Physics A (H156, H556)

Exploring - Capacitors
KSA Physics

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:
Additional resources may be supplied with this paper.

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **50**.
- The total number of marks may take into account some 'either/or' question choices.

1 This question is about lightning.

Sheet lightning occurs when there is an electrical discharge between the upper and lower regions of a thunder cloud.
The upper regions are positive and the lower regions are negative.

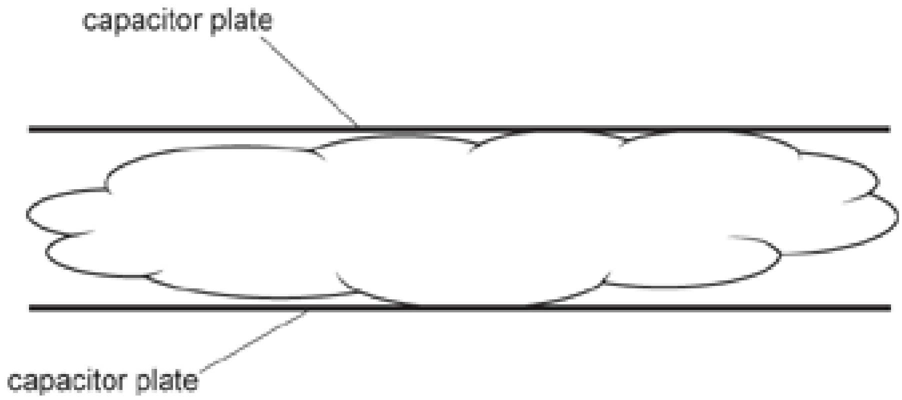
The thunder cloud can be modelled as an ideal parallel plate capacitor with circular horizontal plates.

The data for the capacitor comes from the cloud.

Diameter of cloud	24 km
Distance between upper and lower regions	3.2 km
Electric field strength between the regions	4.0×10^5 V m^{-1}

i. The diagram shows the plates of the model capacitor superimposed on the cloud.

Draw on the diagram to show the electric field lines between capacitor plates.



[2]

ii. Suggest why the actual electric field lines of the cloud would differ from what you have drawn.

____

____ **[1]**

iii. Show that the potential difference (p.d.) *V* between the plates is about 1×10^9 V.

[1]

iv. Calculate the capacitance C of the model capacitor.

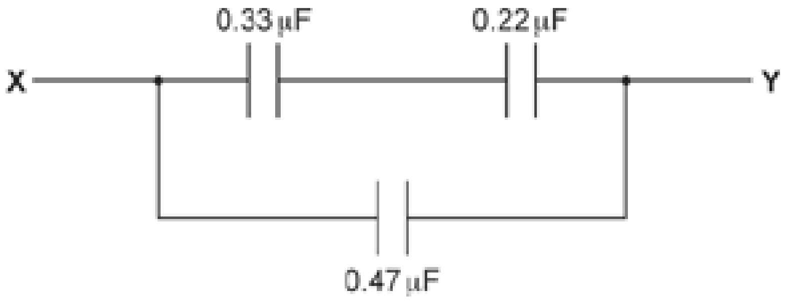
Assume the permittivity of the material of the cloud is the same as the permittivity of free space.

C = ... F **[2]**

v. Calculate the magnitude of the charge Q on one of the plates of the model capacitor.

Q = ... C **[2]**

2 Three capacitors are arranged in a circuit.



The capacitance of each capacitor is shown.

What is the total capacitance between **X** and **Y**?

A 0.25 μF
B 0.60 μF
C 1.02 μF
D 8.0 μF

Your answer [ ] **[1]**

3(a) In an experiment a circuit is set up so that a capacitor with a resistor in series can be charged and at some later time discharged through the same resistor without changing the positions of the components. This process can be repeated.

The supply has a potential difference (p.d.) 6.0 V d.c.

The capacitor has capacitance 1.0 μF.

The resistor has resistance 10 kΩ.

A voltmeter is used to measure the p.d. across the capacitor.

Draw a circuit diagram for this experiment.

