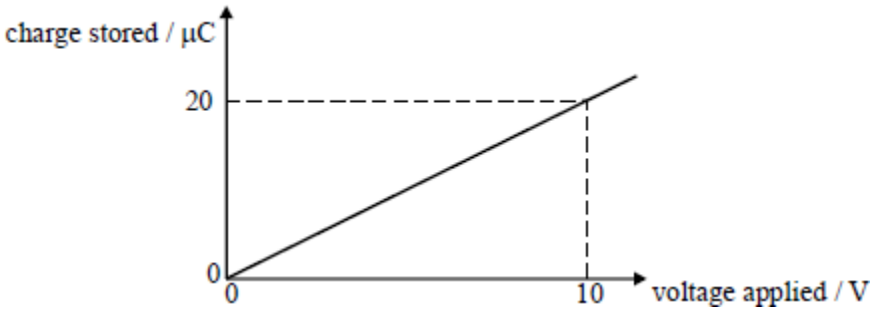
1 The graph shows the charge stored in a capacitor as the voltage across it is varied.



The energy stored, in μJ, when the potential difference across the capacitor is 5 V, is

A 25

B 50

C 100

D 200

(Total 1 mark)

2 A capacitor is first charged through a resistor and then discharged through the same resistor.

The magnitude of which one of the following quantities varies with time in the same way during both charging and discharging?

A Energy stored

B Current

C Potential difference

D Charge

(Total 1 mark)

3 In experiments to pass a very high current through a gas, a bank of capacitors of total capacitance 50 μF is charged to 30 kV. If the bank of capacitors could be discharged completely in 5.0 ms what would be the mean power delivered?

A 9.0 MW

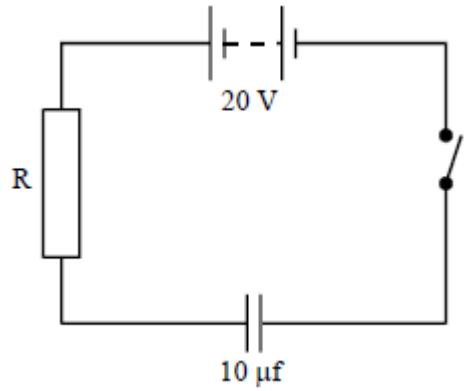
B 4.5 MW

C 110 kW

D 22 kW

(Total 1 mark)

4



A capacitor of capacitance 10 µF is fully charged through a resistor R to a p.d. of 20 V using the circuit shown. Which one of the following statements is **incorrect?**

A The p.d. across the capacitor is 20 V.

B The p.d. across the resistor is 0 V.

C The energy stored by the capacitor is 2 mJ.

D The total energy taken from the battery during the charging process is 2 mJ.

(Total 1 mark)

5

A 1 µF capacitor is charged using a constant current of 10 µA for 20 s. What is the energy finally stored by the capacitor?

A 2×10^{-3} J

B 2×10^{-2} J

C 4×10^{-2} J

D 4×10^{-1} J

(Total 1 mark)

6

A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During this process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

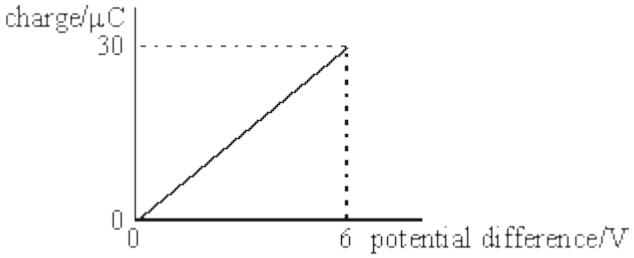
B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

7 The graph shows how the charge stored by a capacitor varies with the potential difference across it as it is charged from a 6 V battery.



Which one of the following statements is **not** correct?

A The capacitance of the capacitor is 5.0 μF.

B When the potential difference is 2 V the charge stored is 10 μC.

C When the potential difference is 2 V the energy stored is 10 μJ.

D When the potential difference is 6 V the energy stored is 180 μJ.

(Total 1 mark)

8 A 1.0 μF capacitor is charged by means of a **constant** current of 10 μA for 20 s. What is the energy finally stored in the capacitor?

