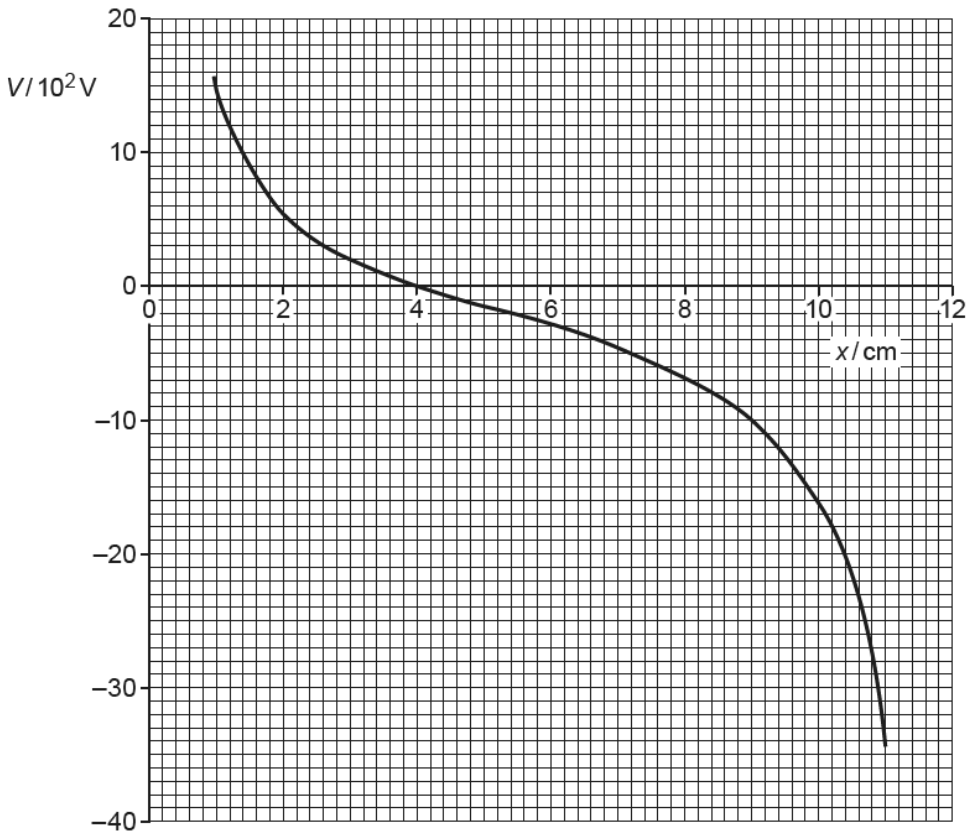


Fig. 5.2

STEMUP.CO.UK

Use Fig. 5.2 to determine:

(i) the charge of B

charge = ... C [3]

(ii) the change in electric potential when point P moves from the position where $x = 9.0\,\text{cm}$ to the position where $x = 3.0\,\text{cm}$.

change = ... V [1]

(c) An α-particle moves along the line joining point charges A and B in Fig. 5.1.

The α-particle moves from the position where $x = 9.0\,\text{cm}$ and just reaches the position where $x = 3.0\,\text{cm}$.

Use your answer in **(b)(ii)** to calculate the speed v of the α-particle at the position where $x = 9.0\,\text{cm}$.

v = ... m s^{-1} [3]

[Total: 9]

STEMUP.CO.UK

2. Nov/2020/Paper_42/No.5

(a) **(i)** State what is meant by a *field of force*.

.....

.....

..... [2]

(ii) State **one** similarity and **one** difference between the electric field due to a point charge and the gravitational field due to a point mass.

similarity: .....

.....

.....

difference: .....

.....

.....

[2]

(b) An isolated solid metal sphere of radius 0.15 m is situated in a vacuum, as illustrated in Fig. 5.1.

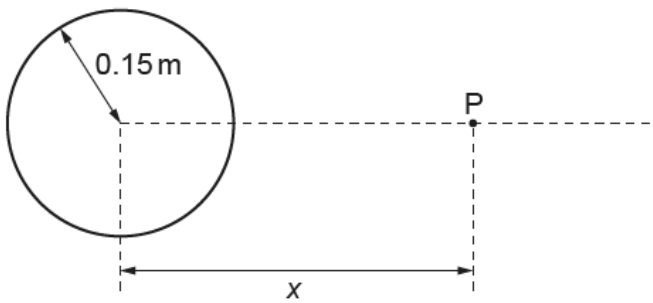


Fig. 5.1

The electric field strength at the surface of the sphere is 84 V m^{-1}.

Determine:

(i) the charge Q on the sphere

Q = ... C [2]

STEMUP.CO.UK

(ii) the electric field strength at point P, a distance $x = 0.45\,\text{m}$ from the centre of the sphere.

electric field strength = ... V m^{-1} [2]

(c) Use information from **(b)** to show, on the axes of Fig. 5.2, the variation of the electric field strength E with distance x from the centre of the sphere for values of x from $x = 0$ to $x = 0.45\,\text{m}$.

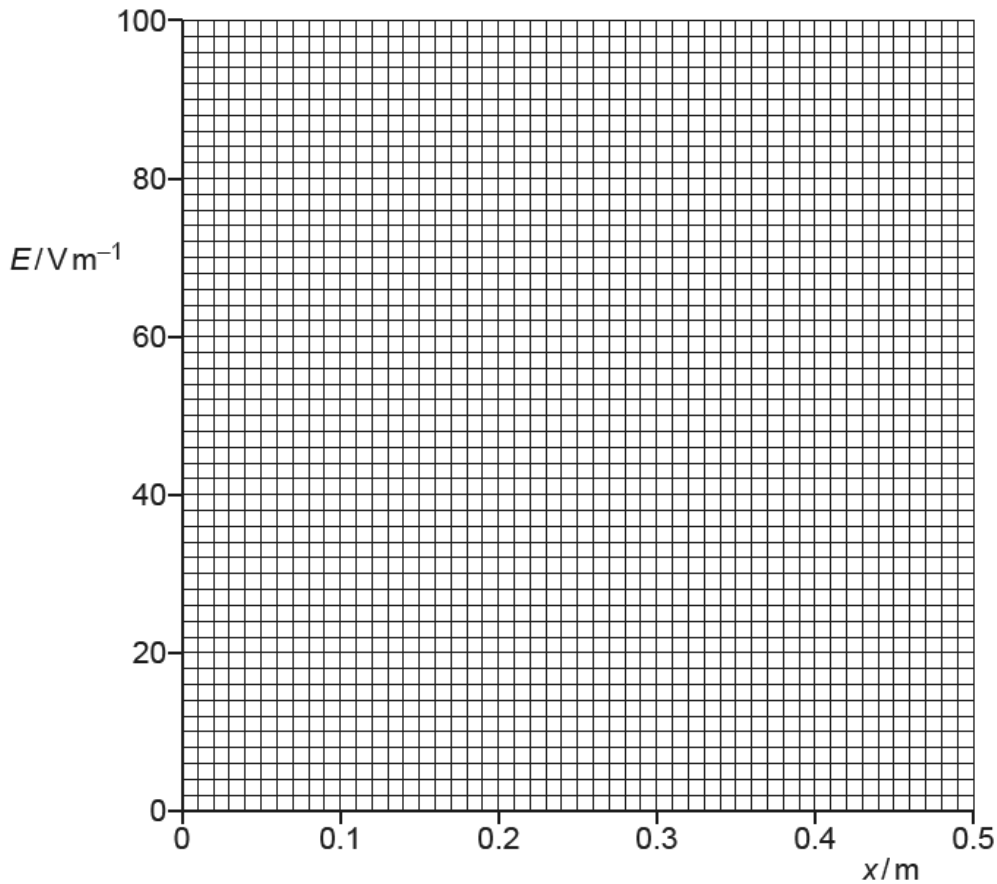


Fig. 5.2

[3]

[Total: 11]

STEMUP.CO.UK

3. June/2020/Paper_41/No.5

(a) State **one** similarity and **one** difference between the fields of force produced by an isolated point charge and by an isolated point mass.

similarity: .....

.....

difference: .....

.....

[2]

(b) An isolated solid metal sphere A of radius R has charge $+Q$, as illustrated in Fig. 5.1.

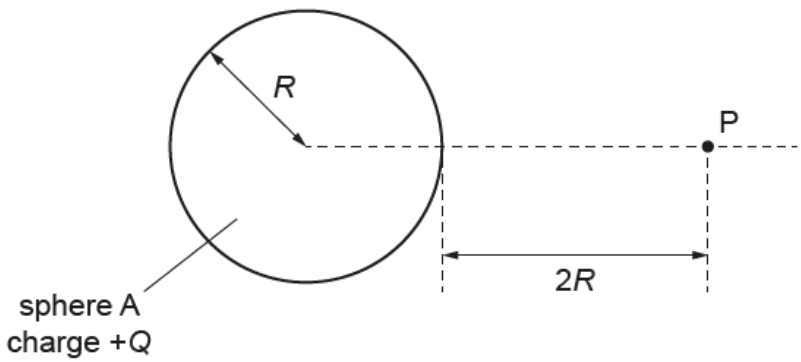


Fig. 5.1

A point P is distance $2R$ from the surface of the sphere.

Determine an expression that includes the terms R and Q for the electric field strength E at point P.

E = ... [2]

STEMUP.CO.UK

(c) A second identical solid metal sphere B is now placed near sphere A. The centres of the spheres are separated by a distance 6*R*, as shown in Fig. 5.2.

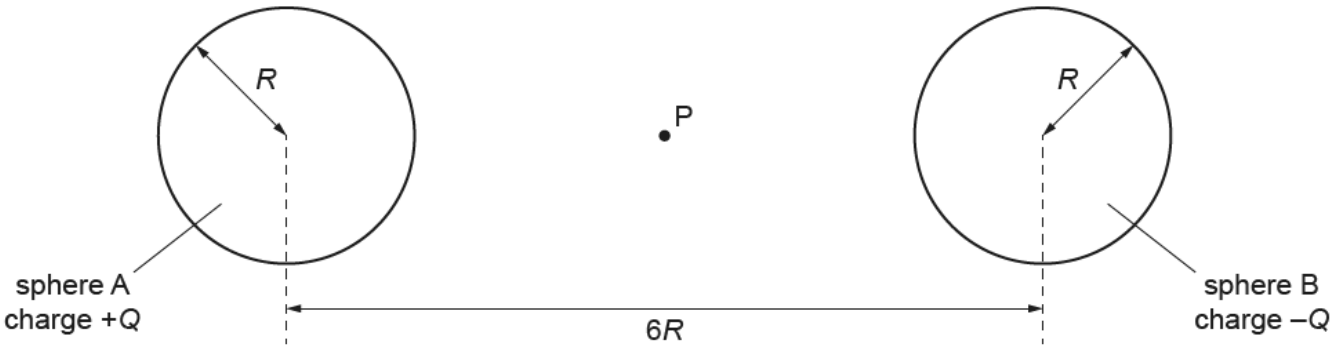


Fig. 5.2

Point P lies midway between spheres A and B.

