PEARSON EDEXCEL A-LEVEL PHYSICS · 9PH0

PHYSICS



MARK SCHEME

TOPIC 7: ELECTRIC AND MAGNETIC FIELDS

CAPACITANCE

SCORE	PERCENTAGE
/288	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions and mark schemes in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question or mark scheme material in this pack. Pearson has not endorsed, approved or been involved in the production of it. Pearson, Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson publishes its past papers and mark schemes free of charge. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of Q = CV (1) • Use of $Q = Q_0 e^{-t/RC}$ (1) • Q/Q_0 = 0.01 (1) • t = 11.6 ms (1) • Use of $I = \frac{Q}{t}$ (1) • I = 12 A (1)	Example of calculation: $Q = CV = 56 \times 10^{-6}\ F \times 2500\ V = 0.14\ C$ $\ln\left(\frac{Q}{Q_0}\right) = e^{-t/RC}$ $\ln(0.01) = -\frac{t}{45\Omega \times 56 \times 10^{-6} F} \therefore t = 0.0116s$ $I = \frac{Q}{t} = \frac{0.14s}{0.0116s} = 12.1A$	**(6)**

Q2.

Question Number	Answer		Mark
(a)	Use of $C=Q/V$	(1)	
	V= 15 V	(1)	
	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** $W = Q^2/2C$	(1)	
	$W = 2.5 \times 10^{-5}$ J	(1)	**4**
	(candidates who use 6.6×10^{-6} C can only score MP1 and MP3)		
	Example of calculation $V = Q/C = 3.3 \times 10^{-6}$ C / 220×10^{-9} F V= 15 V $W = QV/2 = (3.3 \times 10^{-6}$ C × 15 V)/2 $W = 2.5 \times 10^{-5}$ J		
(b)	$Q = 0.2\ Q_0$ **Or** $Q = 6.6\times 10^{-7}$ C	(1)	
	Use of $Q = Q_0\ e^{-t/RC}$	(1)	
	t = 7.1 s	(1)	**3**
	(candidates who use $Q = 0.8\ Q_0$ can only score MP2)		
	Example of calculation $Q = 0.2\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.2\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.2) = - t/ ($20\times 10^6\ \Omega \times 220 \times 10^{-9}$ F) t = 7.1 s		

(c)	**Either** refers to $W = Q^2/2C$ **Or** $W \propto Q^2$	(1)	
	If Q halves, $W \rightarrow Q^2/8C$ Or halving Q quarters W	(1)	
	(Since W becomes a quarter in the time for Q to half) it takes less time for the energy to halve than the charge to halve. (dependent mark on either MP1 or MP2)	(1)	
	Or Refers to $W = QV/2$	(1)	
	Q and V both decrease over time	(1)	
	W will decrease faster so takes less time to half in value. (dependent mark on either MP1 or MP2)	(1)	**3**
(d)	Synchronous readings **Or** data logger records readings at exact time **Or** voltmeter and stop watch need 2 people and data logger only one	(1)	
	More readings can be taken in a shorter time **Or** higher sampling rate	(1)	**2**
	(treat as neutral any reference to graph plotting automatically, human reaction time or accuracy)		
	Total for question		**12**

STEMUP.CO.UK

Q3.

Question Number	Answer		Mark
(a)(i)	Capacitor, resistor, supply and switch all in series (ignore voltmeter) Voltmeter directly across capacitor	**(1)** **(1)**	**2**
(a)(ii)	Datalogger allows large number of readings to be taken **Or** graph can be plotted directly/automatically **Or** simultaneous reading of t and V can be taken **Or** idea that people can't record quickly enough, (treat as neutral accuracy, precision misreading or human reaction time)	**(1)**	**1**
(b)	Use of $C = Q/V$ $Q = 5.0 \times 10^{-4}$ C Example of calculation $Q = 100 \times 10^{-6}$ F $\times$ 5.0 V $Q = 5.0 \times 10^{-4}$ C	**(1)** **(1)**	**2**
(c)(i)	Use of $I = \Delta Q/ \Delta t$ e.c.f their value of C from (b) $I = 0.05$ A (accept recalculation of Q using $V = 4.90$ or 4.95 V) Example of calculation $I = 5.0 \times 10^{-4}$ C / 10×10^{-3} s $I = 0.05$ A	**(1)** **(1)**	**2**
(c)(ii)	tangent drawn at t = 0 $\Delta V/ \Delta t = 2000$ - 3300 V s^{-1} Initial current = 0.22 - 0.28 A (MP2 & 3 can be scored even if no tangent drawn) (No credit for exponential calculation) Example of calculation $\Delta V/ \Delta t = 1.1$ V/ 0.5 ms = 2200 V s^{-1} $I = (\Delta V/ \Delta t) \times C$ $I = 2200$ V $s^{-1} \times 100 \times 10^{-6}$ F $I = 0.22$ A	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Use of $V = IR$ using answer from (ii) correct evaluation of R (5V used with current range in (ii) gives 18 - 23 Ω) Example of calculation 5 V = 0.22 A $\times$ R $R = 23$ Ω	**(1)** **(1)**	**2**
	Total for question		**12**

STEMUP.CO.UK

Q4.