A 4.0×10^{-4} J

B 2.0×10^{-3} J

C 2.0×10^{-2} J

D 4.0×10^{-2} J

(Total 1 mark)

9 In experiments to pass a very high current through a gas, a bank of capacitors of total capacitance 50 μF is charged to 30 kV. If the bank of capacitors could be discharged completely in 5.0 m s what would be the mean power delivered?

A 22 kW

B 110 kW

C 4.5 MW

D 9.0 MW

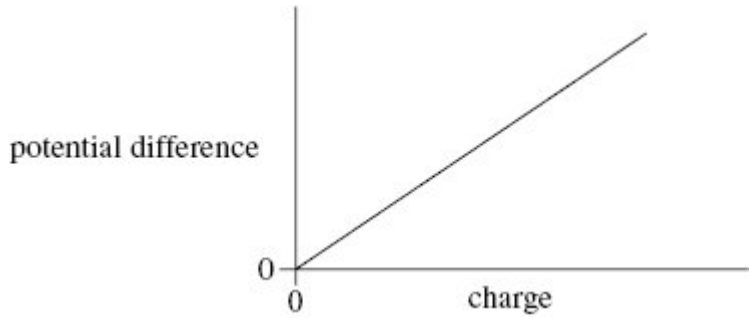
(Total 1 mark)

10 A 1000 μF capacitor, X, and a 100 μF capacitor, Y, are charged to the same potential difference. Which row, **A** to **D**, in the table gives correct ratios of charge stored and energy stored by the capacitors?

	$\frac{\text{charge stored by X}}{\text{charge stored by Y}}$	$\frac{\text{energy stored by X}}{\text{energy stored by Y}}$
A	1	1
B	1	10
C	10	1
D	10	10

(Total 1 mark)

11 The graph shows how the potential difference across a capacitor varies with the charge stored by it.



Which one of the following statements is correct?

A The gradient of the line equals the capacitance of the capacitor.

B The gradient of the line equals the energy stored by the capacitor.

C The reciprocal of the gradient equals the energy stored by the capacitor.

D The reciprocal of the gradient equals the capacitance of the capacitor.

(Total 1 mark)

12 A 10 mF capacitor is charged to 10 V and then discharged completely through a small motor. During the process, the motor lifts a weight of mass 0.10 kg. If 10% of the energy stored in the capacitor is used to lift the weight, through what approximate height will the weight be lifted?

A 0.05 m

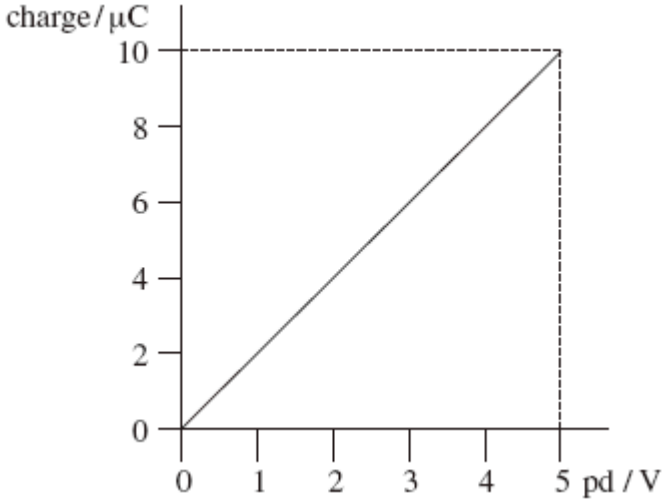
B 0.10 m

C 0.50 m

D 1.00 m

(Total 1 mark)

13 The graph shows how the charge stored by a capacitor varies with the pd applied across it.



Which line, **A** to **D**, in the table gives the capacitance and the energy stored when the potential difference is 5.0 V?

	capacitance/μF	energy stored/μJ
A	2.0	25
B	2.0	50
C	10.0	25
D	10.0	50

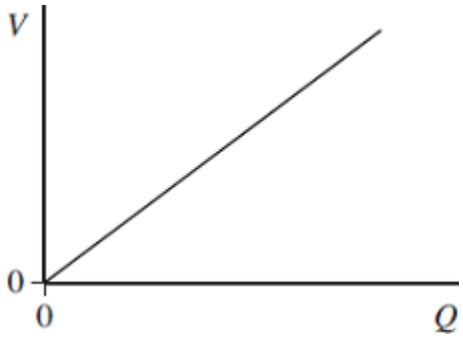
(Total 1 mark)