Sphere B has charge –*Q*.

Explain why:

(i) the magnitude of the electric field strength at P is given by the sum of the magnitudes of the field strengths due to each sphere

.....

..... [1]

(ii) the electric field strength at point P due to the charged metal spheres is not, in practice, equal to 2*E*, where *E* is the electric field strength determined in **(b)**.

.....

.....

..... [2]

[Total: 7]

STEMUP.CO.UK

4. June/2020/Paper_42/No.7

A metal sphere of radius R is isolated in space.

Point P is a distance x from the centre of the sphere, as illustrated in Fig. 7.1.

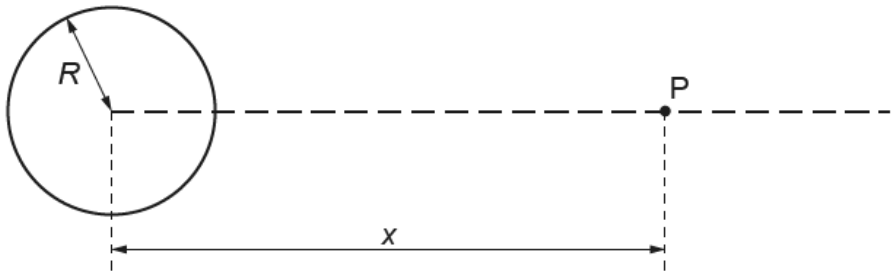


Fig. 7.1

The variation with distance x of the electric field strength E due to the charge on the sphere is shown in Fig. 7.2.

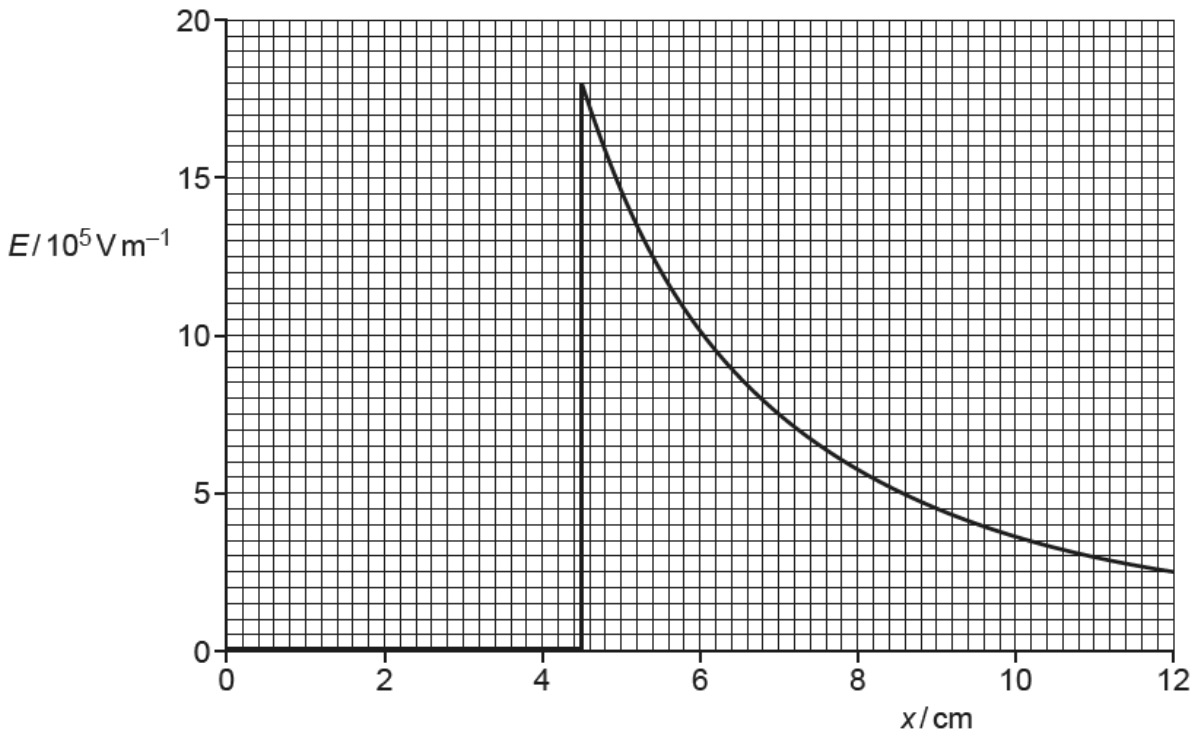


Fig. 7.2

(a) State what is meant by *electric field strength*.

.....

.....

..... [2]

STEMUP.CO.UK

(b) **(i)** Use Fig. 7.2 to determine the radius R of the sphere. Explain your working.

R = ... cm [2]

(ii) Use Fig. 7.2 to determine the charge Q on the sphere.

Q = ... C [3]

(c) An α-particle is situated a distance 8.0 cm from the centre of the sphere.

Calculate the acceleration of the α-particle.

acceleration = ... $m\,s^{-2}$ [3]

[Total: 10]

STEMUP.CO.UK

5. March/2020/Paper_42/No.6

Two positively charged identical metal spheres A and B have their centres separated by a distance of 24 cm, as shown in Fig. 6.1.

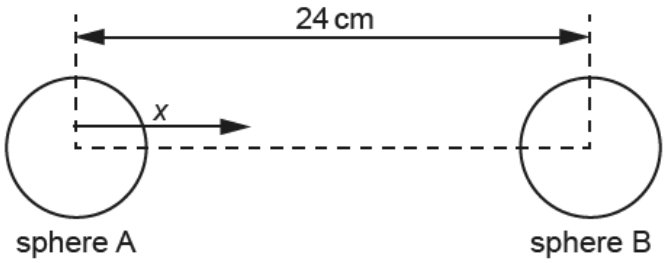


Fig. 6.1 (not to scale)

The variation with distance x from the centre of A of the electric field strength E due to the two spheres, along the line joining their centres, is represented in Fig. 6.2.

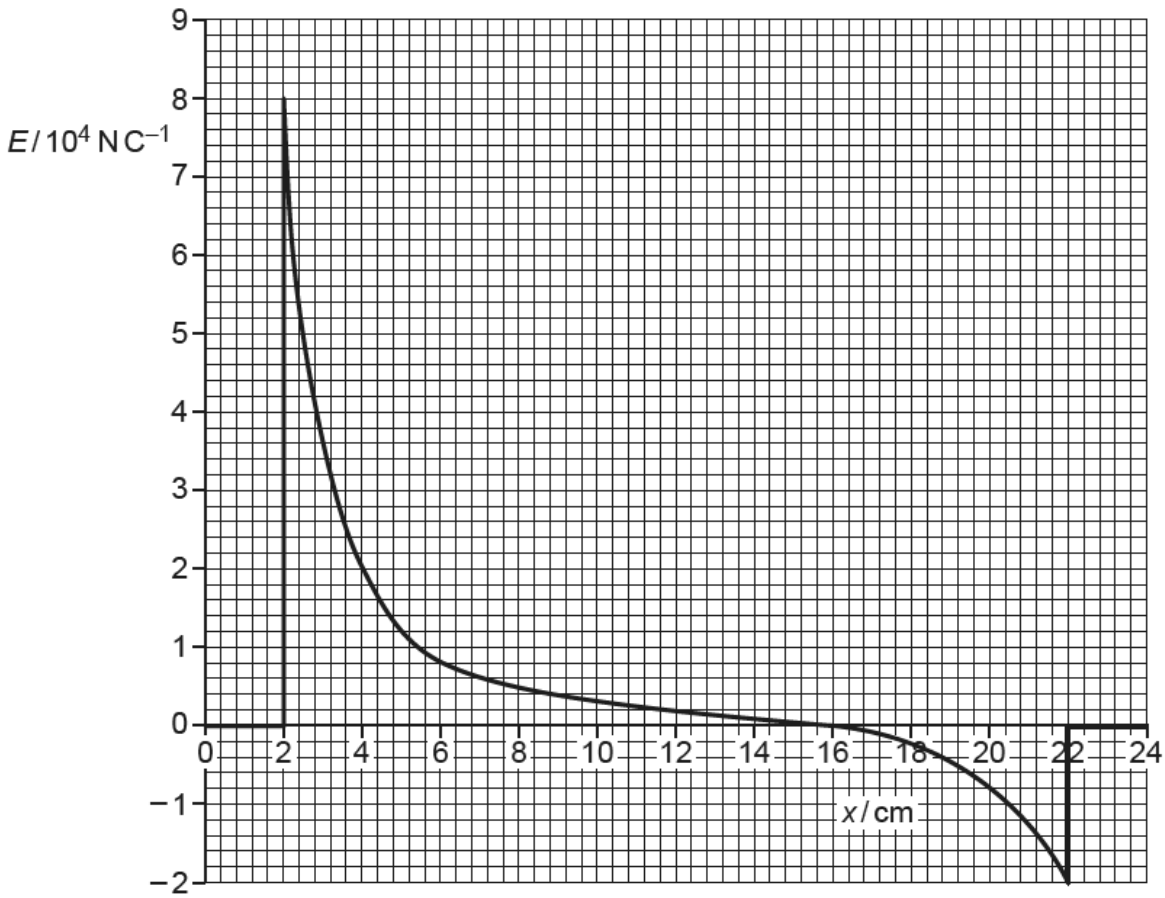


Fig. 6.2

(a) State the radius of the two spheres.

radius = ... cm [1]

STEMUP.CO.UK

(b) The charge on sphere A is 3.6×10^{-9} C. Determine the charge Q_B on sphere B.

Assume that spheres A and B can be treated as point charges at their centres.

Explain your working.

Q_B = ... C [3]

(c) **(i)** Sphere B is removed.

Use information from **(b)** to determine the electric potential on the surface of sphere A.

electric potential = ... V [2]

(ii) Calculate the capacitance of sphere A.

capacitance = ... F [2]

[Total: 8]

STEMUP.CO.UK

Electric Fields – 2021 A2

1. Nov/2021/Paper_42/No.6

(a) Define *electric potential*.

.....

.....