Question Number	Answer		Mark
(a)	Use of $Q = It$ $Q = 2.8$ C Example of calculation $Q = 2.0 \times 10^{3}$ A $\times 1.4 \times 10^{-3}$ s $Q = 2.8$ C	**(1)** **(1)**	**2**
(a)(ii)	See $\tau = RC$ $\tau = 3.0 \times 10^{-4}$ (s) Relates time constant to the time for which current is required Example of calculation $\tau = 0.50\Omega \times (600 \times 10^{-6}$ F) $\tau = 3.0 \times 10^{-4}$ s 1.4×10^{-3}s / 3.0×10^{-4} s = 4.7RC	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $Q = CV$ $V = 4700$ V (e.c.f from (a)(i)) Example of calculation $V = 2.8$V / $(600 \times 10^{-6}$ F) $V = 4670$ V	**(1)** **(1)**	**2**
(b)(ii)	Use of $W = ½\ QV$ **Or** $W = ½\ Q^2/C$ **Or** $W = ½\ CV^2$ Use of $P = W/t$ $P = 4.7$ MW (e.c.f. from (a)(i) and/or (b)(i)) Example of calculation $P = (2.8$ C $\times 2.8$ C) / $(2 \times 600 \times 10^{-6}$ F $\times 1.4 \times 10^{-3}$ s) $P = 4.7$ MW	**(1)** **(1)** **(1)**	**3**
	Total for question		**10**

Q5.

Question Number	Answer		Mark
(a)(i)	Use of $Q = CV$ $Q = 3900$ (C) Example of answer $Q =$ 1500 F × 2.6 V $Q = 3900$ C	(1) (1)	2
(a)(ii)	Straight line through the origin Passing through 2.6 V and answer to (a)(i) or 4000 C	(1) (1)	2
(a)(iii)	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** use of area under graph $W =$ 5.1 kJ (use of 4000 C gives $W =$ 5.2 kJ (allow ecf from (a)(i)) Example of answer $W =$ 3900 C × 2.6 V / 2 $W =$ 5070 J	(1) (1)	2
(b)(i)	Exponential decay Current decreases by equal fractions in equal time intervals	(1) (1)	2
(b)(ii)	See attempt of I_0/e Finds time (accept 0.75-0.80s) Use of $\tau = RC$ $R = 0.0005\ \Omega$ **Or** Finds the time for I_o to half Uses $t_{1/2} = \tau \ln 2$ Use of $\tau = RC$ $R = 0.00050 - 0.00053\ \Omega$ **Or**	(1) (1) (1) (1) (1) (1) (1) (1)	
	See attempt of 37% of 5400 A Finds time (accept 0.75 to 0.80 s) Use of $\tau = RC$ $R = 0.0005 - 0.00053\Omega$ **Or** Draws tangent at $t = 0$ to meet time axis. Records intercept of tangent with axis (accept 0.6 s - 0.9 s) Use of $\tau = RC$ $R = 0.0004\ \Omega - 0.0006\ \Omega$ **Or** reads a value off the y-axis and corresponding time Subs into formula using 5400 (A) to find RC Substitutes for C to find R $R = 0.00050\ \Omega - 0.00058\ \Omega$ Example of calculation 37% of 5400 A is 1998 A Time to fall to this value is 0.75 s $RC = 0.75$ s $R =$0.75 s / 1500 F = 0.0005 Ω	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	4

(c)	**Max 3** Ultracapacitor used for: overtaking **Or** going up a hill **Or** starting (from rest) **Or** accelerating. **(1)** Because this requires a large current/power. **(1)** Batteries used for travelling at constant speed **(1)** Because this requires a small current/power for a longer time **(1)**		**3**
	Total for question		**15**

Q6.

Question Number	Answer		Mark
(a)	Use of $Q = CV$ $Q = 0.18$ C Example of calculation $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
(b)	Use of $W = ½ CV^2$ **Or** of $W = ½ QV$ **Or** of $W = ½ Q^2/C$ $W = 110$ J Allow ecf from (a) if $½ QV$ or $½ Q^2/C$ used Example of calculation $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
(c)(i)	$R = 86$ (Ω) Example of calculation $R = V/I = 1200$ V / 14 A $R = 85.7$ Ω	**(1)**	**1**
(c)(ii)	$Q = 0.25\ Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\ e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7×10^{-3} s scores 1 mark] **Or** Use of RC Use of $2 \times 0.69 \times RC$ $t = 0.018$ s Example of calculation $Q = 0.25\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.25\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.25) = - t/ (86 Ω $\times$ 150 $\times 10^{-6}$ F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**

Q7.

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

STEMUP.CO.UK

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

(6)

Indicative content

- the capacitor can be charged to a higher p.d. than that of the battery
- storing larger amount of energy on capacitor as predicted by $E = \frac{1}{2} CV^2$
- with a low resistance in the bulb the capacitor discharges rapidly
- this produces enough power, $P = W/t$ to produce the flash
- use of $T = RC$ to estimate a value for T (1 ms)
- comparison of time constant with 4 ms

Example of calculation:

$T = 6\ \Omega \times 185\ \mu\text{F} = 1.1\ \text{ms}$

Accept $5T > 4\ \text{ms}$

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	• p.d. across capacitor increases **Or** p.d. across resistor decreases (1) • p.d. across capacitor increases to 5V (1) • p.d. across resistor starts at 5V and reduces to 0V (1) • Exponentially (1)		**4**

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	D uses $W = \frac{1}{2}CV^2$ so if V is doubled W is 4×	$4W$	**1**
	A divides the energy by 4 (rather than multiply) B forgets to square the potential difference and divides C forgets to square the potential difference		

Q10.