[2]

(b) Calculate the charge Q stored on the capacitor when it is fully charged.

Q = ...C **[1]**

(c) Use a calculation to explain why it will not be possible to measure the variation of p.d. across the capacitor with time, using a stop watch.

[4]

(d) State how this experiment can be modified to measure the variation of p.d. across the capacitor with time as the capacitor charges.

--- **[1]**

(e) The capacitor was completely charged and then discharged to 4.12 V.

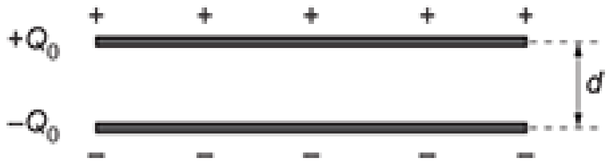
i. Calculate the time *t* required for the p.d. across the capacitor to reach 4.12 V when discharging.

t = ...s **[2]**

ii. Calculate the average rate at which energy is lost by the capacitor as it discharges from 6.0 V to 4.12 V.

average rate at which energy is lost = ...J s^{-1} **[3]**

4 The diagram below shows a simple capacitor.



The capacitor consists of two horizontal metal plates in a vacuum. The magnitude of the charge on each plate is Q_0. The potential difference (p.d.) between the plates is V_0. The capacitor plates have capacitance C_0. The separation between the plates is d. The energy stored by the capacitor is E_0.
The top plate is moved vertically upwards. The new separation between the plates is $2d$.
The charge on each plate remains the **same**.
The energy stored by the capacitor **increases**.

i. Determine the new:

1 capacitance in terms of C_0

capacitance = ... C_0 **[1]**

2 p.d. between the plates in terms of V_0

p.d. = ... V_0 **[1]**

3 energy stored in terms of E_0.

energy = ... E_0 **[1]**

ii. Explain, in terms of forces between the plates, why the energy stored increases.

____

____ **[1]**

5 Fig. 22.1 shows two horizontal metal plates in a vacuum.

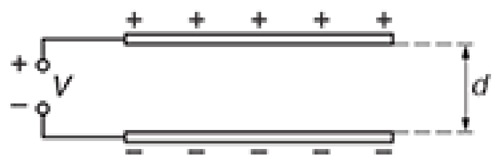


Fig. 22.1

The plates are connected to a power supply. The potential difference V between the plates is constant. The magnitude of the charge on each plate is Q. The separation between the plates is d.

Fig. 22.2 shows the variation with d of the charge Q on the positive plate.

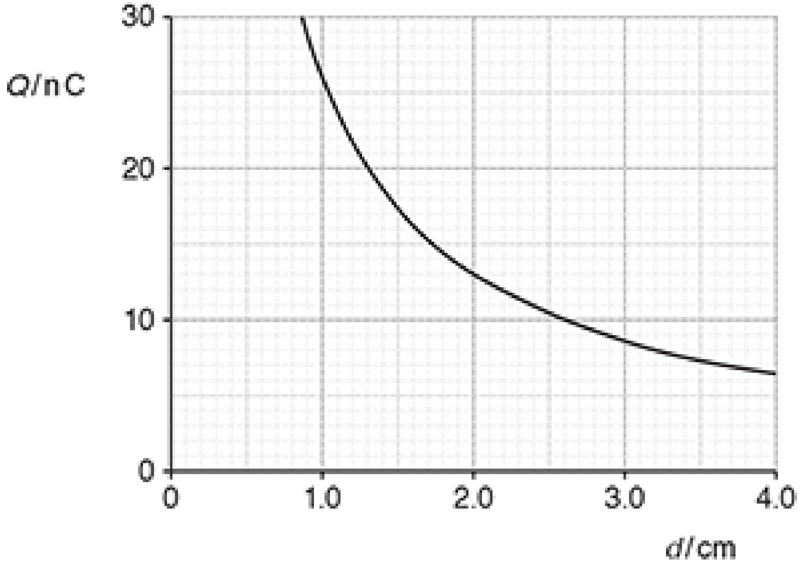


Fig. 22.2

i. Use Fig. 22.2 to propose and carry out a test to show that Q is inversely proportional to d.