14 A capacitor of capacitance *C* stores an amount of energy *E* when the pd across it is *V*. Which line, **A** to **D**, in the table gives the correct stored energy and pd when the charge is increased by 50%?

	energy	pd
A	1.5 *E*	1.5 *V*
B	1.5 *E*	2.25 *V*
C	2.25 *E*	1.5 *V*
D	2.25 *E*	2.25 *V*

(Total 1 mark)

15 The graph shows the results of an experiment which was carried out to investigate the relationship between the charge Q stored by a capacitor and the pd V across it.



Which one of the following statements is **not** correct?

A The energy stored can be calculated by finding the area under the line.

B If a capacitor of smaller capacitance had been used the gradient of the graph would be steeper.

C If Q were doubled, the energy stored would be quadrupled.

D The gradient of the graph is equal to the capacitance of the capacitor.

(Total 1 mark)

16 An initially uncharged capacitor of capacitance 20 μF is charged by a constant current of 80 μA. Which line, **A** to **D**, in the table gives the potential difference across, and the energy stored in, the capacitor after 50 s?

	potential difference / V	**energy stored / J**
A	4.0×10^{-3}	2.0×10^{-3}
B	4.0×10^{-3}	4.0×10^{-1}
C	2.0×10^{2}	2.0×10^{-3}
D	2.0×10^{2}	4.0×10^{-1}

(Total 1 mark)

17 A nuclear fusion device is required to deliver at least 1 MJ of energy using capacitors. If the largest workable potential difference is 10 kV, what is the minimum capacitance of the capacitors that should be used?

A 0.01 F

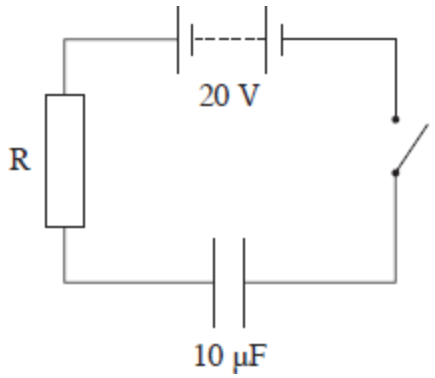
B 0.02 F

C 2 F

D 100 F

(Total 1 mark)

18 A capacitor of capacitance 10 μF is charged through a resistor R to a potential difference (pd) of 20 V using the circuit shown.



When the capacitor is fully charged which one of the following statements is **incorrect**?

A The energy stored by the capacitor is 2 mJ.

B The total energy taken from the battery during the charging process is 2 mJ.

C The pd across the capacitor is 20 V.

D The pd across the resistor is 0 V.

(Total 1 mark)

19 The figure below shows a capacitor of capacitance 370 pF. It consists of two parallel metal plates of area 250 cm^2. A sheet of polythene that has a relative permittivity 2.3 completely fills the gap between the plates.

not to scale

(a) Calculate the thickness of the polythene sheet.

thickness = _____m

(2)

(b) The capacitor is charged so that there is a potential difference of 35 V between the plates. The charge on the capacitor is then 13 nC and the energy stored is 0.23 μJ.

The supply is now disconnected and the polythene sheet is pulled out from between the plates without discharging or altering the separation of the plates.

Show that the potential difference between the plates increases to about 80 V.

(2)

(c) Calculate the energy that is now stored by the capacitor.

energy stored = _____ μJ

(2)

(d) Explain why there is an increase in the energy stored by the capacitor when the polythene sheet is pulled out from between the plates.

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(2)
(Total 8 marks)

20 Capacitors and rechargeable batteries are examples of electrical devices that can be used repeatedly to store energy.

(a) (i) A capacitor of capacitance 70 F is used to provide the emergency back-up in a low voltage power supply.

Calculate the energy stored by this capacitor when fully charged to its maximum operating voltage of 1.2 V. Express your answer to an appropriate number of significant figures.

answer = ...J

(3)

(ii) A rechargeable 1.2 V cell used in a cordless telephone can supply a steady current of 55 mA for 10 hours. Show that this cell, when fully charged, stores almost 50 times more energy than the capacitor in part (a)(i).