..... [2]

(b) An isolated conducting sphere in a vacuum has radius r and is initially uncharged. It is then charged by friction so that it carries a final charge Q. This charge can be considered to be acting at the centre of the sphere.

By considering the electric potential at its surface, show that the capacitance C of the sphere is given by

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

where ε_0 is the permittivity of free space.

[2]

(c) The dome of an electrostatic generator is a spherical conductor of radius 13 cm. It is initially charged so that the electric potential at the surface is 4.5 kV.

A smaller isolated sphere of radius 5.2 cm, initially uncharged, is brought near to the dome. Sparking causes a current between the two spheres until they reach the same potential. Assume that any charge on a sphere may be considered to act as a point charge at its centre.

Calculate the charge that is transferred between the two spheres.

charge = ... C [3]

[Total: 7]

STEMUP.CO.UK

2. June/2021/Paper_41/No.6

(a) An isolated metal sphere of radius r is charged so that the electric field strength at its surface is E_0.

On Fig. 6.1, sketch the variation of the electric field strength E with distance x from the centre of the sphere. Your sketch should extend from $x = 0$ to $x = 3r$.

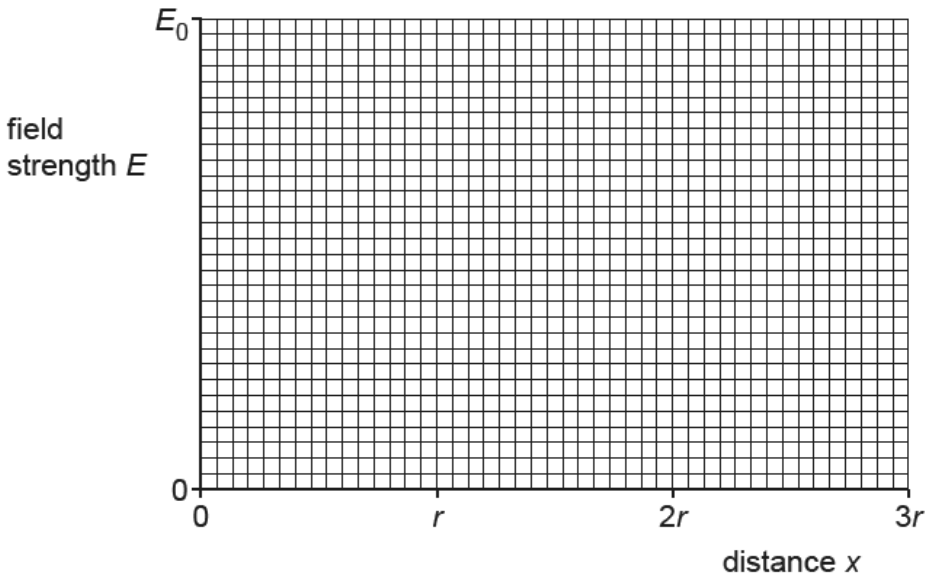


Fig. 6.1

[3]

STEMUP.CO.UK

(b) The de Broglie wavelength of a particle is λ_0 when its momentum is p_0.

On Fig. 6.2, sketch the variation with momentum p of the de Broglie wavelength λ of the particle for values of momentum from $\frac{p_0}{2}$ to p_0.

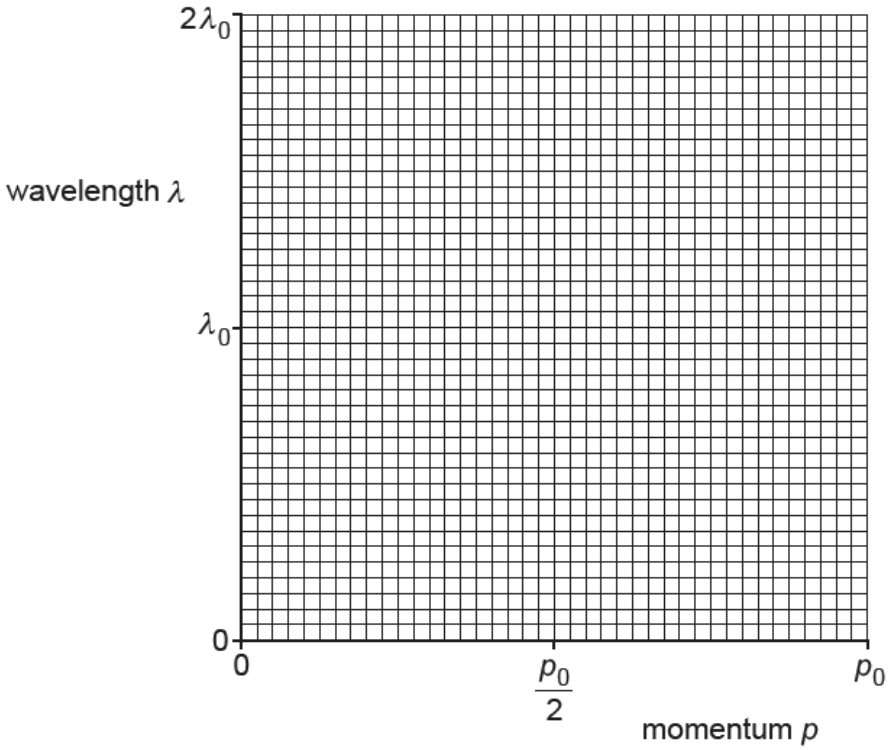


Fig. 6.2

[2]

STEMUP.CO.UK

(c) A radioactive isotope decays with a half-life of 15 s to form a stable product.

A fresh sample of the radioactive isotope at time $t = 0$ contains N_0 nuclei and no nuclei of the stable product.

On Fig. 6.3, sketch the variation with t of the number n of nuclei of the stable product for time $t = 0$ to time $t = 45$ s.

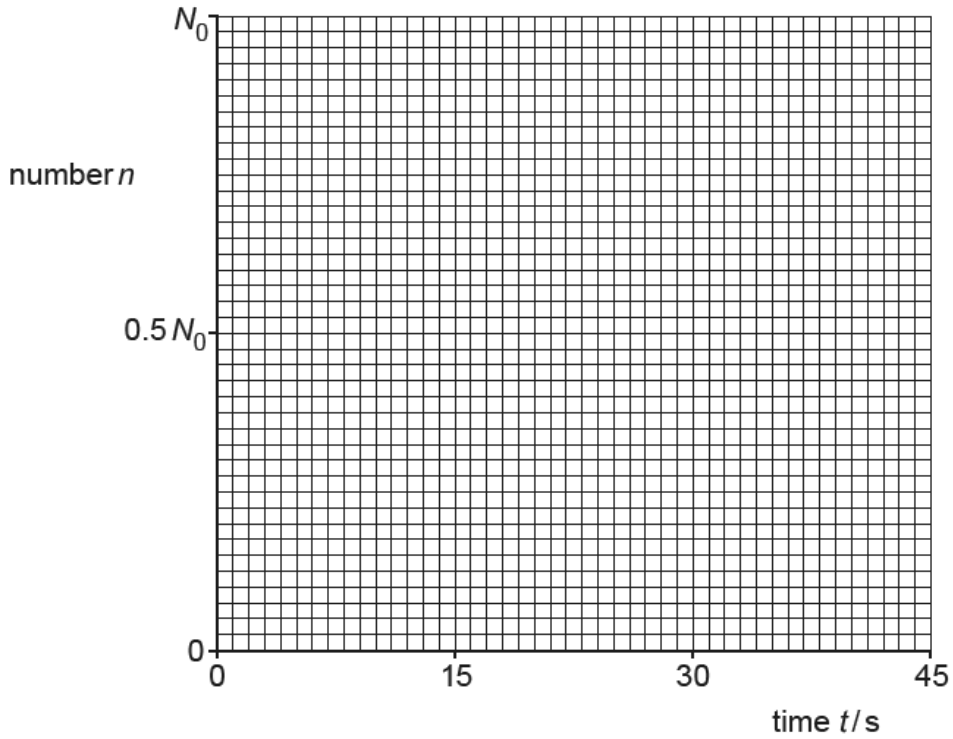


Fig. 6.3

[3]

[Total: 8]

STEMUP.CO.UK

3. June/2021/Paper_42/No.5

(a) An isolated metal sphere of radius r is charged so that the electric potential at its surface is V_0.

On Fig. 5.1, sketch the variation with distance x from the centre of the sphere of the electric potential. Your graph should extend from $x = 0$ to $x = 3r$.

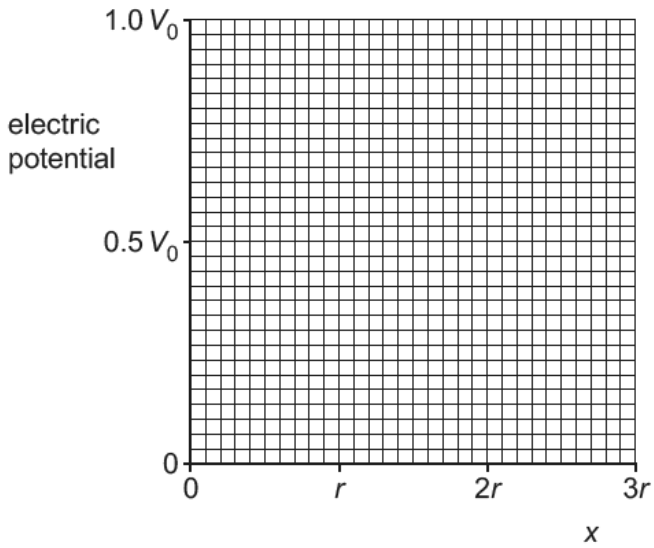


Fig. 5.1

[3]

(b) Photons having wavelength λ are incident on a metal surface.
The maximum wavelength for which there is emission of electrons is λ_0.
For photons of wavelength $\frac{\lambda_0}{2}$, the maximum kinetic energy of the emitted electrons is E_{MAX}.

On Fig. 5.2, sketch the variation with wavelength λ of the maximum kinetic energy for values of wavelength between $\lambda = \frac{\lambda_0}{3}$ and $\lambda = \lambda_0$.

