Q1. An electron and a proton are 1.0×10^{-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

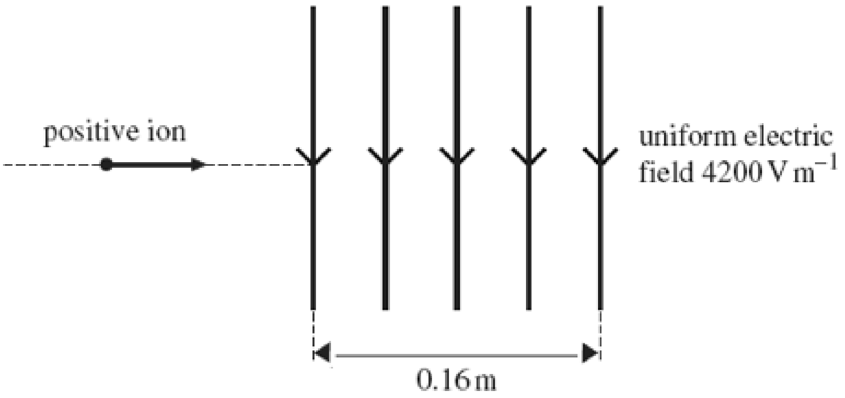
B -2.3×10^{-18}J

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

D -2.3×10^{-18}J

(Total 1 mark)

Q2.



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

A The ion passes through the field in 2.0×10^{-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 1.6×10^{-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 4.3×10^{-9} kg and it carries a charge of magnitude 3.2×10^{-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

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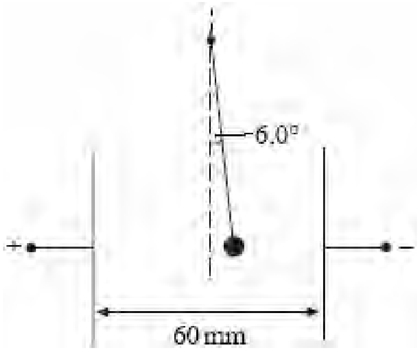
(3)
(Total 6 marks)

Q5. A small charged sphere of mass 2.1×10^{-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° to the vertical, as shown in the diagram below.



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

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(3)

(b) Calculate the charge on the sphere.

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(3)
(Total 6 marks)

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

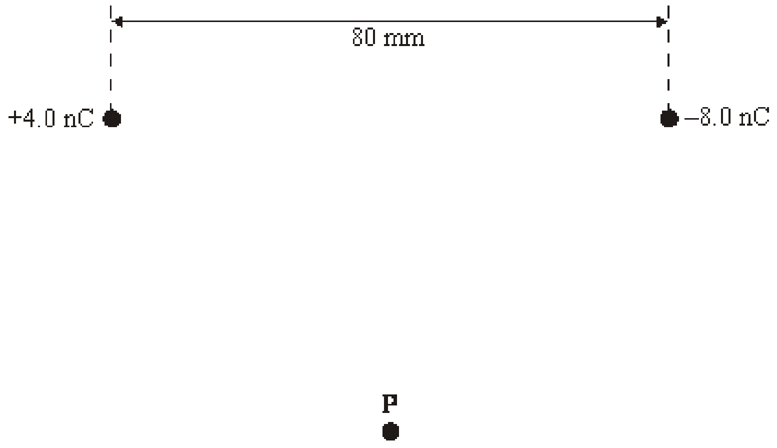
....

....

....

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

(b) Point charges of +4.0 nC and –8.0 nC are placed 80 mm apart, as shown in the figure below.



(i) Calculate the magnitude of the force exerted on the +4.0 nC charge by the –8.0 nC charge.

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

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(4)

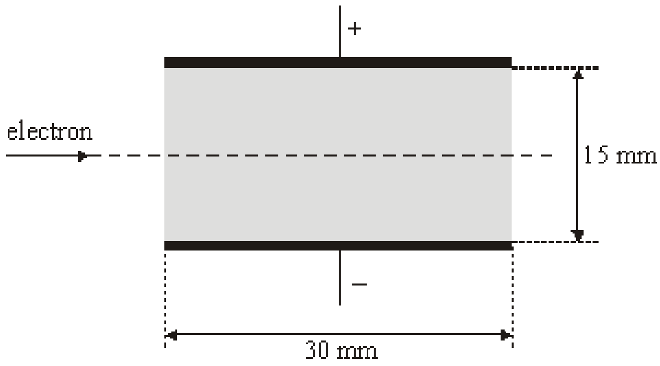
(c) Point **P** in the figure above is equidistant from the two charges.

(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 3.2×10^7 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 9.3×10^4 Vm^{-1}.

....

....

(ii) Calculate the time taken by the electron to pass through the electric field.

....

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(iii) Show that the acceleration of the electron whilst in the field is 1.6×10^{16} m s^{-2} and state the direction of this acceleration.

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(5)

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

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....

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(3)
(Total 8 marks)

M1. B

[1]

M2. C

[1]

M3. D

[1]

M4. (a)

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

$E\left(\frac{mg}{Q}\right) = \frac{4.3 \times 10^{-9} \times 9.81}{3.2 \times 10^{-12}}$ = 1.32 × 10^4 (V m^{-1}) **(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)** 6º correct **(1)** $\tan 6^\circ = F/mg$ **(1)**]

3

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

(use of $Q = \frac{F}{E}$ gives) $Q \left(\frac{mg \tan 6^\circ}{E}\right) = \frac{2.1 \times 10^{-4} \times 9.81 \tan 6^\circ}{7.0 \times 10^{-4}}$ **(1)**

$= 3.1 \times 10^{-9}$C **(1)**

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) $F\left(= \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}\right) = \frac{4.0 \times 10^{-9} \times 8.0 \times 10^{-9}}{4\pi \times 8.85 \times 10^{-12} \times (80 \times 10^{-3})^2}$ **(1)**

$= 4.5(0) \times 10^{-5}$N **(1)**

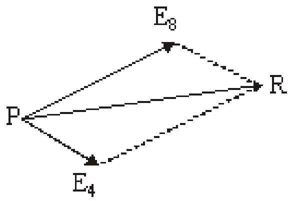
(ii) (use of gives) $0 = \left(\frac{4.0 \times 10^{-9}}{4\pi\varepsilon_0 x}\right) - \left(\frac{8.0 \times 10^{-9}}{4\pi\varepsilon_0 (80 \times 10^{-3} - x)}\right)$

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

$x = 26.7$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) $E\left(=\frac{V}{d}\right)=\frac{1400}{15\times10^{-3}}$ **(1)** $\left(=9.3\times10^{4}\,\text{Vm}^{-1}\right)$

(ii) $t\left(=\frac{l}{v}\right)=\frac{30\times10^{-3}}{3.2\times10^{7}}=9.38\times10^{-10}$ s **(1)**

(iii) $ma_y = Ee$ **(1)**

$ay = \frac{9.3\times10^{4}\times1.60\times10^{-19}}{9.11\times10^{31}}$ **(1)** (= 1.64×10^{16} m s^{-2})
acceleration is upwards [or towards + plate]**(1)**

5

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

$v=\sqrt{(1.54\times10^{7})^2+(3.2\times10^{7})^2}$ = 3.55×10^{7}m s^{-1}**(1)**

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

3

[8]