(2)

(b) Give **two** reasons why a capacitor is **not** a suitable source for powering a cordless telephone.

Reason 1.....

.....

Reason 2.....

.....

(2)
(Total 7 marks)

21 (a) A particular heart pacemaker uses a capacitor which has a capacitance of 4.2 μF.
Explain what is meant by *a capacitance of 4.2 μF*.

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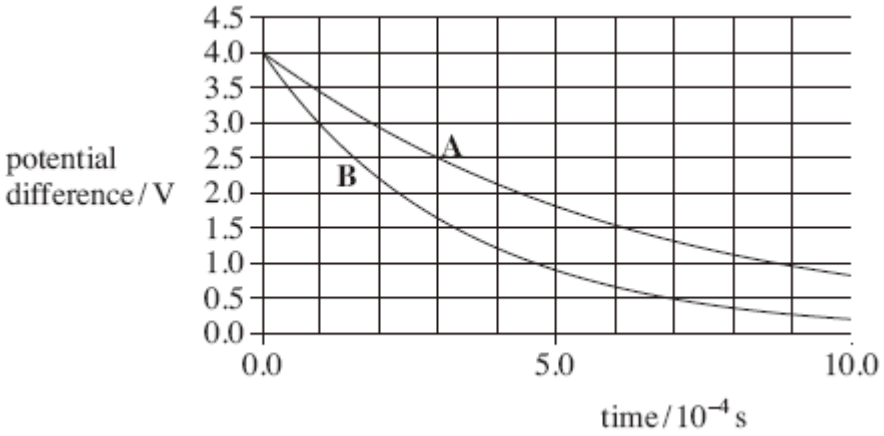
(2)

(b) Capacitor **A**, of capacitance 4.2 μF, is charged to 4.0 V and then discharged through a sample of heart tissue. This capacitor is replaced by capacitor **B** and the charge and discharge process repeated through the same sample of tissue.
The discharge curves are shown in the figure below.



(i) By considering the discharge curve for capacitor **A**, show that the resistance of the sample of heart tissue through which the discharge occurs is approximately 150 Ω.

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(4)

(ii) State and explain whether capacitor **B** has a larger or smaller capacitance than that of capacitor **A**.

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(2)

(c) Capacitor **A** was charged to a potential difference of 4.0V before discharging through the sample of heart tissue.
Determine how much energy it passed to the sample of heart tissue in the first 0.90 m s of the discharge.

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energy ..... J

(3)
(Total 11 marks)

22 **Figure 1** shows a circuit that is used in a defibrillator in which a short pulse of charge is used to revive a patient who suffers a cardiac arrest in which their heart stops beating.

Figure 2 shows how the charge on the capacitor varies with time when the capacitor is charging.

Figure 1

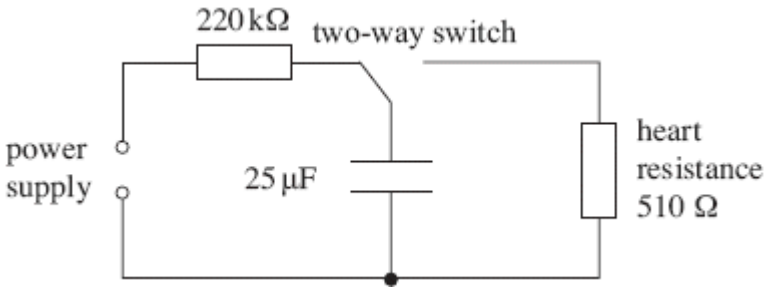
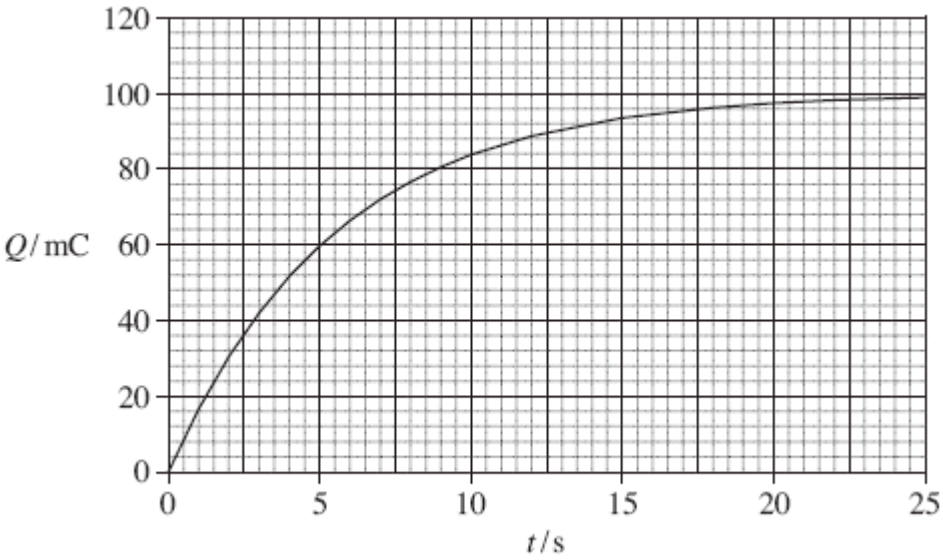