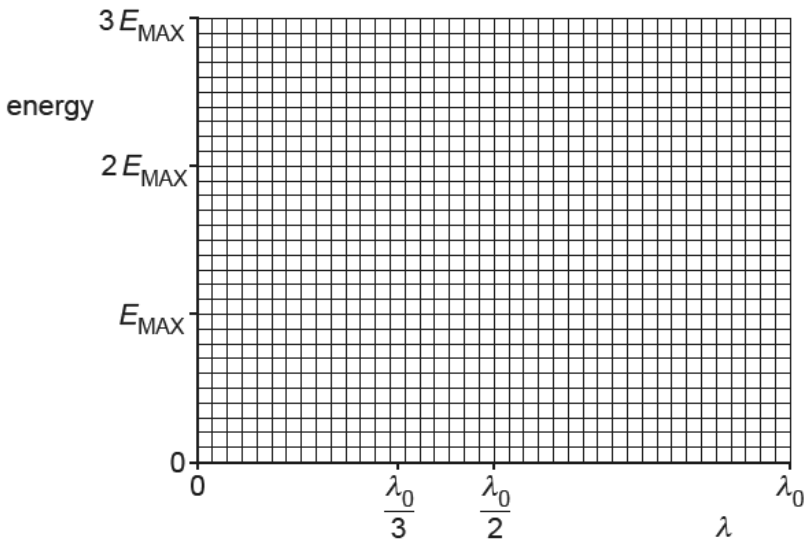


Fig. 5.2

[3]

STEMUP.CO.UK

(c) A pure sample of a radioactive isotope contains N_0 nuclei. The half-life of the isotope is $T_{\frac{1}{2}}$. The product of the radioactive decay is stable.

The variation with time t of the number N of nuclei of the radioactive isotope is shown in Fig. 5.3.

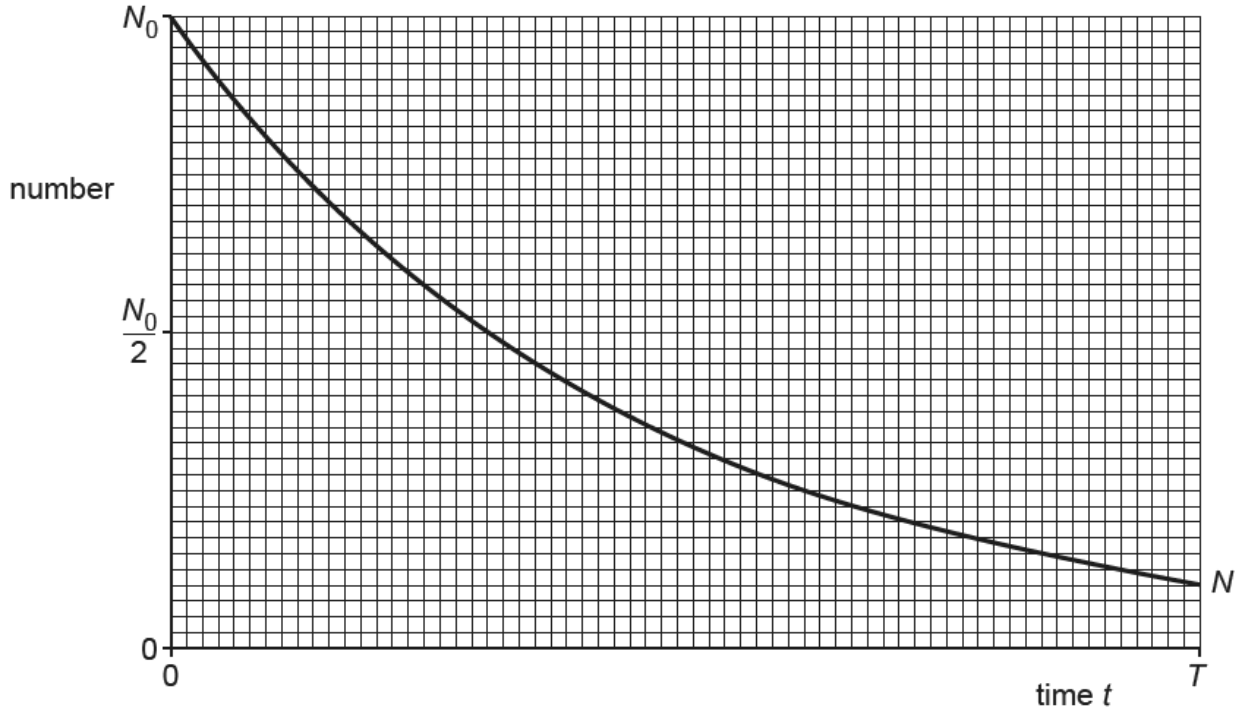


Fig. 5.3

On Fig. 5.3:

- label, on the time axis, the time $t = 1.0T_{\frac{1}{2}}$ and the time $t = 2.0T_{\frac{1}{2}}$
- sketch the variation with time t of the number of nuclei of the decay product for time $t = 0$ to time $t = T$.

[3]

[Total: 9]

STEMUP.CO.UK

4. March/2021/Paper_42/No.6

(a) State a similarity between the gravitational field lines around a point mass and the electric field lines around a point charge.

.....

..... [1]

(b) The variation with radius r of the electric field strength E due to an isolated charged sphere in a vacuum is shown in Fig. 6.1.

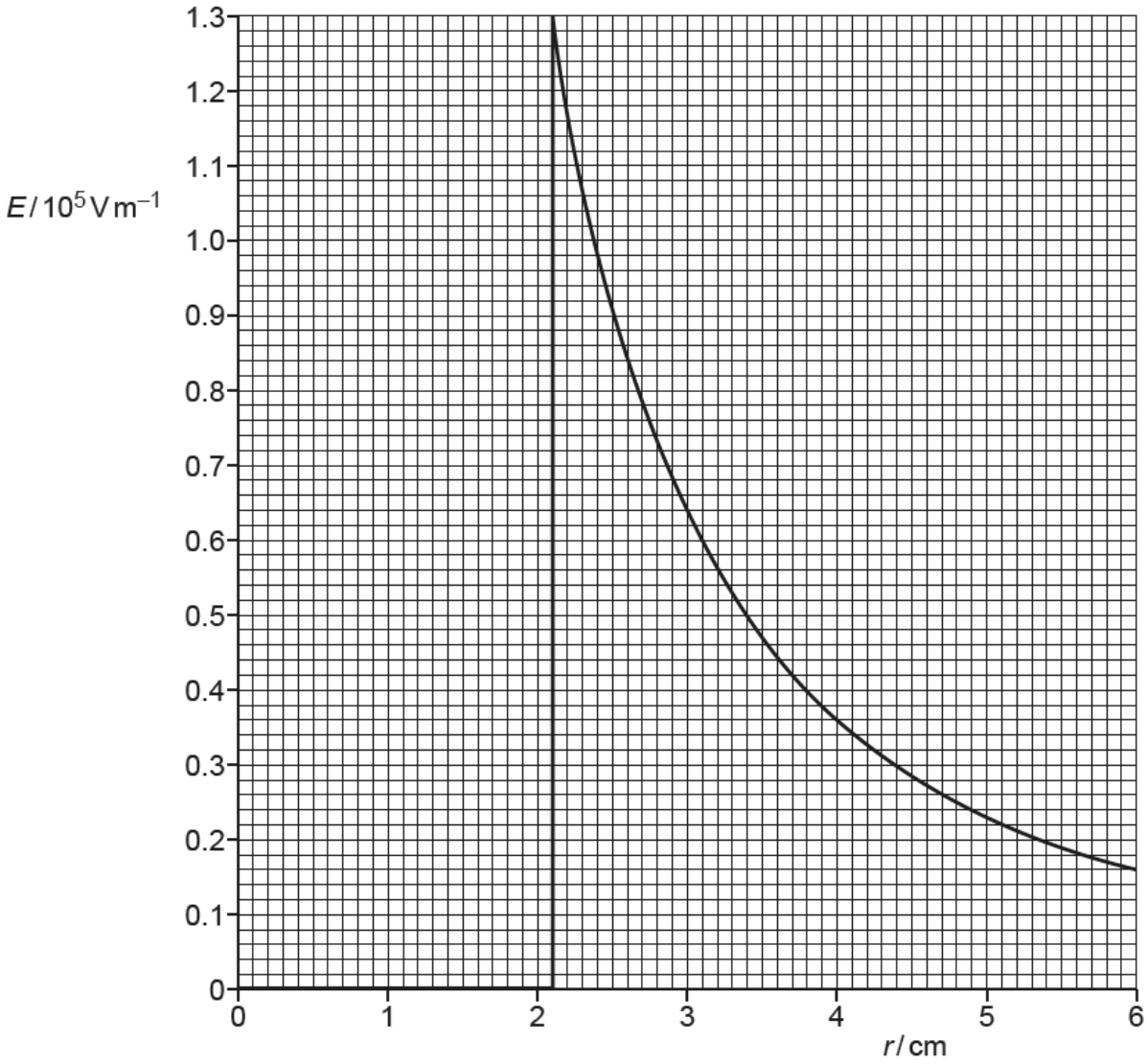


Fig. 6.1

Use data from Fig. 6.1 to:

(i) state the radius of the sphere

radius = ... cm [1]

STEMUP.CO.UK

(ii) calculate the charge on the sphere.

charge = ... C [2]

(c) Using the formula for the electric potential due to an isolated point charge, determine the capacitance of the sphere in **(b)**.

capacitance = ... F [3]

[Total: 7]

STEMUP.CO.UK

1. Nov/2023/Paper_9702/41/No.5

(a) Define electric potential at a point.

.....

.....

..... [2]

(b) Two isolated charged metal spheres X and Y are situated near to each other in a vacuum with their centres a distance of 24 m apart. Point P is at a variable distance x from the centre of sphere X on the line joining the centres of the spheres.

Fig. 5.1 shows the variation with x of the electric potential V due to the spheres at point P.