Question Number	Answer		Mark
(a)	The capacitor stores charge **Or** capacitor charges from the supply The idea that the capacitor doesn't fully discharge before being recharged.	(1) (1)	2
(b)(i)	(6.4 + 4.4)/2 = 5.4 V	(1)	1
(b)(ii)	Use of $V = IR$ Average I = 5.4 V/(2.2 × $10^3\Omega$) = 2.5× 10^{-3} A ecf value form (b)(i)	(1) (1)	2
(b)(iii)	Time = 17 ms or 17.5 ms	(1)	1
(b)(iv)	Use of $Q = It$ Use of $C = Q/V$ Use of ΔV = 2.0 V C = 21 μF (ecf values of I and t from above) Example of calculation Q = 2.5× 10^{-3} A × 17 × 10^{-3} s = 4.25 × 10^{-5} C C = 4.25 × 10^{-5} C / 2.0 V C = 21 μF	(1) (1) (1) (1)	4
(c)	Uses a larger capacitance Because a larger time constant is needed **Or** stores more charge **Or** less $\Delta V \rightarrow \Delta Q/C$	(1) (1)	2
	Total for question		12

Mark Scheme

Q1.

Question Number	Answer		Mark
(a)	Use of $C=Q/V$	(1)	
	$V = 15$ V	(1)	
	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** $W = Q^2/2C$	(1)	
	$W = 2.5 \times 10^{-5}$ J	(1)	**4**
	(candidates who use 6.6×10^{-6} C can only score MP1 and MP3)		
	Example of calculation $V = Q/C = 3.3 \times 10^{-6}$ C / 220×10^{-9} F $V = 15$ V $W = QV/2 = (3.3 \times 10^{-6}$ C $\times$ 15 V)/2 $W = 2.5 \times 10^{-5}$ J		
(b)	$Q = 0.2\ Q_0$ **Or** $Q = 6.6\times 10^{-7}$ C	(1)	
	Use of $Q = Q_0\ e^{-t/RC}$	(1)	
	$t = 7.1$ s	(1)	**3**
	(candidates who use $Q = 0.8\ Q_0$ can only score MP2)		
	Example of calculation $Q = 0.2\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.2\ Q_0 = Q_0\ e^{-t/RC}$ $\ln(0.2) = -t/(20\times 10^6\ \Omega \times 220 \times 10^{-9}$ F) $t = 7.1$ s		

(c)	**Either** refers to $W = Q^2/2C$ **Or** $W \propto Q^2$ If Q halves, $W \rightarrow Q^2/8C$ Or halving Q quarters W (Since W becomes a quarter in the time for Q to half) it takes less time for the energy to halve than the charge to halve. (dependent mark on either MP1 or MP2) **Or** Refers to $W = QV/2$ Q and V both decrease over time W will decrease faster so takes less time to half in value. (dependent mark on either MP1 or MP2)	(1) (1) (1) (1) (1) (1)	3
(d)	Synchronous readings **Or** data logger records readings at exact time **Or** voltmeter and stop watch need 2 people and data logger only one More readings can be taken in a shorter time **Or** higher sampling rate (treat as neutral any reference to graph plotting automatically, human reaction time or accuracy)	(1) (1)	2
	Total for question		**12**

Q2.

Question Number	Answer		Mark
(a)	Use of $Q = It$ $Q = 2.8$ C Example of calculation $Q = 2.0 \times 10^{3}$ A $\times 1.4 \times 10^{-3}$ s $Q = 2.8$ C	**(1)** **(1)**	**2**
(a)(ii)	See $\tau = RC$ $\tau = 3.0 \times 10^{-4}$ (s) Relates time constant to the time for which current is required Example of calculation $\tau = 0.50\Omega \times (600 \times 10^{-6}$ F) $\tau = 3.0 \times 10^{-4}$ s 1.4×10^{-3}s / 3.0×10^{-4} s = 4.7RC	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $Q = CV$ $V = 4700$ V (e.c.f from (a)(i)) Example of calculation $V = 2.8$V / $(600 \times 10^{-6}$ F) $V = 4670$ V	**(1)** **(1)**	**2**
(b)(ii)	Use of $W = ½\ QV$ **Or** $W = ½\ Q^2/C$ **Or** $W = ½\ CV^2$ Use of $P = W/t$ $P = 4.7$ MW (e.c.f. from (a)(i) and/or (b)(i)) Example of calculation $P = (2.8$ C $\times 2.8$ C) / $(2 \times 600 \times 10^{-6}$ F $\times 1.4 \times 10^{-3}$ s) $P = 4.7$ MW	**(1)** **(1)** **(1)**	**3**
	Total for question		**10**

Q3.