Test proposed:

Working:

[2]

ii. Use capacitor equations to show that Q is inversely proportional to d.

[2]

6(a)

A capacitor of capacitance 7.2 pF consists of two parallel metal plates separated by an insulator of thickness 1.2 mm. The area of overlap between the plates is 4.0×10^{-4} m^2. Calculate the permittivity of the insulator between the capacitor plates.

permittivity = ____________________ F m^{-1} **[2]**

(b) Fig. 21 shows a circuit.

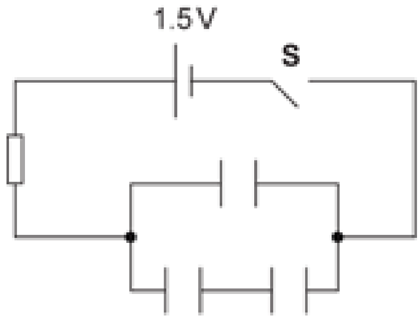


Fig. 21

The capacitance of each capacitor is 1000 μF. The resistance of the resistor is 10 kΩ. The cell has e.m.f. 1.5 V and negligible internal resistance.

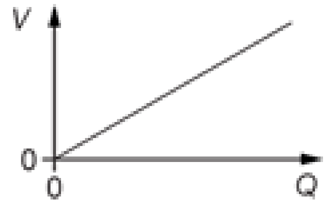
i. Calculate the total capacitance *C* in the circuit.

C = ____________________ μF **[2]**

ii. The switch **S** is closed at time $t = 0$. There is zero potential difference across the capacitors at $t = 0$. Calculate the potential difference *V* across the resistor at time $t = 12$ s.

V = ____________________ V **[2]**

7 The graph below shows the variation of potential difference V with charge Q for a capacitor.

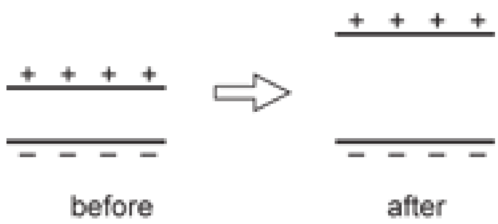


Which row is correct for the gradient of the graph and the area under the graph?

	Gradient of graph	Area under the graph
A	capacitance^{-1}	work done
B	capacitance^{-1}	permittivity
C	capacitance	power
D	capacitance	energy

Your answer ☐ **[1]**

8 Two isolated parallel capacitor plates have an equal and opposite charge.
The separation between the plates is doubled.
The charge on each plate remains the same but the potential difference between the plates doubles.



Which statement is correct?

A The capacitance of the capacitor doubles.

B The energy stored by the capacitor is halved.

C The permittivity of free space doubles.

D The electric field strength between the plates remains the same.

Your answer ☐ **[1]**

9 Fig. 20.1 shows a capacitor connected to a power supply.

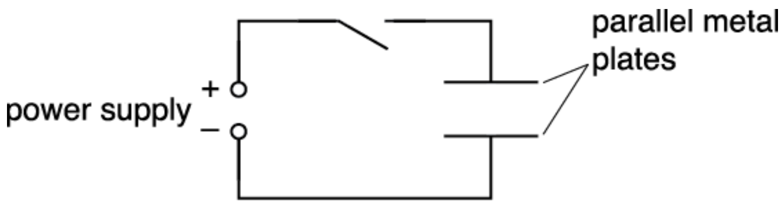


Fig. 20.1

The capacitor consists of two parallel metal plates separated by air.

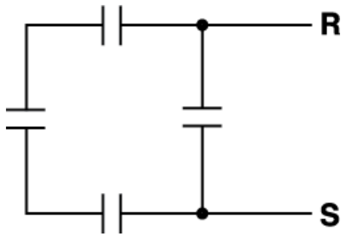
The switch is closed to charge the capacitor.

The switch is then opened and the separation between the charged plates is **doubled**.

State and explain what happens to the energy stored by the capacitor.