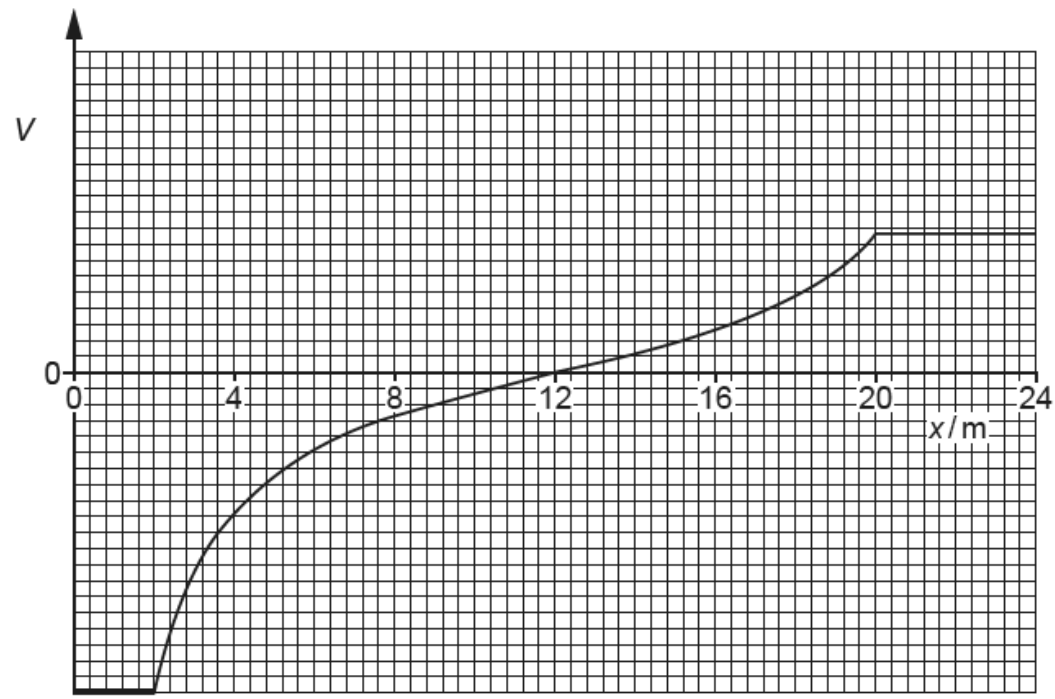


Fig. 5.1

STEMUP.CO.UK

State **three** conclusions that can be drawn about the spheres from Fig. 5.1. The conclusions may be qualitative or quantitative.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) A positively charged particle is placed at point P in **(b)**, such that $x = 12\,\text{m}$.
The particle is released.

Describe and explain the subsequent motion of the particle.

.....

.....

.....

.....

..... [3]

[Total: 8]

STEMUP.CO.UK

2. Nov/2023/Paper_9702/42/No.5

(a) State Coulomb's law.

.....

.....

..... [2]

(b) Two identical oil droplets are in a vacuum. The centres of the droplets are a distance of 3.8×10^{-6} m apart. The droplets have equal charge and exert an electric force on each other of magnitude 6.3×10^{-17} N.

Determine the magnitude of the charge on each droplet.

charge = ... C [2]

(c) One of the oil droplets in **(b)** is now placed between two horizontal metal plates, as shown in Fig. 5.1.

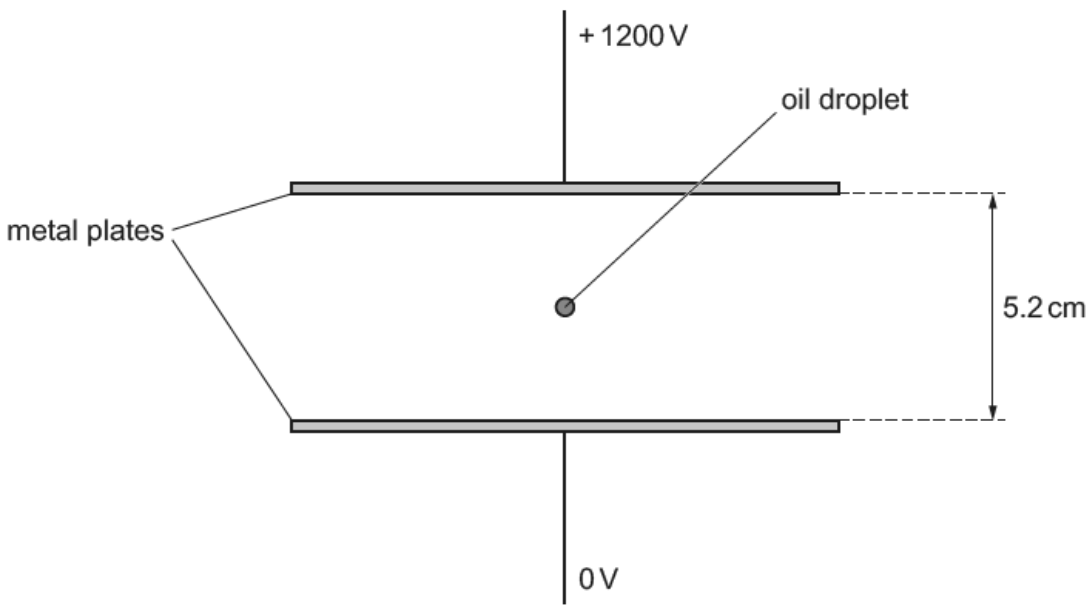


Fig. 5.1 (not to scale)

A potential difference (p.d.) of 1200 V is applied between the plates, with the top plate at the higher potential. The oil droplet is stationary and in equilibrium.

STEMUP.CO.UK

(i) State the sign of the charge on the oil droplet.

..... [1]

(ii) On Fig. 5.1, draw four lines to represent the electric field between the plates. [3]

iii) The distance between the plates is 5.2 cm.

Determine the mass of the oil droplet.

mass = ... kg [3]

[Total: 11]

STEMUP.CO.UK

3. June/2023/Paper_9702/41/No.1

(a) **(i)** Define gravitational field.

.....

..... [1]

(ii) Define electric field.

.....

..... [1]

(iii) State **one** similarity and **one** difference between the gravitational potential due to a point mass and the electric potential due to a point charge.

similarity: .....

.....

difference: .....

.....

[2]

(b) An isolated uniform conducting sphere has mass M and charge Q.
The gravitational field strength at the surface of the sphere is g.
The electric field strength at the surface of the sphere is E.

(i) Show that

$$\frac{M}{Q} = \alpha \frac{g}{E}$$

where α is a constant.

[3]

(ii) Show that the numerical value of α is $1.35 \times 10^{20}\,\text{kg}^2\,\text{C}^{-2}$.

[1]

STEMUP.CO.UK

(c) Assume that the Earth is a uniform conducting sphere of mass 5.98×10^{24} kg.
The surface of the Earth carries a charge of -4.80×10^{5} C that is evenly distributed.

(i) Use the information in **(b)** to determine the electric field strength at the surface of the Earth. Give a unit with your answer.

electric field strength = ... unit ..... [2]

(ii) State how the direction of the electric field at the surface of the Earth compares with the direction of the gravitational field.

..... [1]

[Total: 11]

STEMUP.CO.UK

4. March/2023/Paper_9702/42/No.4

(a) State Coulomb's law.

.....

.....

.....

..... [2]

(b) A charged sphere X is supported on an insulating stand. A second charged sphere Y is suspended by an insulating thread so that sphere Y is in equilibrium at the position shown in Fig. 4.1.

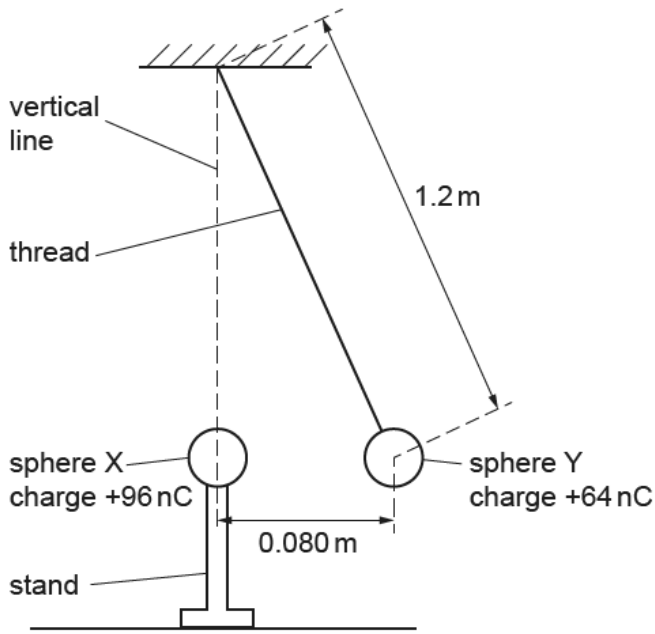


Fig. 4.1

The charge on sphere X is +96 nC and the charge on sphere Y is +64 nC.
Assume that the spheres behave as point charges.

The length of the thread is 1.2 m and the centres of sphere X and sphere Y are separated horizontally by a distance of 0.080 m.

STEMUP.CO.UK

(i) On Fig. 4.2, draw and label all the forces acting on sphere Y.

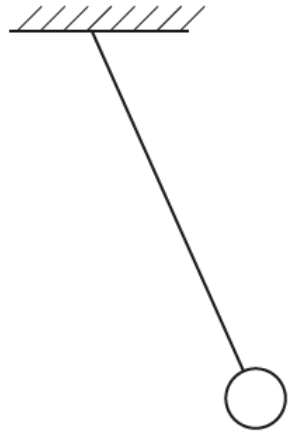


Fig. 4.2

[1]

(ii) Determine the mass of sphere Y.

mass = ... kg [4]

(iii) Calculate the total electric potential energy stored between X and Y.

energy = ... J [1]

STEMUP.CO.UK

(c) An electron enters the region between two parallel plates P and Q, that are separated by a distance of 18 mm, as shown in Fig. 4.3.

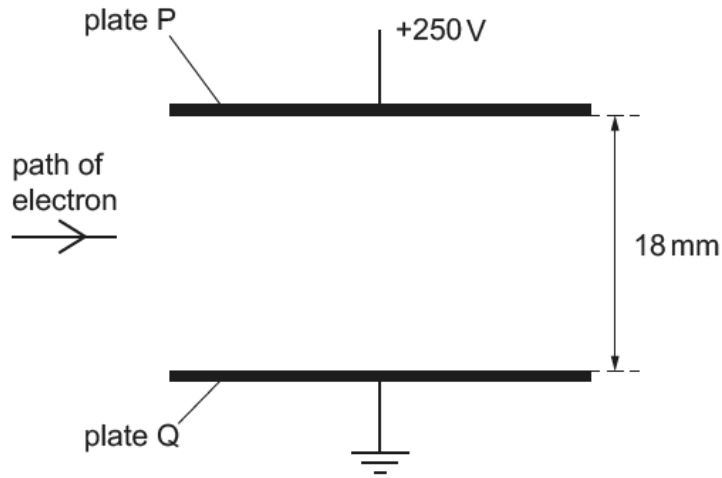


Fig. 4.3

The space between the plates is a vacuum.
The potential difference between the plates is 250 V. The electric field may be assumed to be uniform in the region between the plates and zero outside this region.

(i) State the direction of the electric force on the electron when between the plates.

..... [1]

(ii) Determine the magnitude of the force acting on the electron due to the electric field.

force = ... N [2]

(iii) Explain why the electron does **not** follow a circular path.

.....

..... [1]

[Total: 12]

STEMUP.CO.UK

Electric Field - 2018

1. 9702/11/M/J/18/No.28

A particle has a charge of +2.0 mC and is in a vertical uniform electric field. An electric force of 1.0×10^{-2} N acts upwards on the particle.

