M1. D

[1]

M2. A

[1]

M3. C

[1]

M4. A

[1]

M5. C

[1]

M6. A

[1]

M7. C

[1]

M8. (a) (i) E (= ½ CV^2 = 0.5 × 180 × 10^{-6} × 100^2) = 0.90J **(1)**

(ii) W (= QV = CV^2 = 180 × 10^{-6} × 100^2) = 1.8 J **(1)**

2

(b) (i) ($V = V_0 e^{-t/RC}$) gives $30 = 100\ e^{-t/RC}$ **(1)**

$\therefore t = (-RC \ln (30/100) = -1.5 \times 180 \times 10^{-6} \times -1.204$ s)
$= 3.3 \times 10^{-4}$ s **(1)**

(ii) image would be less sharp (or blurred) because the discharge would last longer and the image would be photographed as it is moving **(1)**

image would be brighter becau e the capacitor tore more energy and therefore produces more light **(1)**

4

[6]

M9. (a) Q (= CV = 330 × 9.0) = 2970 (μC) **(1)**
E (= ½QV) = ½ x $2.97 \times 10^{-3} \times 9.0 = 1.34 \times 10^{-2}$J **(1)**
[or E (½CV^2) ½ × 300 × 10^{-6} × 9 0^2 **(1)** 1 34 × 10^{-2}J **(1)**]

2

(b) time constant (= RC) = $470 \times 10^3 \times 330 \times 10^{-6}$ = 155 s **(1)**

1

(c) $Q\left(= Q_0 e^{-t/RC}\right) = 2970 \times e^{-60/155}$

= 2020 (μC)

(allow C.E. for time constant from (b))

$V = \left(\frac{Q}{C}\right) = \frac{2020}{330} = 6.11\ V$ **(1)**
(allow C.E. for Q)

[or $V = V_0 e^{-t/RC}$ **(1)** = $9.0\ e^{-60/155}$ **(1)** = 6.11 V **(1)**]

3

[6]

M10. (a) $E \propto V^2$ (or $E = {}^1/_2 CV^2$) **(1)**

pd after 25 s = 6 V **(1)**

2

(b) (i) use of $Q = Q_0 e^{-t/RC}$ or $V = V_0 e^{-t/RC}$ **(1)**

(e.g. $6 = 12e^{-25/RC}$) gives $e^{\frac{25}{RC}} = \frac{12}{6}$ and $\frac{25}{RC}$ = 1n 2 **(1)**

(RC = 36(.1) s)

[alternatives for (i):

$V = 12\ e^{-25/36}$ gives V = 6.0 V **(1)** (5.99 V)

or time for pd to halve is 0.69RC

$\therefore RC = \frac{25}{0.69}$ **(1)** = 36(.2) s]

(ii) $R = \frac{36.1}{680 \times 10^{-6}}$ **(1)** = 5.3(0) × 10^4 Ω**(1)**

4

[6]

M11. (a) (i) energy stored by capacitor (= ½ CV^2)

= ½ × 70 × 1.2^2 ✓ (= 50.4) = 50 (J) ✓

to **2 sf** only ✓

3

(ii) energy stored by cell (= $I\ V\ t$) = 55 × 10^{-3} × 1.2 × 10 × 3600 ✓

(= 2380 J)

$\frac{\text{energy stored by cell}}{\text{energy stored by capacitor}} = \frac{2380}{50} = 48$ (ie about 50) ✓

2

(b) capacitor would be impossibly large (to fit in phone) ✓

capacitor would need recharging very frequently
[**or** capacitor could only power the phone for a short time] ✓

capacitor voltage [**or** current supplied or charge] would fall
continuously while in use ✓

max 2

[7]

M12. (a) **The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.**

The candidate's answer will be assessed holistically. The answer will be assigned to one of the three levels according to the following criteria.

High Level (good to excellent) 5 or 6 marks

The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.

The candidate provides a comprehensive and logical description of the sequence of releasing the ball and taking measurements of initial and final voltages. They should identify the correct distance measurement and show a good appreciation of how to use these measurements to calculate the time and acceleration from them. Time should be found from capacitor discharge, using known C and R values. Repeated readings would be expected in any answer worthy of full marks, but five marks may be awarded where repetition is omitted.

Intermediate Level (modest to adequate) 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides a comprehensive and logical description of the sequence of releasing the ball and taking measurements of the initial and final voltages. They are likely to show some appreciation of the use of suvat equations to calculate the acceleration, although they may not recognise the need to measure a distance.

Low Level (poor to limited) 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may only be partly appropriate.

The candidate is likely to have recognised that initial and final voltages should be measured, but may not appreciate the need for any other measurement. They may present few details of how to calculate the acceleration from the voltage measurements.

The explanation expected in a competent answer should include a coherent selection of the following points.

Measurements

- initial pd across C (V_0) from voltmeter (before releasing roller)
- distance *s* along slope between plungers
- final pd across C (V_1) from voltmeter
- measurements repeated to provide a more reliable result

Analysis

- time t is found from $V_1 = V_0 e^{-t/RC}$, giving $t = RC \ln (V_0/V_1)$
- from $s = ut + ½ at^2$ with $u = 0$, acceleration $a = 2s/t^2$
- repeat and find average a from several results

(b) (i) $RC = 22 \times 10^{-6} \times 200 \times 10^3$ [or = 4.4 (s)] **(1)** (4.40)

$5.8 = 12.0\ e^{-t/4.40}$ **(1)**

gives $t = 4.40 \ln (12.0/5.8) = 3.2$ (3.20) (s) **(1)**

3

(ii) $a\left(= \frac{2s}{t^2}\right) = \frac{2 \times 2.5}{3.20^2}$ **(1)**

= 0.49 (0.488) (m s^{-2}) **(1)**

2

[11]