--- **[3]**

10 The diagram below shows a circuit connected by a student.



The capacitance of each capacitor is 300 pF.
What is the total capacitance between points **R** and **S**?

A 75 pF
B 230 pF
C 400 pF
D 1200 pF

Your answer

[1]

11 A capacitor consists of two parallel plates separated by air. The capacitor is connected across a d.c. supply. The charged capacitor is then disconnected and the separation between the plates is doubled.

Which statement is correct about the charge stored by the capacitor?

A The charge is the same.
B The charge doubles.
C The charge halves.
D The charge quarters.

Your answer

[1]

12 Four capacitors of capacitance 10 μF, 20 μF, 30 μF and 40 μF are connected in **series** to a battery.

Which capacitor has the **largest** potential difference across it?

A 10 μF capacitor
B 20 μF capacitor
C 30 μF capacitor
D 40 μF capacitor

Your answer

[1]

13(a) **Fig. 20.1** shows a capacitor and a switch connected in series to a cell.

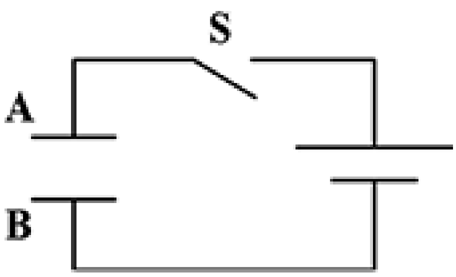


Fig. 20.1

The switch **S** is closed.

Describe and explain how the capacitor plates **A** and **B** acquire opposite charges.

--- **[2]**

(b) **Fig. 20.2** shows an arrangement of capacitors connected to a battery.

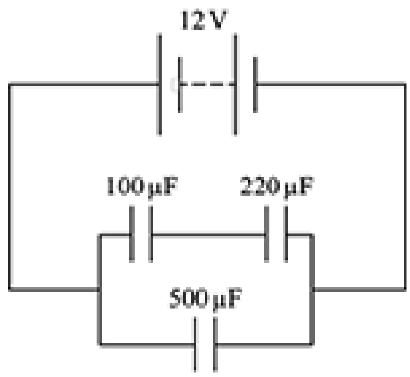


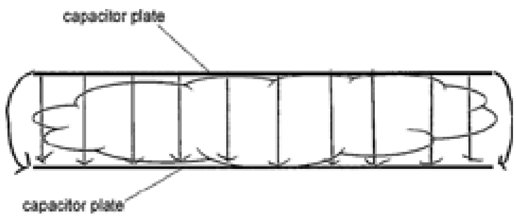
Fig. 20.2

The e.m.f. of the battery is 12 V.

Calculate the total energy *E* stored by the capacitors in this circuit.

E = ________________ J **[4]**

END OF QUESTION PAPER

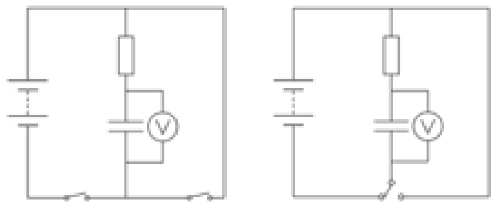
Question			Answer/Indicative content	Marks	Guidance
1		i	At least 4 equidistant parallel vertical (straight) lines With arrows pointing downwards	B1 B1	By eye **Ignore** field lines outside of plates At least one line must touch top and bottom plate At least one arrow, and all arrows given must be correct <u>Examiner's Comments</u> Most candidates were able to score at least 1 mark on this question. The most common loss of marks was an uneven spacing between the lines. Some candidates (helpfully) wrote on the diagram that the spacing was equal. As it is apparent that most candidates know the spacing should be regular, it would be best to do this with a ruler rather than leave it judgement. Similarly, the lines should be vertical and straight, again best done with a ruler. Exemplar 3  Exemplar 3 only scored the second mark, as the spacing is unequal. At first glance it may look like the spacing is regular and this is possible what the candidate meant to do, but those at the right hand side (ignoring those outside of the plates) are definitely not equally spaced by eye. It would have been far better for the candidate to use a ruler to make the spacing equal.