What is the electric field strength?

$E = \frac{F}{Q} = \frac{1.0 \times 10^{-2}}{2 \times 10^{-3}}$

$= 5 \text{ N m}^{-1}$ upwards

A 0.20 V m^{-1} downwards

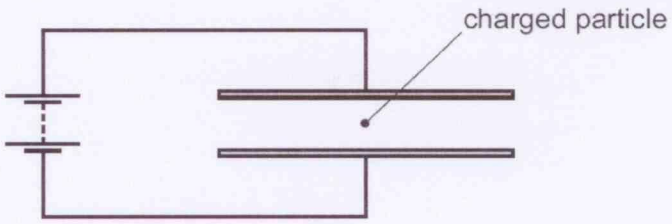
B 0.20 V m^{-1} upwards

C 5.0 V m^{-1} downwards

D 5.0 V m^{-1} upwards

2. 9702/11/M/J/18/No.29

A charged particle is in the electric field between two horizontal metal plates connected to a battery, as shown. There is a force *F* on the particle due to the electric field.



The separation of the plates is doubled.

What is the new force on the particle?

A $\frac{F}{4}$ **B** $\frac{F}{2}$ **C** F **D** $2F$

$E = \frac{V}{d}$

$F = \frac{V_2}{d}$

$F_2 = \frac{V_2}{2d}$

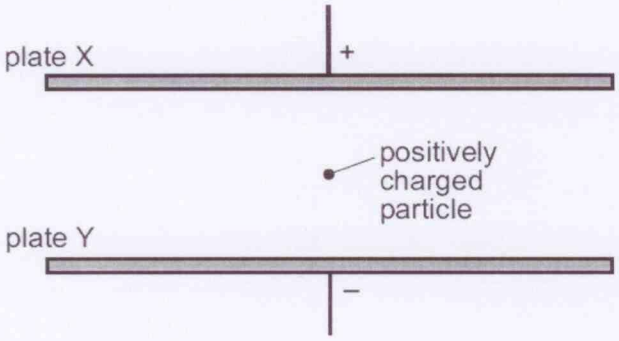
1- Substitute F in F_2.

$F_2 = \frac{F}{2}$

STEMUP.CO.UK

3. 9702/12/M/J/18/No.30

Two large parallel metal plates X and Y are situated in a vacuum as shown.



- +ve particle is repelled by plate X and attracted by plate Y.
- The two forces are equal
- The force is constant.

Plates X and Y carry equal and opposite charges.

What happens to the force on a positively charged particle as it moves from plate X to plate Y?

A It decreases because the positively charged particle is moving away from the positively charged plate.

B It decreases because the positively charged particle is moving in the direction of the electric field between the plates.

C It increases because the positively charged particle is moving closer to a negatively charged plate.

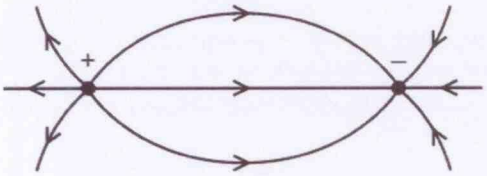
D It remains constant because the positively charged particle is in the uniform electric field between the plates. ✓

4. 9702/12/M/J/18/No.31

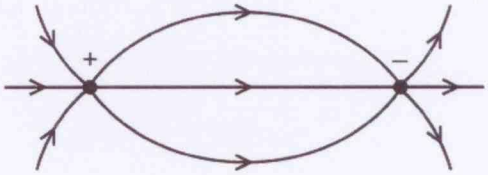
Four diagrams representing the electric field between two oppositely-charged point charges are shown.

Which diagram correctly shows the electric field lines?

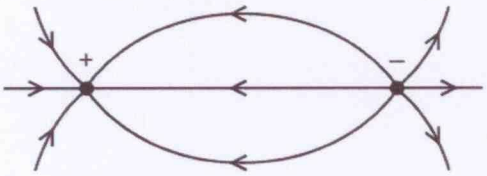
A ✓



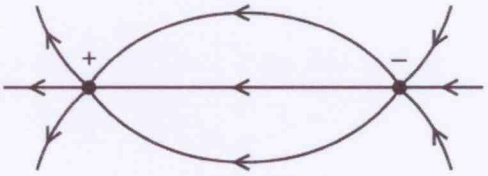
B



C



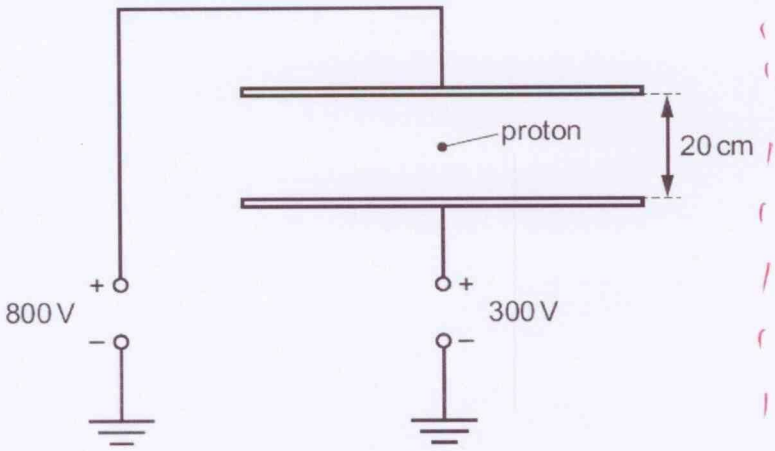
D



STEMUP.CO.UK

5. 9702/13/M/J/18/No.27

Two parallel metal plates are situated 20 cm apart in a vacuum. They are connected to two sources of potential difference as shown.



A proton is released in the space between the plates.

What is the magnitude and direction of the acceleration of the proton?

A ✓ $2.4 \times 10^{11}\ \text{m s}^{-2}$ downwards

B $2.4 \times 10^{11}\ \text{m s}^{-2}$ upwards

C $5.3 \times 10^{11}\ \text{m s}^{-2}$ downwards

D $5.3 \times 10^{11}\ \text{m s}^{-2}$ upwards

$F = \frac{Vq}{d}$

$= \frac{500 \times 1.6 \times 10^{-19}}{0.2}$

$= 4 \times 10^{-16}\ \text{N}$

$F = ma$

$a = \frac{F}{m_p}$

$= \frac{4 \times 10^{-16}\ \text{N}}{1.67 \times 10^{-27}\ \text{kg}}$

$= 2.395 \times 10^{11}\ \text{m s}^{-2}$

$= 2.4 \times 10^{11}\ \text{m s}^{-2}$

- downwards since proton is true - upper plate is truly charged.

P.d across plate = 800 − 300 = 500 V.

Charge on proton = $+1.6 \times 10^{-19}$ C

d = 0.2 m.

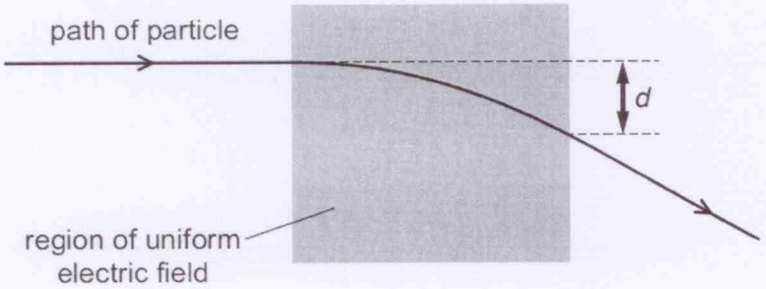
mass of proton = 1.67×10^{-27} kg.

6. 9702/13/M/J/18/No.28

A particle having mass m and charge $+q$ enters a uniform electric field with speed v.

Initially, the particle is travelling at right-angles to the electric field.

During its movement through the field, the particle is deflected through distance d, as shown.



A second particle of mass $2m$, charge $+q$ and speed v enters the electric field along the same path.

What is the distance through which this particle is deflected in the electric field?

A $\frac{d}{4}$ B ✓ $\frac{d}{2}$ C $2d$ D $4d$

STEMUP.CO.UK

7. 9702/13/M/J/18/No.29

What is a possible charge on a particle?

- charge should be multiple of 1.6×10^{-19} C.

A 6.40×10^{-20} C

B 4.00×10^{-19} C

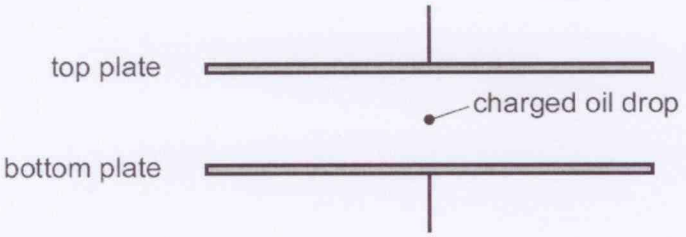
C 1.12×10^{-18} C ✓

D 9.11×10^{-18} C

$2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$
$3 \times 1.6 \times 10^{-19} = 4.8 \times 10^{-19}$
$4 \times 1.6 \times 10^{-19} = 6.4 \times 10^{-19}$
$5 \times 1.6 \times 10^{-19} = 8.0 \times 10^{-19}$
$6 \times 1.6 \times 10^{-19} = 9.6 \times 10^{-19}$
$7 \times 1.6 \times 10^{-19} = 1.12 \times 10^{-18}$

8. 9702/12/F/M/18/No.12

A charged oil drop is held stationary between two charged parallel plates.



Which forces act on the oil drop?

- oil drop is matter
- It is attracted by gravity.
- oil drop is charged
- It will feel force due to electric field.

A both electric and gravitational ✓

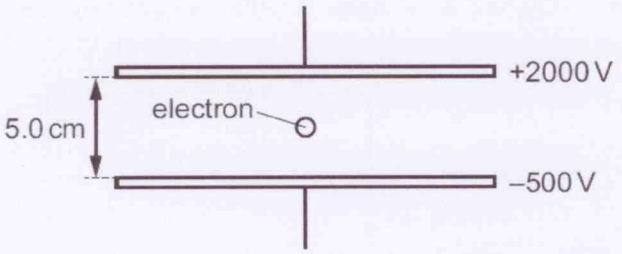
B electric only

C gravitational only

D neither electric nor gravitational

9. 9702/12/F/M/18/No.30

An electron passes into the space between two parallel plates that are 5.0 cm apart and which are maintained at electric potentials of +2000 V and –500 V, respectively.



What is the electric force on the electron?

p.d = 2000 − −500
= 2000 + 500
= 2500 V.

