M1. C

[1]

M2. (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 $186\,000 \times 1.2 \times 10^{-6}$ ✓

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]

M3.(a) (i) use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s / g$ ✓

$t = \sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50

Some working required for full marks. Correct answer only gets 2

3

(ii) ($s = vt$)
= 8.5 × 0.4946 ✓ ecf ai
= 4.2 m ✓ (4.20) ecf from ai

2

(b) (i) $\left(s = \frac{1}{2}(u + v)\,t\right)$

$t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓

$= \frac{2 \times 0.35}{8.5}$ = 8.2×10^{-2} (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1

Allow alternative correct approaches

2

(ii) $a = (v - u) / t$ OR correct substitution OR a = 103 ✓
(= −8.5) / 8.24×10^{-2} = 103.2)

($F = ma$ =) 75 × (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question.

= 7700 N ✓ (7741) ecf (see above)

Or from loss of KE

Some working required for full marks. Correct answer only gets 2

3

[10]

M4.(a) (i) $(s = \frac{1}{2}gt^2)$

Allow g=10 (0.5477)

$1.5 = \frac{1}{2}9.81t^2$ OR $t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2\times 1.5}{9.81}}$ ✓

(= 0.553) = 0.55 (s) ✓

0.6 gets 2 marks only if working shown. 0.6 on its own gets 1 mark.

2

(ii) ($s = v\,t$ = 430 × 0.553 = 237.8 =) 240 (m) ✓

ecf a(i)

1

(b) their vertical motion is independent of their horizontal motion
OR downward / vertical acceleration is the same for both
OR acceleration due to gravity is the same for both
OR vertical speed / velocity is the same for both ✓

Allow 'time is constant'
Don't allow 'similar'

(bullets A and B will be in the air) for the same time ✓

(Horizontal acceleration is zero and thus horizontal) distance is proportional to horizontal speed **OR** $s = ut$ where u is the horizontal velocity ✓

'velocity smaller so distance smaller' is not sufficient

3

[6]

M5.(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) $s = (ut) + \quad at^2$ 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 = 3.2×10^{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]

M6.B

[1]

M7.A

[1]

M8. (a) Δh = 2.51 – 1.00 = 1.51 (m) / (*s* =) 1.51 m seen

M1

use of appropriate kinematics formula correctly makes t subject

M1

time = 0.555 (s) / 0.56 (s) (allow 0.55 (s))

A1

3

(b) (i) use of appropriate kinematics equation to find vertical v

C1

v = 5.4 (ms^{-1}) (accept 5.4 to 5.9)

A1

2

(ii) any use of Pythagoras where v_h = 18 or use of appropriate trig ratio where v_h = 18 and angle is to horizontal

C1

velocity = 18.8 / 18.9 / 19 (ms^{-1})

A1

angle = 16.8 to 18.1 (°)

A1

3

[8]