Figure 2



(a) (i) Use **Figure 2** to determine the initial charging current.

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initial charging current ..... A

(2)

(ii) Calculate the emf of the supply used to charge the capacitor.
Assume that the supply has negligible internal resistance.

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emf of the supply V

(2)

(iii) Explain why the current that charges the capacitor falls as the capacitor charges.

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(3)

(b) For the system to work successfully, the capacitor has to deliver 140 J of energy to the heart in a pulse that lasts for 10 ms.

(i) Show that the charge on the capacitor when it is storing this much energy is about 85 mC.

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(2)

(ii) Calculate the average power supplied during the pulse.

.....

.....

.....

average power ..... W

(1)

(c) The circuit designer suggests that the capacitor can be used successfully after a charging time equal to 1.5 time constants of the charging circuit shown in **Figure 1**.

Explain with a calculation whether or not the designer's suggestion is valid.

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(3)
(Total 13 marks)

23 A 680 μF capacitor is charged fully from a 12 V battery. At time $t = 0$ the capacitor begins to discharge through a resistor. When $t = 25$ s the energy remaining in the capacitor is one quarter of the energy it stored at 12 V.

(a) Determine the pd across the capacitor when $t = 25$s.

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(2)

(b) (i) Show that the time constant of the discharge circuit is 36 s.

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(ii) Calculate the resistance of the resistor.

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(4)
(Total 6 marks)

24 (a) As a capacitor was charged from a 12 V supply, a student used a coulomb meter and a voltmeter to record the charge stored by the capacitor at a series of values of potential difference across the capacitor. The student then plotted a graph of pd (on the *y*-axis) against charge (on the *x*-axis).

(i) Sketch the graph obtained.

(ii) State what is represented by the gradient of the line.

.....

(iii) State what is represented by the area enclosed by the line and the *x*-axis of the graph.

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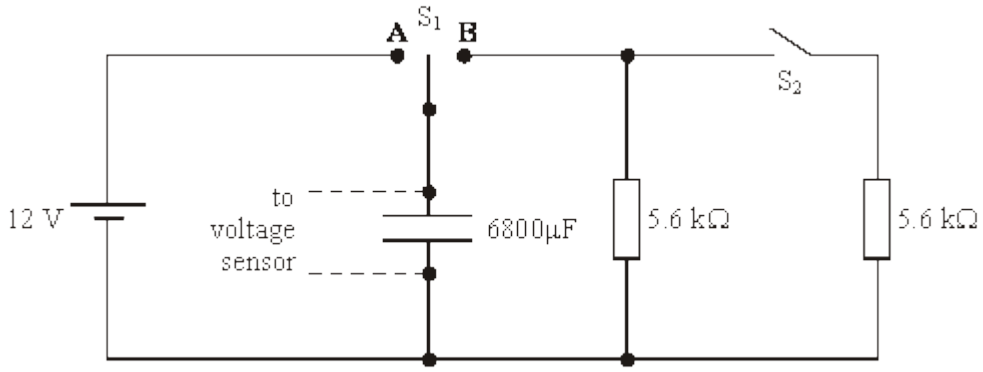
(3)

(b) The student then connected the capacitor as shown in the diagram below to carry out an investigation into the discharge of the capacitor.