$F = \frac{eV}{d}$

$= \frac{1.6 \times 10^{-19} C \times 2500 V}{0.05 m}$

$= 8.0 \times 10^{-15} N$

A 1.6×10^{-15} N

B 4.8×10^{-15} N

C 6.4×10^{-15} N

D 8.0×10^{-15} N ✓

STEMUP.CO.UK

10. 9702/12/F/M/18/No.31

Which statement about electric charges in a uniform electric field is **not** correct?

A Electric charges of the same magnitude, whether positive or negative, experience the same magnitude of force when placed in the same uniform electric field.

B The direction of the force on a positive charge placed in a uniform electric field is independent of the magnitude of the charge.

C The magnitude of the force on a positive charge placed in a uniform electric field is proportional to the magnitude of the electric field strength.

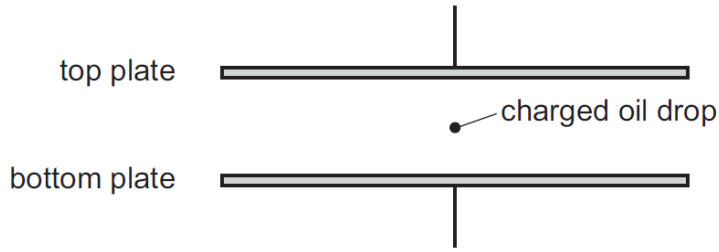
D The work done to move a positive charge a certain distance in a uniform electric field is independent of the direction of the movement.

STEMUP.CO.UK

Electric fields – 2021 AS

1. June/2021/Paper_11/No.11

A charged oil drop is held stationary between two charged parallel plates.



Which forces act on the oil drop?

A both electric and gravitational

B electric only

C gravitational only

D neither electric nor gravitational

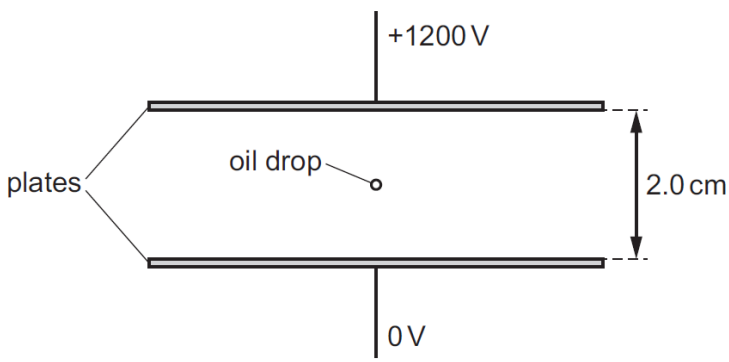
2. June/2021/Paper_11/No.30

What is the electric field strength in a region where a proton accelerates at $2.00\,m\,s^{-2}$ due to the field?

A $11.4\,pV\,m^{-1}$ **B** $5.22\,nV\,m^{-1}$ **C** $10.4\,nV\,m^{-1}$ **D** $20.9\,nV\,m^{-1}$

3. June/2021/Paper_11/No.31

An oil drop of mass 2.6×10^{-15} kg and with a charge of -4.8×10^{-19} C is in a vacuum between two horizontal plates. The plates have a separation of 2.0 cm and a potential difference (p.d.) between them of 1200 V, as shown.



Which statement describes the motion of the oil drop?

A It is stationary.

B It has a downward acceleration of $9.7\,m\,s^{-2}$.

C It has an upward acceleration of $1.3\,m\,s^{-2}$.

D It has an upward acceleration of $11\,m\,s^{-2}$.

STEMUP.CO.UK

4. June/2021/Paper_12/No.11

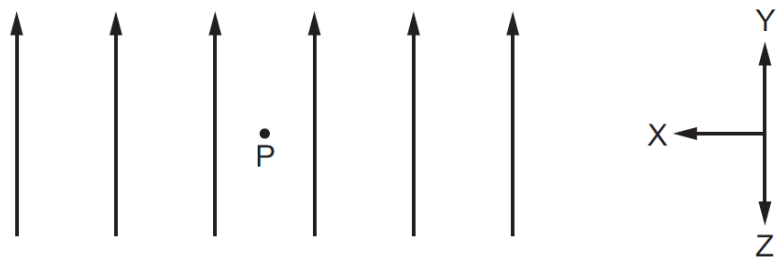
A charged particle is placed in a uniform field of force. The direction of the force on the particle is opposite to the direction of the field.

What is the field and what is the charge on the particle?

	field	charge on particle
A	electric	negative
B	electric	positive
C	gravitational	negative
D	gravitational	positive

5. June/2021/Paper_12/No.30

A positively charged particle P is in an electric field, as shown.



The field lines (lines of force) are evenly spaced and parallel.

Which statement is correct?

A Moving P a small distance in any direction will not change the electric force on P.

B Moving P a small distance in direction Y will increase the electric force on P.

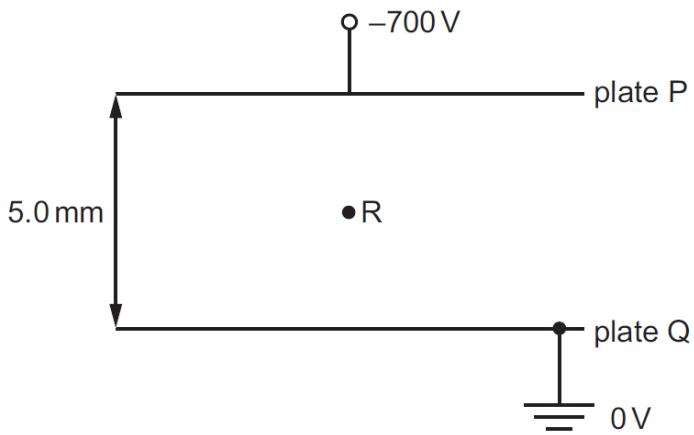
C Moving P a small distance in direction Z will increase the electric force on P.

D Moving P a small distance in direction X will increase the electric force on P.

STEMUP.CO.UK

6. June/2021/Paper_12/No.31

The diagram shows two parallel metal plates P and Q, separated by a distance of 5.0 mm. There is a potential difference of 700 V between the plates. Plate Q is earthed.



What is the magnitude and direction of the electric field at point R?

A $1.4 \times 10^2\,\text{N C}^{-1}$ from P towards Q

B $1.4 \times 10^2\,\text{N C}^{-1}$ from Q towards P

C $1.4 \times 10^5\,\text{N C}^{-1}$ from P towards Q

D $1.4 \times 10^5\,\text{N C}^{-1}$ from Q towards P

7. Nov/2021/Paper_11/No.30

What is meant by electric field strength?

A force per unit charge acting on a small mass

B force per unit charge acting on a small positive charge

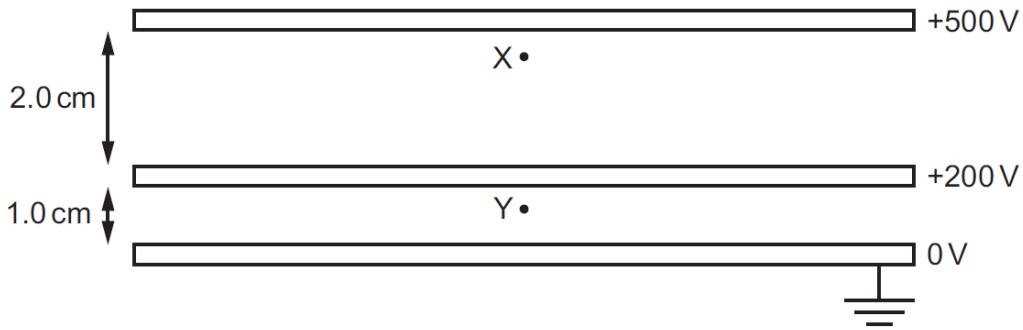
C force per unit mass acting on a small mass

D force per unit mass acting on a small positive charge

STEMUP.CO.UK

8. Nov/2021/Paper_11/No.31

Three parallel metal plates of the same area are fixed with a separation of 2.0 cm between the top plate and the middle plate, and 1.0 cm between the middle plate and the bottom plate. The top plate is held at a potential of +500 V, the middle plate at +200 V and the bottom plate is earthed, as shown.



What is the value of the ratio $\frac{\text{magnitude of force on an electron at X}}{\text{magnitude of force on an electron at Y}}$?

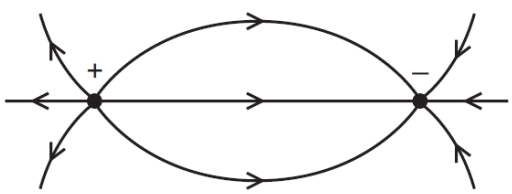
A 0.75 **B** 1.00 **C** 1.25 **D** 1.50

9. Nov/2021/Paper_12/No.31

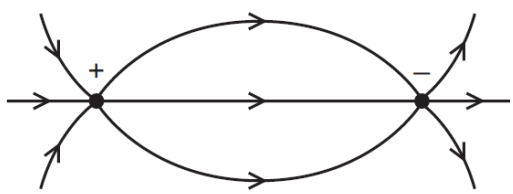
Four diagrams representing the electric field between two oppositely charged point charges are shown.

Which diagram correctly shows the electric field lines?

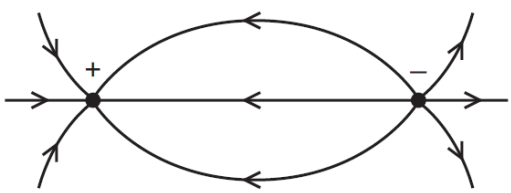
A



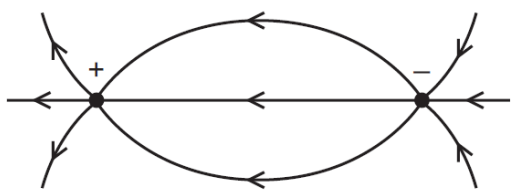
B



C



D

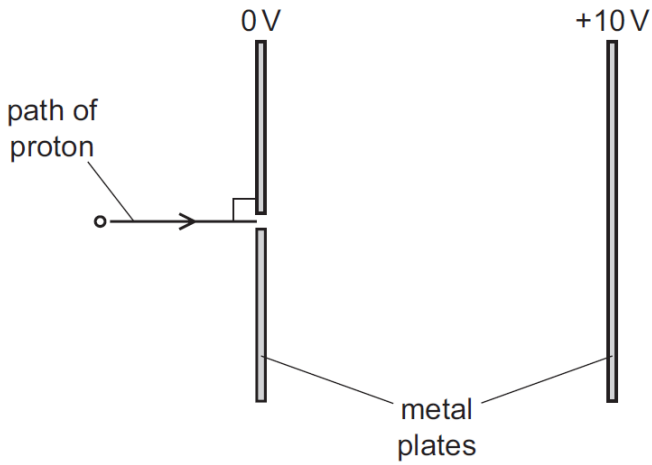


STEMUP.CO.UK

10. Nov/2021/Paper_12/No.32

A proton enters the uniform electric field between two parallel vertical metal plates in a vacuum.