Question Number	Answer		Mark
(a)(i)	Use of $Q = CV$ $Q = 3900$ (C) Example of answer $Q =$ 1500 F × 2.6 V $Q = 3900$ C	(1) (1)	2
(a)(ii)	Straight line through the origin Passing through 2.6 V and answer to (a)(i) or 4000 C	(1) (1)	2
(a)(iii)	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** use of area under graph $W =$ 5.1 kJ (use of 4000 C gives $W =$ 5.2 kJ (allow ecf from (a)(i)) Example of answer $W =$ 3900 C × 2.6 V / 2 $W =$ 5070 J	(1) (1)	2
(b)(i)	Exponential decay Current decreases by equal fractions in equal time intervals	(1) (1)	2
(b)(ii)	See attempt of I_0/e Finds time (accept 0.75-0.80s) Use of $\tau = RC$ $R = 0.0005\ \Omega$ **Or** Finds the time for I_o to half Uses $t_{1/2} = \tau \ln 2$ Use of $\tau = RC$ $R = 0.00050 - 0.00053\ \Omega$ **Or**	(1) (1) (1) (1) (1) (1) (1) (1)	
	See attempt of 37% of 5400 A Finds time (accept 0.75 to 0.80 s) Use of $\tau = RC$ $R = 0.0005 - 0.00053\Omega$ **Or** Draws tangent at $t = 0$ to meet time axis. Records intercept of tangent with axis (accept 0.6 s - 0.9 s) Use of $\tau = RC$ $R = 0.0004\ \Omega - 0.0006\ \Omega$ **Or** reads a value off the y-axis and corresponding time Subs into formula using 5400 (A) to find RC Substitutes for C to find R $R = 0.00050\ \Omega - 0.00058\ \Omega$ Example of calculation 37% of 5400 A is 1998 A Time to fall to this value is 0.75 s $RC = 0.75$ s $R =$0.75 s / 1500 F = 0.0005 Ω	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	4

(c)	**Max 3** Ultracapacitor used for: overtaking **Or** going up a hill **Or** starting (from rest) **Or** accelerating. **(1)** Because this requires a large current/power. **(1)** Batteries used for travelling at constant speed **(1)** Because this requires a small current/power for a longer time **(1)**		**3**
	Total for question		**15**

Q4.

Question Number	Answer		Mark
(a)	Use of $Q = CV$ $Q = 0.18$ C Example of calculation $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
(b)	Use of $W = ½ CV^2$ **Or** of $W = ½ QV$ **Or** of $W = ½ Q^2/C$ $W = 110$ J Allow ecf from (a) if $½ QV$ or $½ Q^2/C$ used Example of calculation $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
(c)(i)	$R = 86$ (Ω) Example of calculation $R = V/I = 1200$ V / 14 A $R = 85.7$ Ω	**(1)**	**1**
(c)(ii)	$Q = 0.25\ Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\ e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7×10^{-3} s scores 1 mark] **Or** Use of RC Use of $2 \times 0.69 \times RC$ $t = 0.018$ s Example of calculation $Q = 0.25\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.25\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.25) = - t/ (86 Ω $\times$ 150 $\times 10^{-6}$ F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**

Q5.

Question Number	Acceptable answers	Additional guidance	Mark
i	• Use of $\ln V = \ln V_o - \frac{t}{RC}$ (1) • Substitution $V = 2.0$ V and $V_o = 8.0$ V (1) • $t = 5.6(1)$ ms (1)	Alternative use of $V = V_o e^{-\frac{t}{RC}}$ Rearrange to $\ln 4 = t / 2700\ \Omega \times 1.5 \times 10^{-6} F$ Example of calculation $t = 2700\ \Omega \times 1.5 \times 10^{-6}$ F $(\ln 8 - \ln 2)$ $t = 5.61$ ms	3
ii	• Use of $W = ½\ CV^2$ (1) • $W = 3.0 \times 10^{-6}$ J (1)	Example of calculation $W = \frac{1}{2} 1.5 \times 10^{-6}$F $\times 2^2$ V$^2 = 3.0 \times 10^{-6}$ J	2

Q6.

Question number	Acceptable answers	Additional guidance	Mark
	A		1

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is C A is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$ B is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$ D is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$		1

Q8.

Question Number	Answer	Mark
	B	1

Q9.

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

(6)

Indicative content

- the capacitor can be charged to a higher p.d. than that of the battery
- storing larger amount of energy on capacitor as predicted by $E = \frac{1}{2} CV^2$
- with a low resistance in the bulb the capacitor discharges rapidly
- this produces enough power, $P = W/t$ to produce the flash
- use of $T = RC$ to estimate a value for T (1 ms)
- comparison of time constant with 4 ms

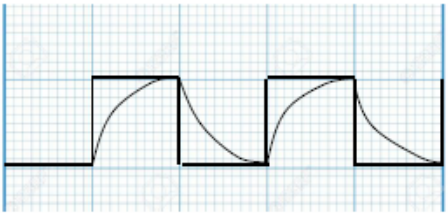
Example of calculation:
$T = 6\ \Omega \times 185\ \mu\text{F} = 1.1\ \text{ms}$
Accept $5T > 4\ \text{ms}$

Q10.

Question Number	Acceptable answers	Additional guidance	Mark
	D uses $W = \frac{1}{2}CV^2$ so if V is doubled W is 4×	$4W$	**1**
	A divides the energy by 4 (rather than multiply) B forgets to square the potential difference and divides C forgets to square the potential difference		

Mark Scheme

Q1.

Question Number	Acceptable answers		Additional guidance	Mark
	• Time axis: one cycle = 50 OR two cycles =100	(1)	Example of calculation $T = 1/f = 1/20\ Hz = 0.050\ s$ Two cycles $= 2 \times 0.050\ s = 0.10\ s = 100\ ms$ Time Constant $= 100 \times 50 \times 10^{-6} = 0.005\ s$ In half a cycle (0.025 s) there are 0.025 s / 0.005 s = 5 Time constants	5
	• Use of time constant = *RC*	(1)		
	• Charging curve, from 25 ms to 50 ms, just about reaching 5V as shown (ecf from their T)	(1)	Ignore anything drawn in the first half cycle	
	• One corresponding discharge curve	(1)		
	• Curve should look exponential	(1)	Time period should be marked 50 ms or equivalent	

Q2.