The student used a voltage sensor, datalogger and computer to obtain values for the pd across the capacitor at various times during the discharge.

(i) At time $t = 0$, with switch S_2 open, switch $S_1$was moved from position **A** to position **B**. Calculate the pd across the capacitor when $t = 26$ s.

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(ii) At time $t = 26$ s, as the discharge continued, the student closed switch S_2. Calculate the pd across the capacitor 40 s after switch S_1 was moved from position **A** to position **B**.

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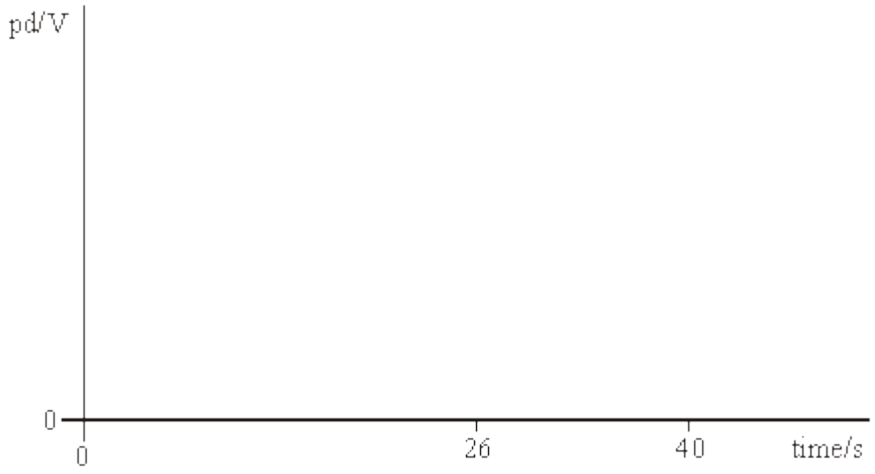
(iii) Sketch a graph of pd against time for the student's experiment described in parts (b)(i) and (b)(ii).



(7)
(Total 10 marks)

25 A capacitor of capacitance 330 μF is charged to a potential difference of 9.0 V. It is then discharged through a resistor of resistance 470 kΩ.

Calculate

(a) the energy stored by the capacitor when it is fully charged,

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(2)

(b) the time constant of the discharging circuit,

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(1)

(c) the p.d. across the capacitor 60 s after the discharge has begun.

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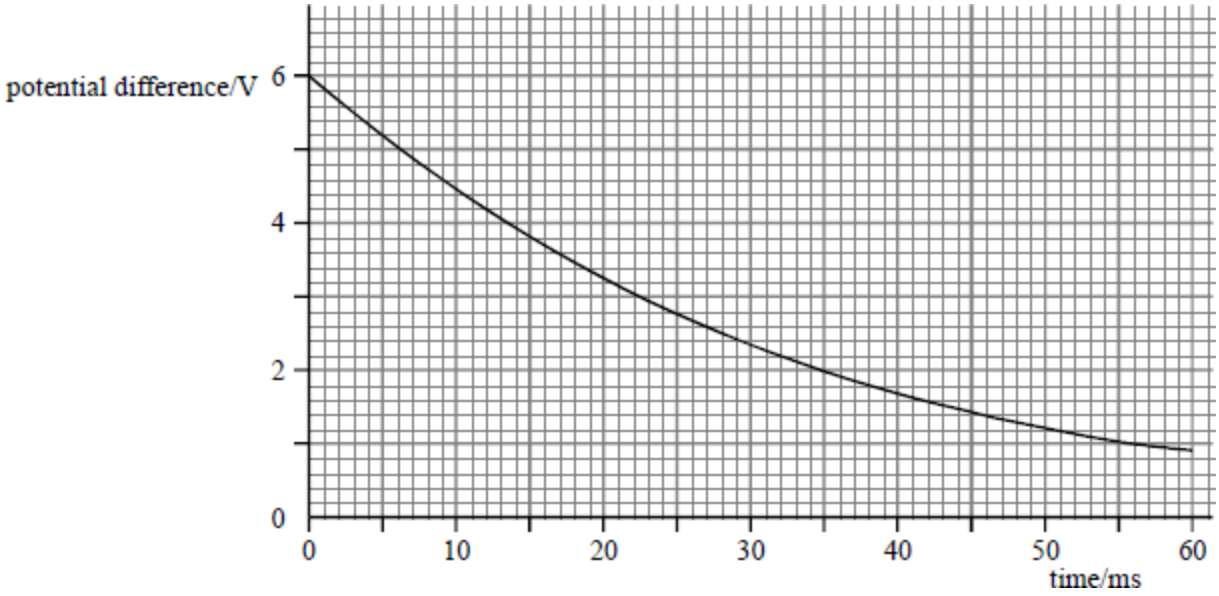
(3)
(Total 6 marks)