One plate is at a potential of 0 V and the other plate is at a potential of +10 V, as shown.



What is the initial change in the motion of the proton caused by the electric field, immediately after the proton enters the field?

A It begins to move downwards.

B It begins to move upwards.

C Its speed decreases.

D Its speed increases.

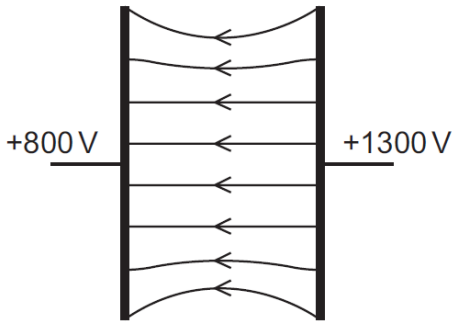
STEMUP.CO.UK

11. Nov/2021/Paper_13/No.31

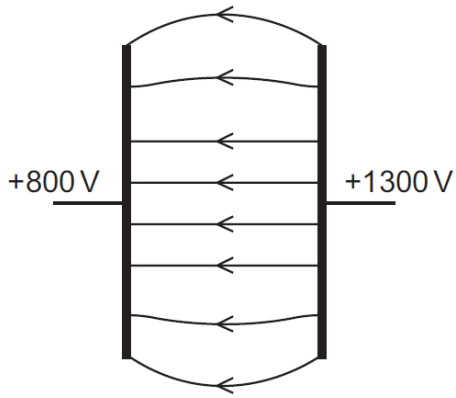
Two parallel metal plates are at electric potentials of +800 V and +1300 V.

Which diagram best represents the electric field between the metal plates?

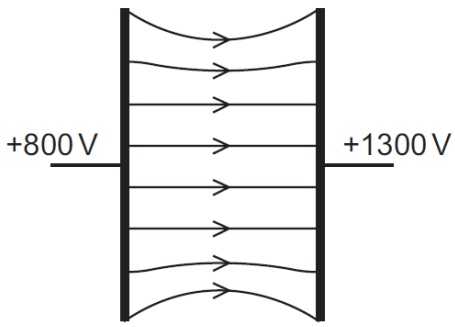
A



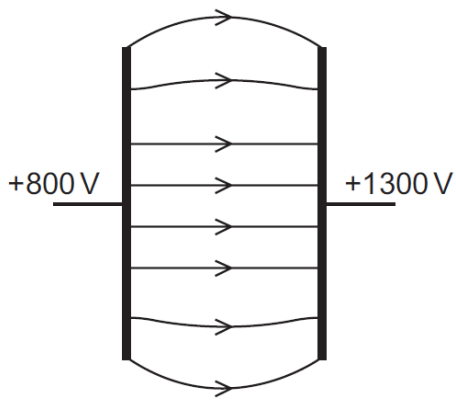
B



C



D



12. Nov/2021/Paper_13/No.32

An electron is in a uniform electric field of field strength 1500 V m^{-1}.

What is the acceleration of the electron due to the electric field?

A $8.5 \times 10^{-9}\,m\,s^{-2}$

B $1.6 \times 10^{-5}\,m\,s^{-2}$

C $1.4 \times 10^{11}\,m\,s^{-2}$

D $2.6 \times 10^{14}\,m\,s^{-2}$

STEMUP.CO.UK

13. Nov/2021/Paper_13/No.33

A lightning strike transfers 1×10^{20} electrons past a point in a time of 30 μs.

What is the average current during the lightning strike?

A 0.5 mA **B** 0.5 A **C** 500 A **D** 500 kA

STEMUP.CO.UK

1. Nov/2021/Paper_22/No.2

A charged oil drop is in a vacuum between two horizontal metal plates. A uniform electric field is produced between the plates by applying a potential difference of 1340 V across them, as shown in Fig. 2.1.

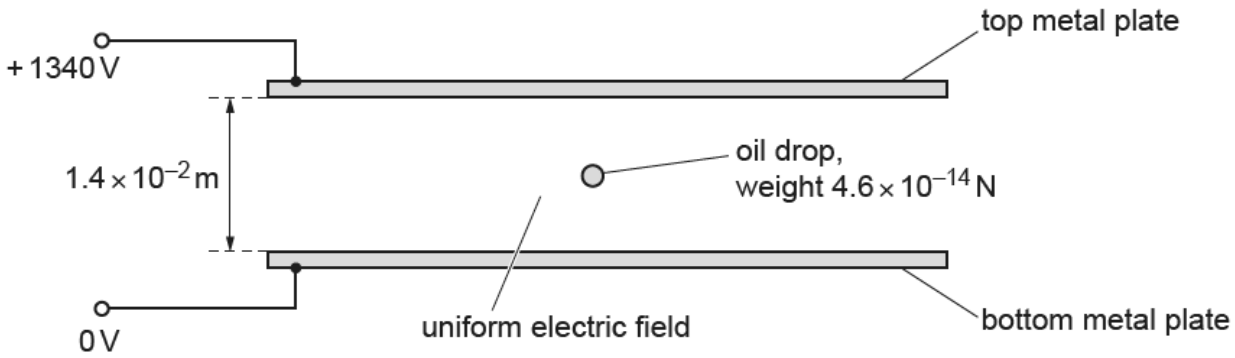


Fig. 2.1

The separation of the plates is 1.4×10^{-2} m.

The oil drop of weight 4.6×10^{-14} N remains stationary at a point mid-way between the plates.

(a) (i) Calculate the magnitude of the electric field strength.

electric field strength = ... NC^{-1} [2]

(ii) Determine the magnitude and the sign of the charge on the oil drop.

magnitude of charge = ... C

sign of charge .....

[3]

STEMUP.CO.UK

(b) The electric potentials of the plates are instantaneously reversed so that the top plate is at a potential of 0 V and the bottom plate is at a potential of +1340 V. This change causes the oil drop to start moving downwards.

(i) Compare the new pattern of the electric field lines between the plates with the original pattern.

.....

..... [2]

(ii) Determine the magnitude of the resultant force acting on the oil drop.

resultant force = ... N [1]

(iii) Show that the magnitude of the acceleration of the oil drop is $20\,m\,s^{-2}$.

[2]

(iv) Assume that the radius of the oil drop is negligible.

Use the information in **(b)(iii)** to calculate the time taken for the oil drop to move to the bottom metal plate from its initial position mid-way between the plates.

time = ... s [2]

STEMUP.CO.UK

(c) The oil drop in **(b)** starts to move at time $t = 0$. The distance of the oil drop from the bottom plate is x.

On Fig. 2.2, sketch the variation with time t of distance x for the movement of the drop from its initial position until it hits the surface of the bottom plate. Numerical values of t are not required.

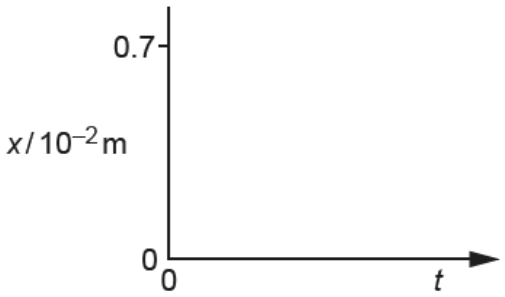


Fig. 2.2

[2]

[Total: 14]

STEMUP.CO.UK

2. Nov/2021/Paper_23/No.4

An α-particle moves in a straight line through a vacuum with a constant speed of $4.1 \times 10^6\,m\,s^{-1}$. The α-particle enters a uniform electric field at point A, as shown in Fig. 4.1.

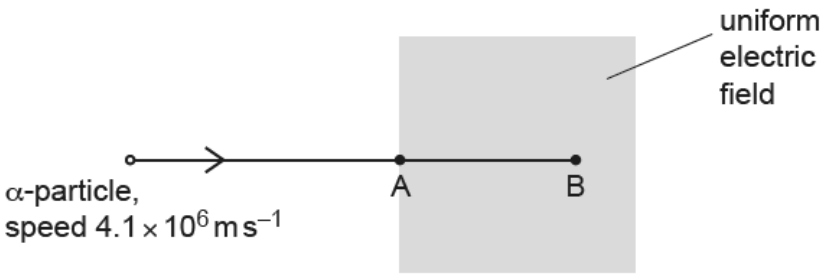


Fig. 4.1

The α-particle continues to move in the same straight line until it is brought to rest at point B by the electric field. The deceleration of the α-particle by the electric field is $2.7 \times 10^{14}\,m\,s^{-2}$.

(a) State the direction of the electric field.

..... [1]

(b) Calculate the distance AB.

distance = ... m [2]

(c) Calculate the electric field strength.

electric field strength = ... $V\,m^{-1}$ [3]

STEMUP.CO.UK

(d) The α-particle is at point A at time $t = 0$.

On Fig. 4.2, sketch the variation with time t of the momentum of the α-particle as it travels from point A to point B. Numerical values are not required.

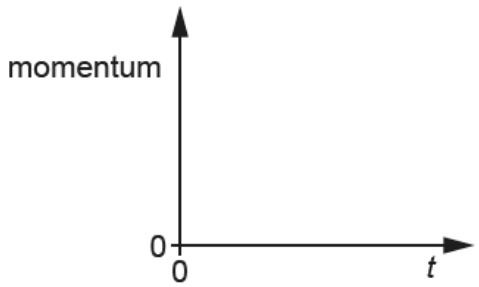


Fig. 4.2

[1]

(e) State the name of the quantity that is represented by the gradient of the graph in **(d)**.

..... [1]

(f) A β^- particle now enters the electric field along the same initial path as the α-particle and with the same initial speed of $4.1 \times 10^6\,m\,s^{-1}$.

(i) Calculate the kinetic energy, in J, of the β^- particle at point A.

kinetic energy = ... J [3]

(ii) State and explain the differences between the electric force on the β^- particle in the electric field and the electric force on the α-particle in the electric field.

.....

.....

.....

.....

..... [3]

(iii) The β^- particle is produced by the decay of a nucleus. State the name of another lepton that is produced at the same time as the β^- particle.

..... [1]

[Total: 15]

STEMUP.CO.UK