Question number	Acceptable answers	Additional guidance	Mark
	Either • Use $Q = 2.6$ to read time constant from graph **(1)** **OR** draw tangent to curve at t = 0 and obtain time constant from intercept on x axis **(1)** • $t = 17 – 18$ (ms) **(1)** • Use of $T = RC$ with their T **(1)** • $C = 0.019$ - 0.021 mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • Any corresponding values of Q and t read from graph **(1)** • Use of $Q=Q_0 e^{-t/RC}$ with their values for Q_0, Q and t **(1)** • $C = 0.0195 – 0.0196$ mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • $Q=3.5$ (mC) when $T_{1/2} = 12.3$ (ms) **(1)** • Use of $T_{1/2} = RC \ln 2$ **(1)** • $C = 0.0195 – 0.0196$ mF **(1)**	Example of calculation: $T = 19$ (ms) $C = 19 \times 10^{-3}/900 =$ 0.021 mF	**4**

Q3.

Question Number	Answer	Mark
	B	**1**

Q4.

Question Number	Answer		Mark
(a)(i)	Capacitor, resistor, supply and switch all in series (ignore voltmeter) Voltmeter directly across capacitor	**(1)** **(1)**	**2**
(a)(ii)	Datalogger allows large number of readings to be taken **Or** graph can be plotted directly/automatically **Or** simultaneous reading of t and V can be taken **Or** idea that people can't record quickly enough, (treat as neutral accuracy, precision misreading or human reaction time)	**(1)**	**1**
(b)	Use of $C = Q/V$ $Q = 5.0 \times 10^{-4}$ C Example of calculation $Q = 100 \times 10^{-6}$ F $\times$ 5.0 V $Q = 5.0 \times 10^{-4}$ C	**(1)** **(1)**	**2**
(c)(i)	Use of $I = \Delta Q/ \Delta t$ e.c.f their value of C from (b) $I = 0.05$ A (accept recalculation of Q using $V = 4.90$ or 4.95 V) Example of calculation $I = 5.0 \times 10^{-4}$ C / 10×10^{-3} s $I = 0.05$ A	**(1)** **(1)**	**2**
(c)(ii)	tangent drawn at t = 0 $\Delta V/ \Delta t = 2000$ - 3300 V s^{-1} Initial current = 0.22 - 0.28 A (MP2 & 3 can be scored even if no tangent drawn) (No credit for exponential calculation) Example of calculation $\Delta V/ \Delta t = 1.1$ V/ 0.5 ms = 2200 V s^{-1} $I = (\Delta V/ \Delta t) \times C$ $I = 2200$ V $s^{-1} \times 100 \times 10^{-6}$ F $I = 0.22$ A	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Use of $V = IR$ using answer from (ii) correct evaluation of R (5V used with current range in (ii) gives 18 - 23 Ω) Example of calculation 5 V = 0.22 A $\times$ R $R = 23$ Ω	**(1)** **(1)**	**2**
	Total for question		**12**

Q5.

Question Number	Answer		Mark
(a)	Use of $Q = It$ $Q = 2.8$ C Example of calculation $Q = 2.0 \times 10^{3}$ A $\times 1.4 \times 10^{-3}$ s $Q = 2.8$ C	**(1)** **(1)**	**2**
(a)(ii)	See $\tau = RC$ $\tau = 3.0 \times 10^{-4}$ (s) Relates time constant to the time for which current is required Example of calculation $\tau = 0.50\Omega \times (600 \times 10^{-6}$ F) $\tau = 3.0 \times 10^{-4}$ s 1.4×10^{-3}s / 3.0×10^{-4} s = 4.7RC	**(1)** **(1)** **(1)**	**3**
(b)(i)	Use of $Q = CV$ $V = 4700$ V (e.c.f from (a)(i)) Example of calculation $V = 2.8$V / $(600 \times 10^{-6}$ F) $V = 4670$ V	**(1)** **(1)**	**2**
(b)(ii)	Use of $W = ½\ QV$ **Or** $W = ½\ Q^2/C$ **Or** $W = ½\ CV^2$ Use of $P = W/t$ $P = 4.7$ MW (e.c.f. from (a)(i) and/or (b)(i)) Example of calculation $P = (2.8$ C $\times 2.8$ C) / $(2 \times 600 \times 10^{-6}$ F $\times 1.4 \times 10^{-3}$ s) $P = 4.7$ MW	**(1)** **(1)** **(1)**	**3**
	Total for question		**10**

Q6.

