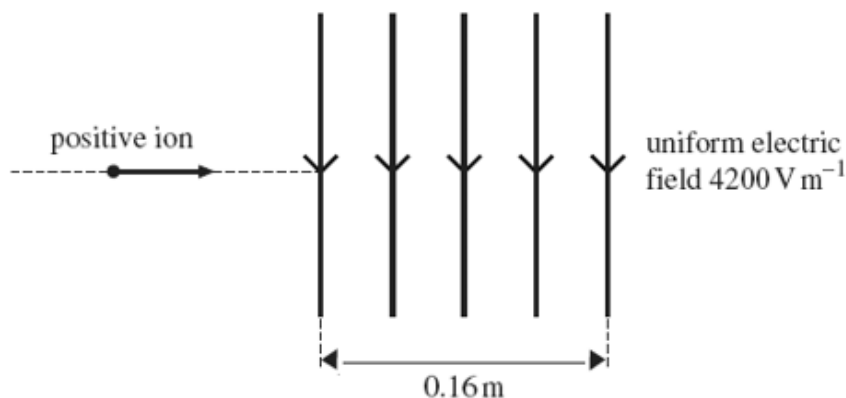


**Q1.** An electron and a proton are  $1.0 \times 10^{-10}$  m apart. In the absence of any other charges, what is the electric potential energy of the electron?

- A  $+2.3 \times 10^{-18}$  J
- B  $-2.3 \times 10^{-18}$  J
- C  $+2.3 \times 10^{-18}$  J
- D  $-2.3 \times 10^{-18}$  J

(Total 1 mark)

**Q2.**



An ion carrying a charge of  $+4.8 \times 10^{-19}$  C travels horizontally at a speed of  $8.0 \times 10^5 \text{ ms}^{-1}$ . It enters a uniform vertical electric field of strength  $4200 \text{ V m}^{-1}$ , which is directed downwards and acts over a horizontal distance of 0.16 m. Which one of the following statements is **not** correct?

- A The ion passes through the field in  $2.0 \times 10^{-7}$  s.
- B The force on the ion acts vertically downwards at all points in the field.
- C The magnitude of the force exerted on the ion by the field is  $1.6 \times 10^{-9}$  N.
- D The horizontal component of the velocity of the ion is unaffected by the electric field.

(Total 1 mark)

**Q3.** The electric potential at a distance  $r$  from a positive point charge is 45 V. The potential increases to 50 V when the distance from the charge decreases by 1.5 m. What is the value of  $r$ ?

- A 1.3 m
- B 1.5 m
- C 7.9 m
- D 15 m

(Total 1 mark)

**Q4.** (a) Complete the table of quantities related to fields. In the second column, write an SI unit for each quantity. In the third column indicate whether the quantity is a scalar or a vector.

quantity	SI unit	scalar or vector
gravitational potential		
electric field strength		
magnetic flux density		

(3)

(b) (i) A charged particle is held in equilibrium by the force resulting from a vertical electric field. The mass of the particle is  $4.3 \times 10^{-9}$  kg and it carries a charge of magnitude  $3.2 \times 10^{-12}$  C. Calculate the strength of the electric field.

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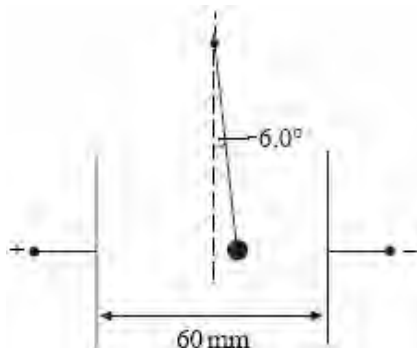
(ii) If the electric field acts upwards, state the sign of the charge carried by the particle

.....

(3)

(Total 6 marks)

- Q5.** A small charged sphere of mass  $2.1 \times 10^{-4}$  kg, suspended from a thread of insulating material, was placed between two vertical parallel plates 60 mm apart. When a potential difference of 4200 V was applied to the plates, the sphere moved until the thread made an angle of  $6.0^\circ$  to the vertical, as shown in the diagram below.



