Mark schemes

1 **A**

[1]

2 **C**

[1]

3 A

[1]

4 C

[1]

5 **A**

[1]

6 B

[1]

7 C

[1]

8 **C**

[1]

9 B

[1]

10 A

[1]

11 A

[1]

12 B

[1]

13 C

[1]

14 (a) (i) (force) to the right **(1)**

(ii) electrons accelerate or speed increases **(1)**

2

(b) (i) sketch to show path curving upwards in the field
(must not become vertical) **(1)**

(ii) horizontal component of velocity is unchanged **(1)**
vertical or upwards acceleration (or force) **(1)**
parabolic path described (or named) **(1)**

max 3

The Quality of Written Communication marks are awarded for the quality of answers to this question.

[5]

15 (a) $mg = T\cos 6$ **(1)**
$F = T\sin 6$ **(1)**
hence $F = mg\tan 6$ **(1)**
[or correct use of triangle:
(1) for sides correct, **(1)** for 6°, **(1)** for $\tan 6 = F/mg$

or $F\Delta x = mg\,\Delta h$, $\tan\theta = \frac{\Delta h}{\Delta x}$ $\tan 6° = \frac{F}{mg}$

3

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

(ii) (use of $Q = \frac{F}{E}$ gives) $Q\left(= \frac{mg\tan 6}{E}\right) = \frac{21 \times 10^{-4} \times 9.8\tan 6}{7 \times 10^4}$

$= 3.1 \times 10^{-9}$ C

(allow C.E. for value of E from (i))

3

[6]

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

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

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

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

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

5

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

$v = \sqrt{(1.54 \times 10^{7})^2 + (3.2 \times 10^{7})^2}$ = 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]

17 (a) (i) Lines of equipotential parallel to the plates

B1

Field lines perpendicular to plates, evenly spaced and with arrows upwards

B1

Lack of clear labelling of at least one of the types of line loses 1 mark
Either field shown to be uniform

B1

3

(ii) KE = 8.8×10^{-17} J

B1

Use of ½ mv^2

C1

Speed = 1.4×10^{7} m s^{-1} **ecf**

A1

Momentum =1.27×10^{-23} kg m s^{-1} **ecf**

B1

4

(b) Use of de Broglie wavelength = *h/mv*

C1

5.2×10^{-11} m **ecf**

A1

diffraction of electrons necessary

M1

will work because wavelength is of same order as atomic separation (not just wavelength is too small)/argument consistent with their (a) (ii).

A1

4

[11]

18 (a) thermionic emission / by heating

B1

cathode heated / heating done by electric current / overcoming work function

B1

Must mention anode for third mark

anode which is positive wrt cathode / accelerated by electric field between anode and cathode

B1

3

(b) (i) one relevant equation seen: *E = V/d / F = Ee / a = F/m*

B1

Equation should be in symbols

$$a = \frac{1.6 \times 10^{-19} \times 270}{9.1 \times 10^{-31} \times 0.015} \quad / \, F = 2.88 \times 10^{-15}$$

B1

Substitution may be done in several stages

3.16×10^{15} (m s^{-2})

B1

Must be more than 2 sf

3

(ii) $s = (ut) + ½ at^2$ or $v = u + at$ and $s = v_{av}t$ OR $s = vt$ used

B1

Appropriate symbol equation seen and used for 1st mark

3.56×10^{-3}m

B1

Expect at least 3 sf but condone 3.6 for candidates who use $a = 3.2 \times 10^{15}$

2

(iii) $v = u + at$ / $v = at$ $v^2 = u^2 + 2as$ used

B1

May also use $eV = ½mv^2$

4.74×10^6 m s^{-1} to at least 3 sf

B1

Allow 4.8 (2 or more sf) – consistent with use of $a = 3.2 \times 10^{15}$

2

(iv) $t = 7.5 \times 10^{-9}$ s seen or used

C1

May use ratios for 1st 2 marks: $s_v/s_h = v_v/v_h$ *C1*

3.53×10^{-2} (m) *A1*

3.53×10^{-2} (m) **ecf** for wrong t

A1

adds 3.56×10^{-3} (m) to their 3.53×10^{-2}

B1

clipped with b(i) and b(ii)

Allow reasonable rounding

3

[13]

19 (a) $t = \sqrt{\frac{2s}{g}}$ or $4.5 = \frac{1}{2} \times 9.81 \times t^2$ ✓

$t = 0.96$ s✓

2

(b) Field strength = 186000V m^{-1}✓

Acceleration = Eq / m

or 186 000 × 1.2 × 10^{-6} ✓

0.22 m s^{-2} ✓

3

(c) 0.10(3)m (allow ecf from (i))✓

1

(d) Force on a particle = mg and

acceleration = F / m so always = g✓

Time to fall (given distance) depends (only) on the distance and acceleration✓

OR:

$g = GM / r^2$ ✓

Time to fall = $\sqrt{2s / g}$

so no m in equations to determine time to fall✓

2

(e) Mass is not constant since particle mass will vary✓

Charge on a particle is not constant✓

Acceleration = Eq / m or (V / d) (q / m) or Vq / dm✓

E or V / d constant but charge and mass are 'random' variables so q / m will vary (or unlikely to be the same)✓

4

[12]