Question Number	Answer		Mark
(a)(i)	Use of $Q = CV$ $Q = 3900$ (C) Example of answer $Q =$ 1500 F × 2.6 V $Q = 3900$ C	(1) (1)	2
(a)(ii)	Straight line through the origin Passing through 2.6 V and answer to (a)(i) or 4000 C	(1) (1)	2
(a)(iii)	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** use of area under graph $W =$ 5.1 kJ (use of 4000 C gives $W =$ 5.2 kJ (allow ecf from (a)(i)) Example of answer $W =$ 3900 C × 2.6 V / 2 $W =$ 5070 J	(1) (1)	2
(b)(i)	Exponential decay Current decreases by equal fractions in equal time intervals	(1) (1)	2
(b)(ii)	See attempt of I_0/e Finds time (accept 0.75-0.80s) Use of $\tau = RC$ $R = 0.0005\ \Omega$ **Or** Finds the time for I_o to half Uses $t_{1/2} = \tau \ln 2$ Use of $\tau = RC$ $R = 0.00050 - 0.00053\ \Omega$ **Or**	(1) (1) (1) (1) (1) (1) (1) (1)	
	See attempt of 37% of 5400 A Finds time (accept 0.75 to 0.80 s) Use of $\tau = RC$ $R = 0.0005 - 0.00053\Omega$ **Or** Draws tangent at $t = 0$ to meet time axis. Records intercept of tangent with axis (accept 0.6 s - 0.9 s) Use of $\tau = RC$ $R = 0.0004\ \Omega - 0.0006\ \Omega$ **Or** reads a value off the y-axis and corresponding time Subs into formula using 5400 (A) to find RC Substitutes for C to find R $R = 0.00050\ \Omega - 0.00058\ \Omega$ Example of calculation 37% of 5400 A is 1998 A Time to fall to this value is 0.75 s $RC = 0.75$ s $R =$0.75 s / 1500 F = 0.0005 Ω	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	4

(c)	**Max 3** Ultracapacitor used for: overtaking **Or** going up a hill **Or** starting (from rest) **Or** accelerating. **(1)** Because this requires a large current/power. **(1)** Batteries used for travelling at constant speed **(1)** Because this requires a small current/power for a longer time **(1)**		**3**
	Total for question		**15**

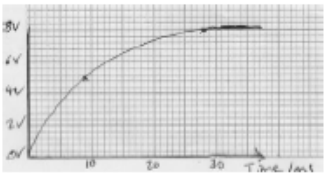
Q7.

Question Number	Answer		Mark
(a)	Use of $Q = CV$ $Q = 0.18$ C Example of calculation $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
(b)	Use of $W = ½ CV^2$ **Or** of $W = ½ QV$ **Or** of $W = ½ Q^2/C$ $W = 110$ J Allow ecf from (a) if $½ QV$ or $½ Q^2/C$ used Example of calculation $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
(c)(i)	$R = 86$ (Ω) Example of calculation $R = V/I = 1200$ V / 14 A $R = 85.7$ Ω	**(1)**	**1**
(c)(ii)	$Q = 0.25\ Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\ e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7×10^{-3} s scores 1 mark] **Or** Use of RC Use of $2 \times 0.69 \times RC$ $t = 0.018$ s Example of calculation $Q = 0.25\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.25\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.25) = - t/ (86 Ω $\times$ 150 $\times 10^{-6}$ F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**

Q8.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to: • Electrons/charge transferred from negatively charged plate to positively charge plate through the resistor **(1)** • Hence the charge on capacitor decreases (exponentially) **(1)** • Until the charge on the capacitor equals 0/negligible **(1)**		**3**

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	• line approximately exponential curve starting at 0 and increasing potential **(1)** • beginning to flatten off at a maximum of 8 V (at 30 ms above 7.5 V) **(1)** • Use of time constant *RC* **(1)**	 This can be evidenced with an exponential curve passing through about 5 V at 9 ms **Or** approximately 2/3 of their maximum	**3**

Q10.

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

STEMUP.CO.UK

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

(6)

Indicative content

- the capacitor can be charged to a higher p.d. than that of the battery
- storing larger amount of energy on capacitor as predicted by $E = \frac{1}{2} CV^2$
- with a low resistance in the bulb the capacitor discharges rapidly
- this produces enough power, $P = W/t$ to produce the flash
- use of $T = RC$ to estimate a value for T (1 ms)
- comparison of time constant with 4 ms

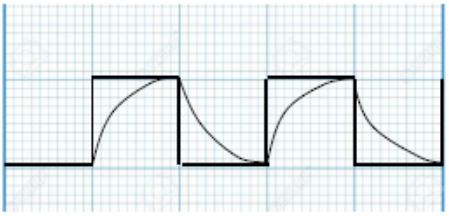
Example of calculation:

$T = 6\ \Omega \times 185\ \mu\text{F} = 1.1\ \text{ms}$

Accept $5T > 4\ \text{ms}$

Mark Scheme

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	• Time axis: one cycle = 50 OR two cycles =100 (1) • Use of time constant = RC (1) • Charging curve, from 25 ms to 50 ms, just about reaching 5V as shown (ecf from their T) (1) • One corresponding discharge curve (1) • Curve should look exponential (1)	Example of calculation $T = 1/f = 1/20\ \text{Hz} = 0.050\ \text{s}$ Two cycles = $2 \times 0.050\ \text{s} = 0.10\ \text{s} = 100\ \text{ms}$ Time Constant = $100 \times 50 \times 10^{-6} = 0.005\ \text{s}$ In half a cycle (0.025 s) there are 0.025 s / 0.005 s = 5 Time constants Ignore anything drawn in the first half cycle  Time period should be marked 50 ms or equivalent	5

Q2.