26 A student used a voltage sensor connected to a datalogger to plot the discharge curve for a 4.7 μF capacitor. She obtained the following graph.



Use data from the graph to calculate

(a) the initial charge stored,

.....

(2)

(b) the energy stored when the capacitor had been discharging for 35 ms,

.....

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(3)

(c) the time constant for the circuit,

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(3)

(d) the resistance of the circuit through which the capacitor was discharging.

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(2)
(Total 10 marks)

27 (a) For a capacitor of capacitance C, sketch graphs of charge, Q, and energy stored, E, against potential difference, V.

graph A

graph b

What is represented by the slope of graph A?

.....

(3)

(b) A capacitor of capacitance 0.68 F is charged to 6.0 V. Calculate

(i) the charge stored by the capacitor,

.....

.....

(ii) the energy stored by the capacitor.

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(2)
(Total 5 marks)

28 (a) A capacitor is made from two parallel metal plates of the same area, separated by an air gap. It is connected across a battery of constant e.m.f.

The plates are moved further apart, maintaining the same area of overlap, whilst the battery remains connected. State and explain what change, if any, occurs to

(i) the potential difference across the plates,

.....

(ii) the capacitance of the capacitor,

.....

(iii) the charge on each plate of the capacitor,

.....

(iv) the energy stored by the capacitor.

.....

(4)

(b) A thunder cloud and the earth beneath it can be considered to form a parallel plate capacitor. The area of the cloud is 8.0 km^2 and it is 0.75 km above the earth.

(i) Calculate the energy stored if the potential difference between the cloud and the earth is 200 kV.

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(ii) The air suddenly conducts, allowing all the charge to flow to earth in 120 μs. Calculate the mean current flowing between the cloud and the earth when this happens.

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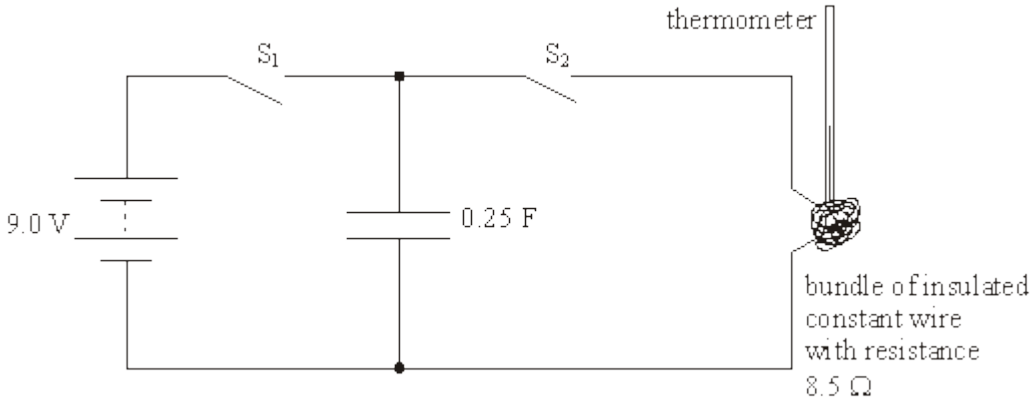
(6)
(Total 10 marks)

29 (a) A 500 μF capacitor and a 1000 μF capacitor are connected in series. Calculate the total capacitance of the combination.

(2)

(b) The figure below shows a diagram of an arrangement used to investigate the energy stored by a capacitor.



The bundle of constantan wire has a resistance of 8.5 Ω. The capacitor is initially charged to a potential difference of 9.0 V by closing $\mathbf{S_1}$.

