Uniform Electric Fields

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Electric Fields
Sub Topic	Uniform Electric Fields
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **68 minutes**

Score: **/56**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a) (i)** *either* force = e × (*V* / *d*) *or* *E* = *V*/*d* C1

= $1.6 \times 10^{-19} \times (250 / 7.6 \times 10^{-3})$ C1

= 5.3×10^{-15} N A1 [3]

(ii) *either* $\Delta E_K = eV$ *or* $\Delta E_K = Fd$ C1

= $1.6 \times 10^{-19} \times 250$ = $5.3 \times 10^{-15} \times 7.6 \times 10^{-3}$ M1

= 4.0×10^{-17} J A0 [2]

(*allow full credit for correct working via calculation of a and v*)

(iii) *either* $\Delta E_K = \frac{1}{2}mv^2$

$4.0 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ C1

$v = 9.4 \times 10^6$ m s^{-1} A1 [2]

or $v^2 = 2as$ and $a = F/m$

$v^2 = (2 \times 5.3 \times 10^{-15} \times 7.6 \times 10^{-3})/(9.11 \times 10^{-31})$ (C1)

$v = 9.4 \times 10^6$ m s^{-1} (A1)

(b) speed depends on (electric) potential difference M2

(*If states* ΔE_K *does not depend on uniformity of field, then award 1 mark, treated as an M mark*)

so speed always the same A1 [3]

2 **(a** force <u>per unit positive</u> charge (on a small test charge) B1 [1]

(b) field strength = (210/{1.5×10^{-2}} =) 1.4×10^{4} N C^{-1} A1 [1]

(c) **(i)** acceleration = Eq / m C1
= $(1.4 \times 10^{4} \times 1.6 \times 10^{-19}) / (9.1 \times 10^{-31})$ C1
= 2.5×10^{15} m s^{-2} (2.46×10^{15}) A1
towards positive plate / upwards (and normal to plate) B1 [4]

(ii) time = 2.4×10^{-9} s A1 [1]

(d) *either* vertical displacement after acceleration for 2.4×10^{-9} s
= ½ $\times 2.46 \times 10^{15} \times (2.4 \times 10^{-9})^2$ C1
= 7.1×10^{-3} m A1
(0.71 cm < 0.75 cm and) so will pass between plates A1 [3]
i.e. valid conclusion based on a numerical val

or $0.75 \times 10^{-2} = ½ \times 2.46 \times 10^{15} \times t^2$ (C1)
t is time to travel 'half-way across' plates = 2.47×10^{-9} s (A1)
(2.4 ns < 2.47 ns) so will pass between plates (A1)
i.e. valid conclusion based on a numerical value

3 **(a)** force must be upwards (on positive charge) M1
so plate Y is positive A1 **[2]**

(b) **(i)** $E = V / d$ C1
= $630/(0.75 \times 10^{-2})$
= 8.4×10^{4} N C^{-1} A1 **[2]**

(ii) $qE = mg$ C1
q = $(9.6 \times 10^{-15} \times 9.8) / (8.4 \times 10^{4})$ C1
= 1.12×10^{-18} C A1 **[3]**

4 **(a) (i)** lines normal to plate and equal spacing (at least 4 lines) B1
direction from (+) to earthed plate B1 **[2]**

(ii) $E = 160/0.08$ M1
$= 2.0 \times 10^3$ V m^{-1} A0 **[1]**

(b) (correct directions with line of action of arrows
passing through charges B1 **[1]**

(ii) force $= Eq$ C1
$= 2.0 \times 10^3 \times 1.2 \times 10^{-15}$
$= 2.4 \times 10^{-12}$ N A1 **[2]**

(iii) couple = force × perpendicular separation M1
$= 2.4 \times 10^{-12} \times 2.5 \times 10^{-3} \times \sin 35°$
$= 3.4(4) \times 10^{-15}$ N m A1 **[2]**

(iv) either **rotates** to align with the field
or **oscillates** (about a position) M1
with the positive charge nearer
to the earthed plate/clockwise A1 **[2]**

5 (a) (i) arrow from B towards A..... B1

(ii) $E = V/d$
$= 450/(9.0 \times 10^{-2})$ C1
$= 5.0 \times 10^3$ N C^{-1} (accept 1 sig. fig) ..... A1 [3]

(b) (i) energy $= qV$ or Eqd C1
$= 1.6 \times 10^{-19} \times 450$ A1
$= 7.2 \times 10^{-17}$ J A0

(ii) Ek $= \frac{1}{2}mv^2$
$7.2 \times 10^{-17} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$ C1
$v = 1.26 \times 10^7$ m s^{-1} ..... A1 [4]

(c) line from origin, curved in correct direction but not 'level out' ..... B1 [1]

6 **(a) (i)** arrow in upward direction, foot near P B1

(ii) curved path consistent with **(i)** between plates B1
then straight (with no kink at change-over) ..... B1 [3]

(b) $E = VI d$ C1
$= 400 / (0.8 \times 10^{-2})$
$= 5.0 \times 10^{4}$ V m^{-1} ..... (allow 1 sig fig) ..... A1 [2]

(c) (i) $F = Eq$ C1
$= 5.0 \times 10^{4} \times 1.6 \times 10^{-19}$
$= 8.0 \times 10^{-15}$ N ..... (allow 1 sig fig and e.c.f.) A1

(ii) $a = F / m$ C1
$= (8.0 \times 10^{-15}) / (9.1 \times 10^{-31})$
$= 8.8 \times 10^{15}$ m s^{-2} ..... (allow 1 sig fig and e.c.f.) ..... A1 [4]

(d) because FE is normal to horizontal motion M1
no effect ..... A1 [2]