Question			Answer/Indicative content	Marks	Guidance
		ii	The top and the bottom of the clouds will not be parallel / will be uneven	B1	**Allow** uneven charge distribution / charge density **Allow** the field is non-uniform **Allow** the cloud is a non-uniform shape **Ignore** cloud has non uniform density <u>Examiner's Comments</u> Although there were many ways to obtain this mark, only around half of candidates gave a suitable response. Many answers were vague such as 'the cloud is not even' or 'the cloud contains water vapour' which really needs more clarity. The best response is based on the distribution of charges, but alternatives relating to uniformity of a variety of factors are perfectly correct.
		iii	($V = Ed$) = $4.0 \times 10^5 \times 3.2 \times 10^3 = 1.3 \times 10^9$ (V)	B1	Values of *E, d* with correct powers of 10 and correct evaluation must be seen to at least 2sf (1.28) **Ignore** unit <u>Examiner's Comments</u> Again, a 'show that' question needs the calculation to be clear. Here it will involve the multiplication of two quantities using the correct powers. For example, 32k is not a suitable alternative to 32 x 10^3. The value calculated is not the same as the 'show that' value so needs to be given to more significant figures (at least 2) to prove the calculation was carried out. The significant majority of candidates were able to correctly score this mark.

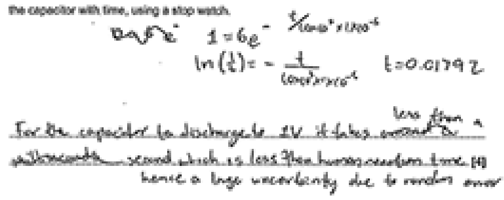
Question			Answer/Indicative content	Marks	Guidance
		iv	$C = \left(\frac{\varepsilon_0 A}{d} = \right)\frac{8.85\times10^{-12}\times\pi\times(12\times10^{3})^{2}}{3.2\times10^{3}}$ $C = 1.3 \times 10^{-6}$ (F)	C1 A1	All values (including ε_0) substituted correctly Correct evaluation to at least 2sf (1.25×10^{-6}) **Note:** use of $C = 4\pi\varepsilon R$ (leading to 1.3×10^{-6} is XP) **Examiner's Comments** Most candidates were able to select the correct formula and make an attempt at a substitution. The main error came from an incorrect calculation of the area, either by using an incorrect method for the circle or incorrectly calculating it using 24km x 3.2km. Candidates are to be reminded that if the working is correct and the calculation wrong, then marks may still be given. Without this working, there is likely to be no credit. Several candidates used the formula for charge on a sphere which gave the same answer (to 2sf) but is a physics error so scores no marks.

Question			Answer/Indicative content	Marks	Guidance
		v	Q (= CV) = $1.25 \times 10^{-6} \times 1.28 \times 10^{9}$ Q = 1600 (C)	C1 A1	Ecf from (a)(iii) and (a)(iv) Correct evaluation to at least 2sf **Allow** 2sf answer of 1700 C for 2sf values used in calculation **Allow** answer of 1250C for p.d. value of 1 x 10^{9} **Examiner's Comments** This response could produce a wide variety of correct answers depending on the rounding of the numbers used, although most candidates used at least 2sf for their values, which is recommended. A noticeable number of candidates correctly evaluated the change then divided it by 2, presumably due to it asking for the charge on one of the plates. **Assessment for learning** Error carried forward. In general, error carried forward can only be applied when the working is clearly seen and the error value is correctly used. In this question, there are two values to be used, each of which may have been incorrectly calculated. It is therefore vital that the calculation is seen, so that the credit can be given. It is, of course, good practice to always show working rather than when just an error carried forward could be applied.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
2			B	1	Examiner's Comments Most candidates were able to correctly calculate the total capacitance, and many showed working to support a correct method. **A** was the most common distractor, being calculated as if the capacitors were resistors.
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
3	a		Circuit showing (6V) supply in series with a capacitor and resistor, with a voltmeter in parallel with the capacitor. Switch/switches allowing discharging of the capacitor through the resistor.	B1 B1	No labels required. **ALLOW** any suitable symbol for d.c. supply **ALLOW** this mark if resistor and capacitor in parallel if switch will allow the discharge Examples of correct circuit for both marks e.g.  <u>Examiner's Comments</u> Many candidates were able to correctly draw the supply, capacitor, and resistor in series with a voltmeter in parallel for a single mark. The position of a switch/switches to allow a discharge was less simple and many candidates had a single switch in series with their components. There are several ways to correctly draw this, and examiners allowed the use of double throw type switches as long as the idea was clear. Placing the capacitor and resistor in parallel with the supply may have allowed access to the second marking point as it would allow the discharge but not the charging. As always, clarity of the diagram makes it easier for examiners to understand. Several candidates appeared not to know the symbol for the capacitor and used a capital C in a circle. Less than one fifth of candidates were able to correctly draw the required diagram.