(i) Calculate the charge stored by the 0.25 F capacitor.

(ii) Calculate the energy stored by the capacitor.

(iii) Switch $\mathbf{S_1}$ is now opened and $\mathbf{S_2}$ is closed so that the capacitor discharges through the constantan wire. Calculate the time taken for the potential difference across the capacitor to fall to 0.10 V.

(7)

(c) The volume of constantan wire in the bundle in the figure above is 2.2×10^{-7} m^3.

density of constantan = 8900 kg m^{-3}

specific heat capacity of constantan = 420 J kg^{-1} K^{-1}

(i) Assume that all the energy stored by the capacitor is used to raise the temperature of the wire. Use your answer to part (b)(ii) to calculate the expected temperature rise when the capacitor is discharged through the constantan wire.

(ii) Give **two** reasons why, in practice, the final temperature will be lower than that calculated in part (c)(i).

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(5)
(Total 14 marks)

30 (a) Explain what is meant by a capacitance of 1 farad (F).

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(1)

(b) A parallel plate capacitor was made from two circular metal plates with air between them. The distance between the plates was 1.8 mm. The capacitance of this capacitor was found to be 2.3×10^{-11} F.

The permittivity of free space $\varepsilon_0 = 8.9 \times 10^{-12}$ F m^{-1}

The relative permittivity of air = 1.0

Calculate:

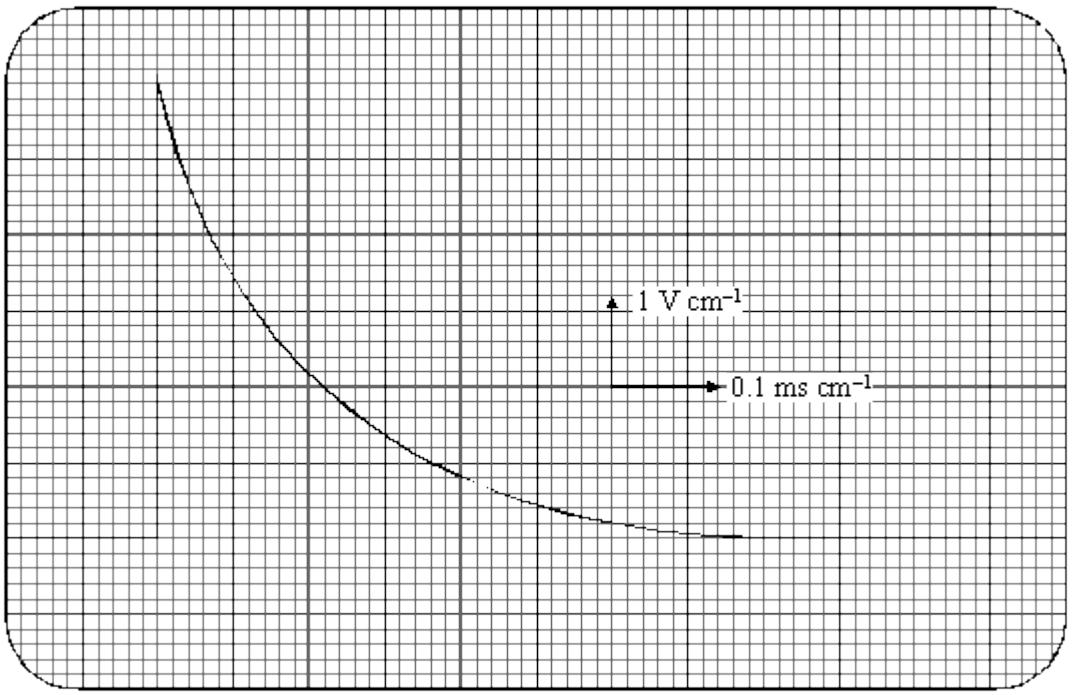
(i) the radius of the plates used in the capacitor;

(3)

(ii) the energy stored when the potential difference between the capacitor plates is 6.0 V.

(2)

(c) A student charged the capacitor and then tried to measure the potential difference between the plates using an oscilloscope. The student observed the trace shown in the diagram below and concluded that the capacitor was discharging through the oscilloscope.



Calculate the resistance of the oscilloscope.

(3)
(Total 9 marks)