Question number	Acceptable answers	Additional guidance	Mark
	Either • Use $Q = 2.6$ to read time constant from graph **(1)** **OR** draw tangent to curve at t = 0 and obtain time constant from intercept on x axis **(1)** • $t = 17 - 18$ (ms) **(1)** • Use of $T = RC$ with their T **(1)** • $C = 0.019$ - 0.021 mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • Any corresponding values of Q and t read from graph **(1)** • Use of $Q=Q_0 e^{-t/RC}$ with their values for Q_0, Q and t **(1)** • $C = 0.0195 - 0.0196$ mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • $Q=3.5$ (mC) when $T_{1/2} = 12.3$ (ms) **(1)** • Use of $T_{1/2} = RC \ln 2$ **(1)** • $C = 0.0195 - 0.0196$ mF **(1)**	Example of calculation: $T = 19$ (ms) $C = 19 \times 10^{-3}/900 = 0.021$ mF	4

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• Use of Q = CV (1) • Use of $Q = Q_0 e^{-t/RC}$ (1) • Q/Q_0 = 0.01 (1) • t = 11.6 ms (1) • Use of $I = \frac{Q}{t}$ (1) • I = 12 A (1)	Example of calculation: $Q=CV = 56 \times 10^{-6}\ F \times 2500\ V = 0.14\ C$ $\ln\left(\frac{Q}{Q_0}\right) = e^{-t/RC}$ $\ln(0.01) = -\frac{t}{45\Omega \times 56 \times 10^{-6} F} \therefore t = 0.0116s$ $I = \frac{Q}{t} = \frac{0.14s}{0.0116s} = 12.1A$	**(6)**

Q4.

Question Number	Answer	Mark
(a)	Use of $C=Q/V$ (1) V= 15 V (1) Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** $W = Q^2/2C$ (1) $W = 2.5 \times 10^{-5}$ J (1) (candidates who use 6.6×10^{-6} C can only score MP1 and MP3) Example of calculation $V = Q/C = 3.3 \times 10^{-6}$ C / 220×10^{-9} F V= 15 V $W = QV/2 = (3.3 \times 10^{-6}$ C × 15 V)/2 $W = 2.5 \times 10^{-5}$ J	**4**
(b)	$Q = 0.2\ Q_0$ **Or** $Q = 6.6\times 10^{-7}$ C (1) Use of $Q = Q_0\ e^{-t/RC}$ (1) t = 7.1 s (1) (candidates who use $Q = 0.8\ Q_0$ can only score MP2) Example of calculation $Q = 0.2\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.2\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.2) = - t/ ($20\times 10^6\ \Omega \times 220 \times 10^{-9}$ F) t = 7.1 s	**3**

(c)	**Either** refers to $W = Q^2/2C$ **Or** $W \propto Q^2$ If Q halves, $W \rightarrow Q^2/8C$ Or halving Q quarters W (Since W becomes a quarter in the time for Q to half) it takes less time for the energy to halve than the charge to halve. (dependent mark on either MP1 or MP2) **Or** Refers to $W = QV/2$ Q and V both decrease over time W will decrease faster so takes less time to half in value. (dependent mark on either MP1 or MP2)	(1) (1) (1) (1) (1) (1)	3
(d)	Synchronous readings **Or** data logger records readings at exact time **Or** voltmeter and stop watch need 2 people and data logger only one More readings can be taken in a shorter time **Or** higher sampling rate (treat as neutral any reference to graph plotting automatically, human reaction time or accuracy)	(1) (1)	2
	Total for question		**12**

Q5.

Question Number	Answer		Mark
(a)(i)	Use of $Q = CV$ $Q = 3900$ (C) Example of answer $Q =$ 1500 F × 2.6 V $Q = 3900$ C	(1) (1)	2
(a)(ii)	Straight line through the origin Passing through 2.6 V and answer to (a)(i) or 4000 C	(1) (1)	2
(a)(iii)	Use of $W = QV/2$ **Or** $W = CV^2/2$ **Or** use of area under graph $W =$ 5.1 kJ (use of 4000 C gives $W =$ 5.2 kJ (allow ecf from (a)(i)) Example of answer $W =$ 3900 C × 2.6 V / 2 $W =$ 5070 J	(1) (1)	2
(b)(i)	Exponential decay Current decreases by equal fractions in equal time intervals	(1) (1)	2
(b)(ii)	See attempt of I_0/e Finds time (accept 0.75-0.80s) Use of $\tau = RC$ $R = 0.0005\ \Omega$ **Or** Finds the time for I_o to half Uses $t_{1/2} = \tau \ln 2$ Use of $\tau = RC$ $R = 0.00050 - 0.00053\ \Omega$ **Or**	(1) (1) (1) (1) (1) (1) (1) (1)	
	See attempt of 37% of 5400 A Finds time (accept 0.75 to 0.80 s) Use of $\tau = RC$ $R = 0.0005 - 0.00053\Omega$ **Or** Draws tangent at $t = 0$ to meet time axis. Records intercept of tangent with axis (accept 0.6 s - 0.9 s) Use of $\tau = RC$ $R = 0.0004\ \Omega - 0.0006\ \Omega$ **Or** reads a value off the y-axis and corresponding time Subs into formula using 5400 (A) to find RC Substitutes for C to find R $R = 0.00050\ \Omega - 0.00058\ \Omega$ Example of calculation 37% of 5400 A is 1998 A Time to fall to this value is 0.75 s $RC = 0.75$ s $R =$0.75 s / 1500 F = 0.0005 Ω	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	4

(c)	**Max 3** Ultracapacitor used for: overtaking **Or** going up a hill **Or** starting (from rest) **Or** accelerating. **(1)** Because this requires a large current/power. **(1)** Batteries used for travelling at constant speed **(1)** Because this requires a small current/power for a longer time **(1)**	**3**
	Total for question	**15**