Question			Answer/Indicative content	Marks	Guidance
	b		Charge = 1.0 x 10^{-6} x 6.0 = **6.0 x 10^{-6}** (C)	A1	**ALLOW** correct answer to 1 significant figure Examiner's Comments The vast majority of candidates were able to calculate this correctly and the main reason for not awarding the mark tended to be from a power of ten error.
	c		(*CR* =) 1 x 10^{-6} x 10 x 10^{3} CR / Time constant / τ = 0.010 (s) Time constant / τ is time taken to fall to 1/e (37%) of initial value The time it takes to record the variation of pd / the capacitor to discharge is far less than (human) <u>reaction time</u> OR $V = V_0 e^{-(\frac{t}{CR})}$ to give $0.6 = 6.0e^{-(\frac{t}{1.0\times10^{-6}\times10\times10^{3}})}$ *t* = 0.023 (s) 0.6 is the voltage when it has fallen to 10% of the initial voltage The time it takes to record the variation of pd / for the capacitor to discharge is far less than human <u>reaction time</u> OR $V = V_0 e^{-(\frac{t}{CR})}$ to give $V = 6.0e^{-(\frac{0.02}{1.0\times10^{-6}\times10\times10^{3}})}$ *V* = 0.81 V 0.02 s is a very short amount of time The time it takes to record the variation of pd / for the capacitor to discharge is far less than human <u>reaction time</u>	C1 A1 B1 B1 (C1) (A1) (B1) (B1) (C1) (A1) (B1) (B1)	**ALLOW** POT error for capacitance if same as in (b) **ALLOW** 1sf **ALLOW** t for τ **NOT** fallen <u>by</u> 37% Substitution into exponential decay equation to fall to a value of *V* less than $0.9V_0$ (<5.4V). **ALLOW** calculation in log form e.g ln 0.6 = ln 6.0 - t/0.01 Justification/explanation for using a given voltage Substitution into exponential decay equation with a time less than 0.1s (t < 0.1s). **ALLOW** calculation in log form lnV = ln 6.0 - 0.02/0.01 Justification/explanation for using a given time Examiner's Comments Candidates were credited with calculations that produced a time or voltage that showed the time for decay was rapid. There were many possible routes to an answer and candidates were credited with any method that would produce a correct solution. As the question also included an explanation, it was often necessary to justify candidates' values for further credit rather than simply determine a numerical answer. The calculations were, in general,

Question			Answer/Indicative content	Marks	Guidance
					completed well and a good number of candidates were able to score 2 or more marks. Explanations in terms of reaction time were quite rare and often a vague answer such as ‘the time is short’ or ‘human error’ was given. Many candidates also related it to the precision of the stopwatch rather than the limitations of their use due to human reaction time. Exemplar 2  the capacitor with time, using a stop watch. For the capacitor to discharge to 1V it takes less than a second which is less than human reaction time. [4] hence a large uncertainty due to random error In this response the candidate has chosen to determine the time taken to fall to 1 V. The calculation has been done correctly for the first 2 marks (although there is no unit, it is clear what *t* is). The third marking point has not been satisfied – a comment would be needed (however brief) on why 1 V was chosen. The final marking point is given for the idea that this is time is less than human reaction time.
	d		Use an oscilloscope / data logger with a voltmeter probe	B1	**ALLOW** connect a voltmeter to a datalogger **Examiner’s Comments** While changing the value of the resistor or capacitor would increase the charging time, that would alter ‘this experiment’ and as such was not credited. In the context of this question, it is how the variation can be determined using the given values. Few candidates appreciated this, however there were significant numbers who knew that an oscilloscope could be used in place of the voltmeter.