- (a) Show that the electrostatic force  $F$  on the sphere is given by  $F = mg \tan 6.0^\circ$ , where  $m$  is the mass of the sphere.

.....  
 .....  
 .....  
 .....  
 .....

(3)

- (b) Calculate the charge on the sphere.

.....  
 .....  
 .....  
 .....

(3)

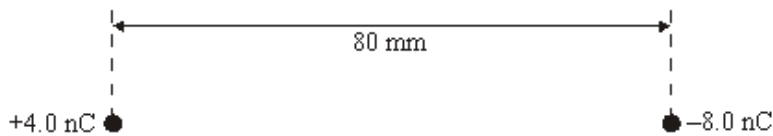
(Total 6 marks)

- Q6.** (a) (i) Define the *electric field strength*,  $E$ , at a point in an electric field.

.....  
 .....  
 .....

- (ii) State whether  $E$  is a scalar or a vector quantity.

- (b) Point charges of  $+4.0 \text{ nC}$  and  $-8.0 \text{ nC}$  are placed  $80 \text{ mm}$  apart, as shown in the figure below.



- (i) Calculate the magnitude of the force exerted on the  $+4.0 \text{ nC}$  charge by the  $-8.0 \text{ nC}$  charge.

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 .....  
 .....

- (ii) Determine the distance from the  $+4.0 \text{ nC}$  charge to the point, along the straight line between the charges, where the electric potential is zero.

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 .....  
 .....  
 .....

(4)

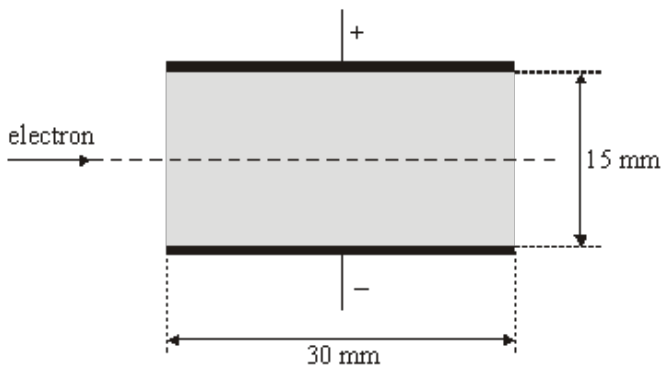
- (c) Point **P** in the figure above is equidistant from the two charges.

- (i) Draw two arrows on the figure above at **P** to represent the directions and relative magnitudes of the components of the electric field at **P** due to each of the charges.
- (ii) Hence draw an arrow, labelled **R**, on the figure above at **P** to represent the direction of the resultant electric field at **P**.

(3)

(Total 10 marks)

- Q7.** (a) An electron travels at a speed of  $3.2 \times 10^7 \text{ ms}^{-1}$  in a horizontal path through a vacuum. The electron enters the uniform electric field between two parallel plates, 30 mm long and 15 mm apart, as shown in the figure below. A potential difference of 1400 V is maintained across the plates, with the top plate having positive polarity. Assume that there is no electric field outside the shaded area.



- (i) Show that the electric field strength between the plates is  $9.3 \times 10^4 \text{ Vm}^{-1}$ .
- .....
- .....
- (ii) Calculate the time taken by the electron to pass through the electric field.
- .....
- .....
- (iii) Show that the acceleration of the electron whilst in the field is  $1.6 \times 10^{16} \text{ m s}^{-2}$  and state the direction of this acceleration.

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(b) Determine the magnitude and direction of the velocity of the electron at the point where it leaves the field.

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.....

.....