Q6.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	An answer which makes reference to: • Diode only lets current through in one direction **(1)** • (In positive half cycle of input) D2 and D4 conduct **(1)** **Or** In positive half cycle of input D2 conducts **Or** (In negative half cycle of input) D3 and D1 conduct **(1)** **Or** negative half cycle D3 conducts • Current towards X **Or** down through *R* **Or** X to Y		**3**
(ii)	• Read off corresponding values of *V* and *t* from graph **(1)** • Use of $lnV = lnV_o - \frac{t}{RC}$ **(1)** • $C = 3.5 \times 10^{-5}$ F **(1)** range 2.7×10^{-5} F to 3.5×10^{-5} F Alternate method • Use of $I = V/R$ • Use of $Q = It$ and $C = \Delta Q/\Delta V$ • $C = 2.7 \times 10^{-5}$ F to 3.5×10^{-5} F	eg this can be any *t* (in ms) and corresponding *V* Example of calculation $ln3.5 = ln4 - \frac{0.008\ s}{2200\ \Omega \times C}$ $C = 2.7 \times 10^{-5}$ F Alternate: $I = 3.8$ V / 2.2 kΩ = 1.73 mA $Q = 1.73$ mA ×8 ms = 13.8×10^{-6} C $C = 13.8 \times 10^{-6}$ C / 0.4 V = 3.4×10^{-5} F	**3**

Q7.

Question Number	Answer		Mark
(a)	Use of $Q = CV$ $Q = 0.18$ C Example of calculation $Q = 150 \times 10^{-6}$ F $\times$ 1200 V $Q = 0.18$ C	**(1)** **(1)**	**2**
(b)	Use of $W = ½ CV^2$ **Or** of $W = ½ QV$ **Or** of $W = ½ Q^2/C$ $W = 110$ J Allow ecf from (a) if $½ QV$ or $½ Q^2/C$ used Example of calculation $W = ½ \times 150 \times 10^{-6}$ F $\times$ (1200 V)^2 $W = 108$ J	**(1)** **(1)**	**2**
(c)(i)	$R = 86$ (Ω) Example of calculation $R = V/I = 1200$ V / 14 A $R = 85.7$ Ω	**(1)**	**1**
(c)(ii)	$Q = 0.25\ Q_0$ **Or** $Q = 0.045$ C Use of RC (0.013 s) Use of $Q = Q_0\ e^{-t/RC}$ to give $t = 0.018$ s (show that value will give $t = 0.019$ s) [Use of ln 4 gives the correct answer if the − sign is ignored , scores 1 for use of RC use of ¾Q →3.7×10^{-3} s scores 1 mark] **Or** Use of RC Use of $2 \times 0.69 \times RC$ $t = 0.018$ s Example of calculation $Q = 0.25\ Q_0$ $Q = Q_0\ e^{-t/RC}$ $0.25\ Q_0 = Q_0\ e^{-t/RC}$ ln (0.25) = - t/ (86 Ω $\times$ 150 $\times 10^{-6}$ F) $t = 0.0178$ s	**(1)** **(1)** **(1)**	**3**
(c)(iii)	Same charge (flows for shorter time) **OR** (Same charge flows for) shorter time	**(1)**	**1**

Q8.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to: • Electrons/charge transferred from negatively charged plate to positively charge plate through the resistor **(1)** • Hence the charge on capacitor decreases (exponentially) **(1)** • Until the charge on the capacitor equals 0/negligible **(1)**		**3**

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
i	• Use of $\ln V = \ln V_o - \frac{t}{RC}$ **(1)** • Substitution $V = 2.0$ V and $V_o = 8.0$ V **(1)** • $t = 5.6(1)$ ms **(1)**	Alternative use of $V = V_o e^{-\frac{t}{RC}}$ Rearrange to $\ln 4 = t / 2700\ \Omega \times 1.5 \times 10^{-6} F$ Example of calculation $t = 2700\ \Omega \times 1.5 \times 10^{-6}$ F $(\ln 8 - \ln 2)$ $t = 5.61$ ms	**3**
ii	• Use of $W = ½\ CV^2$ **(1)** • $W = 3.0 \times 10^{-6}$ J **(1)**	Example of calculation $W = \frac{1}{2} 1.5 \times 10^{-6}$F $\times 2^2$ V$^2 = 3.0 \times 10^{-6}$ J	**2**

Q10.

Question number	Acceptable answers	Additional guidance	Mark
(i)	• use of $F = Q_1Q_2/4\pi\varepsilon_0 r^2$ **(1)** • use of $F = Gm_1m_2/r^2$ **(1)** • Expresses forces as a ratio **(1)** **OR** calculates the individual forces $F_e = 8.1 \times 10^{-8}$ N $F_g =$ • 3.6×10^{-47} N **(1)** • Ratio = 2×10^{39} or 5×10^{-40} and identifies gravitational force as insignificant **(1)**		**4**
(ii)	• use of $F = mv^2/r$ and $F = Q_1Q_2/4\pi\varepsilon_0 r^2$ **(1)** • to derive $v = \sqrt{\frac{Q_1Q_2}{4\pi\epsilon_0 rm}}$ **(1)** • velocity = 2.2×10^6 m s^{-1} **(1)**	Example of calculation: $v = \sqrt{\frac{Q_1Q_2}{4\pi\epsilon_0 rm}}$ $v = \sqrt{\frac{1.6 \times 10^{-19}\text{ C} \times 1.6 \times 10^{-19}\text{ C}}{4\pi \times 8.85^{-12}\text{ Fm}^{-1} \times 5.3 \times 10^{-11}\text{m} \times 9.1 \times 10^{-31}\text{ kg}}}$ $v = 2.185 \times 10^6$ m s^{-1}	**3**