Question			Answer/Indicative content	Marks	Guidance
	e	i	$V = V_0 e^{-\left(\frac{t}{CR}\right)}$ to give $4.12 = 6.0\, e^{-\left(\frac{t}{1.0\times10^{-6}\times10\times10^{3}}\right)}$ = 3.76 x 10^{-3} (s)	C1 A1	**ALLOW** in terms of logs eg ln 4.12 = ln 6.0 $-\frac{t}{0.01}$ Correct to at least 2 significant figures **IGNORE** minus sign in final answer **Examiner's Comments** Most candidates were able to calculate the correct time for the discharge, by taking substituting values into the logarithmic equation. Common errors included incorrect taking of logs by division rather than subtraction (depending on their original set-up) and power of ten errors or transcription errors in the values of *C* or *R*. As with many calculations, those who spent a little time setting out the working carefully were more likely to get the correct answer.
		ii	Change in energy = ½ CV_1^2 - ½ CV_2^2 = (½ x 1×10^{-6} x 6^2) – (½ x 1×10^{-6} x 4.12^2) = 9.5 x10^{-6} (J) rate = 9.5 x10^{-6} / 3.76 x 10^{-3} = 2.53 x 10^{-3} (Js^{-1})	C1 C1 A1	**ALLOW** POT error from (e)(i) Ecf from (e)(i) Correct to at least 2 significant figures **Examiner's Comments** Only around one third of candidates were able to correctly calculate this answer. By far the most common error was to calculate the change in energy using the difference in voltages (using 1.88 V) rather than calculating the separate energies and then subtracting. Several candidates left their answer at this point, rather than going on to divide by their value for the time.
			Total	13	

Question			Answer/Indicative content	Marks	Guidance
4		i	**1** 0.5 (C_0) **2** 2 (V_0) **3** 2 (E_0)	B1 B1 B1	**Allow** ½ **Ignore working** No ecf **Ignore working** No ecf <u>**Examiner's Comments**</u> Around two thirds of candidates were able to score all of these marks. Most showed some limited (but helpful) working, such as writing the equation for the parallel plate capacitor and $C = Q/V$, to assist them in appreciating how each of the factors change. For this question, there is a quite large amount of introductory text and the bold text is there as a supportive guide. The most common incorrect responses were a simple reversal of the correct responses.
		ii	<u>Work</u> done against <u>attractive</u> forces	B1	**Allow** WD for work done <u>**Examiner's Comments**</u> This proved to be a challenging question and only the higher end candidates were able to give a clear and correct response. The question stated, "in terms of forces" and most candidates did not explain the idea of attraction between the plates. Common incorrect responses included using $E = ½\ QV$ or using $W = F \times d$ as a starting point.
			Total	4	