**(3)**  
**(Total 8 marks)**

M1. B

[1]

M2. C

[1]

M3. D

[1]

M4. (a)

quantity	SI unit	
(gravitational potential)	$\text{J kg}^{-1}$ or $\text{N m kg}^{-1}$	scalar
(electric field strength)	$\text{N C}^{-1}$ or $\text{V m}^{-1}$	vector
(magnetic flux density)	$\text{T}$ or $\text{Wb m}^{-2}$ or $\text{N A}^{-1} \text{m}^{-1}$	vector

6 entries correct **(1) (1) (1)**4 or 5 entries correct **(1) (1)**2 or 3 entries correct **(1)**

3

(b) (i)  $mg = EQ$  **(1)**

$$E \left( \frac{mg}{Q} = \frac{4.3 \times 10^{-9} \times 9.81}{3.2 \times 10^{-12}} \right) = 1.32 \times 10^4 \text{ (V m}^{-1}\text{)} \text{ (1)}$$

(ii) positive **(1)**

3

[6]

**M5.** (a)  $T \cos 6^\circ = mg$  (1)

$$T \sin 6^\circ = F$$
 (1)

hence  $F = mg \tan 6^\circ$  (1)

[or by use of triangle: sides correct (1)  $6^\circ$  correct (1)  $\tan 6^\circ = F/mg$  (1)]

3

(b) (use of  $E = \frac{V}{d}$  gives)  $E = \frac{4200}{60 \times 10^{-3}} = 7.0 \times 10^4 \text{ V m}^{-1}$  (1)

$$\begin{aligned} \text{(use of } Q = \frac{F}{E} \text{ gives) } Q \left( \frac{mg \tan 6^\circ}{E} \right) &= \frac{2.1 \times 10^{-4} \times 9.81 \tan 6^\circ}{7.0 \times 10^4} \text{ (1)} \\ &= 3.1 \times 10^{-9} \text{ C (1)} \end{aligned}$$

3

(allow ecf for value of  $E$  from (i))

[6]

**M6.** (a) (i) force per unit charge (1)  
acting on a positive charge (1)

(ii) vector (1)

3

(b) (i)  $F \left( = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2} \right) = \frac{4.0 \times 10^{-9} \times 8.0 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times (80 \times 10^{-3})^2}$  (1)  
 $= 4.5(0) \times 10^{-5} \text{ N (1)}$

(ii) (use of  $V = \frac{Q}{4\pi\epsilon_0 x}$  gives)  $0 = \left( \frac{4.0 \times 10^{-9}}{4\pi\epsilon_0 x} \right) - \left( \frac{8.0 \times 10^{-9}}{4\pi\epsilon_0 (80 \times 10^{-3} - x)} \right)$

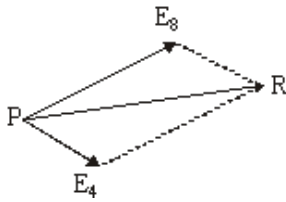
$$\text{or } \frac{4}{x} = \frac{8}{80 - x} \text{ (1)}$$

$$x = 26.7 \text{ mm (1)}$$

4



- (c) correct directions for  $E_4$  and  $E_8$  (1)  
 $E_8$  approx twice as long as  $E_4$  (1)  
 correct direction of resultant R  
 shown (1)



3

[10]

**M7.** (a) (i)  $E \left( = \frac{V}{d} \right) = \frac{1400}{15 \times 10^{-3}} \text{ (1) } (= 9.3 \times 10^4 \text{ Vm}^{-1})$

(ii)  $t \left( = \frac{l}{v} \right) = \frac{30 \times 10^{-3}}{3.2 \times 10^7} = 9.38 \times 10^{-10} \text{ s (1)}$

(iii)  $ma_y = Ee \text{ (1)}$

$$ay = \frac{9.3 \times 10^4 \times 1.60 \times 10^{-19}}{9.11 \times 10^{-31}} \text{ (1) } (= 1.64 \times 10^{16} \text{ m s}^{-2})$$

acceleration is upwards [or towards + plate](1)

5

(b)  $v_y (= a_y t) = 1.64 \times 10^{16} \times 9.38 \times 10^{-10} \text{ (1) } (= 1.54 \times 10^7 \text{ m s}^{-1})$

$$v = \sqrt{(1.54 \times 10^7)^2 + (3.2 \times 10^7)^2} = 3.55 \times 10^7 \text{ m s}^{-1} \text{ (1)}$$

at  $\tan^{-1} \left( \frac{1.54}{3.2} \right) = 26^\circ$  above the horizontal (1)

3

[8]