Question			Answer/Indicative content	Marks	Guidance
5		i	*Qd* = constant At least **two** pairs of values substituted to show that *Qd* = constant	C1 A1	**Allow** straight-line graph of *Q* against 1/*d* passes through the origin **Allow** as *d* increases by a given factor (e.g. doubles) then *Q* decreases by the same factor (e.g. halves) **Allow** numbers that show when *d* doubles then *Q* halves **Ignore** prefixes and POT errors <u>Examiner's Comments</u> The question was not carefully examined by most candidates, because the reference to use **Fig. 22.2** was totally ignored. A significant number of candidates focused either on superfluous practical details or the proof of the relationship between *Q* and *d* – which was required in the next question. About a third of the candidates used at least two points on the graph to show that *Qd* = constant. The powers of ten were overlooked by examiners. A small number of candidates, mainly at the lower-end, calculated the gradient of the curve at arbitrary points to provide support for their incorrect reasoning.
		ii	$Q = VC$ and $C = \frac{\varepsilon_0 A}{d}$ Hence $Q = \frac{V\varepsilon_0 A}{d}$ (and $Q \propto \frac{1}{d}$)	C1 A1	**Allow** ε **Note** *Q*, or *Q*/*V* must be the subject here **Allow** $Q \infty C$ and $C \infty \frac{1}{d}$ <u>Examiner's Comments</u> Most candidates successfully, and elegantly, provided the proof for the relationship. Correct answers ranged from the whole space filled with algebra to a couple of succinct lines. A small number of candidates finished off their working by writing $Q = \frac{1}{d}$ instead $Q \propto \frac{1}{d}$ the 'equal' and the 'proportionality' symbols are not equivalent.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
6	a		$\varepsilon = 7.2 \times 10^{-12} \times 1.2 \times 10^{-3}/4.0 \times 10^{-4}$ permittivity = 2.2×10^{-11} (F m^{-1})	C1 A1	**Allow** any subject **Allow** ε_o instead of ε **Note** answer to 3 sf is 2.16×10^{-11} (F m^{-1}) **Allow** 1 mark for bald 2.4; relative permittivity calculated **Examiner's Comment** Most candidates effortlessly used the equation $C = \varepsilon A / d$ to determine the permittivity *s* of the insulator between the capacitor plates. Once again, most answers were well-structured and showed good calculator skills. The most common errors were: • Taking the prefix pico (p) to be a factor of 10^{-9}. • Confusing permittivity ε and permittivity of free space ε_0. • Calculating relative permittivity (2.4).
	b	i	capacitance of two capacitors in series = 500 (πF) $C = 1000 + 500$ $C = 1500$ (μF)	C1 A1	**Examiner's Comment** The modal score here was two marks, with most scripts showing excellent understanding of capacitors in combination. Many candidates arrived at the final answer of 1500 μF without much calculation. A small number incorrect swapped the equations for series and parallel combinations and arrived at the incorrect answer of 670 μF.
		ii	$V = 1.5 \times e^{-12/15}$ $V = 0.67$ (V)	C1 A1	Possible ecf from **(i)** **Allow** 1 mark for 0.83 V, $V = 1.5[1 - e^{-12/15}]$ used **Examiner's Comment** Many candidates correctly calculated the time constant of the circuit and then either determined the p.d. across the capacitors (0.83 V) or the resistor (0.67 V) - the latter being the correct answer. The most common mistake was calculating e^{-12115} rather than $1.5 \times e^{-12/15}$. Weaker candidates got nowhere by attempting to use $V = IR$ and $Q = VC$.

Question			Answer/Indicative content	Marks	Guidance
			Total	**6**	
7			A	1	
			Total	**1**	
8			D	1	
			Total	**1**	
9			The charge on each plate remains the same.	B1	**Allow** other correct methods.
			$C = \varepsilon_0 A/d$, hence the capacitance is halved.	B1	
			$E = ½\ Q^2/C$, $E \propto 1/C$ and hence energy stored doubles.	B1	
			Total	**3**	
10			C	1	
			Total	**1**	
11			A	1	
			Total	**1**	
12			A	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
13	a		Electrons in the circuit move in a clockwise direction **and** electrons are deposited on plate **B.**	B1	**Allow**: conventional current is in anticlockwise direction.
			(An equal number of) electrons are removed from plate **A** giving it a positive charge (of equal magnitude).	B1	
	b		series capacitors: $C = (100^{-1} + 220^{-1})^{-1} =$ 68.75 (μF)	C1	
			total capacitance = 500 + 68.75 = 568.75 (μF)	C1	
			$E = ½ \times 12^2 \times 568.75 \times 10^{-6}$	C1	
			$E = 4.1 \times 10^{-2}$ (J)	A1	
			Total	**6**	