LONDON SCIENCE COLLEGE

Name:

Date:

CAPACITORS
TEST 1

A2-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

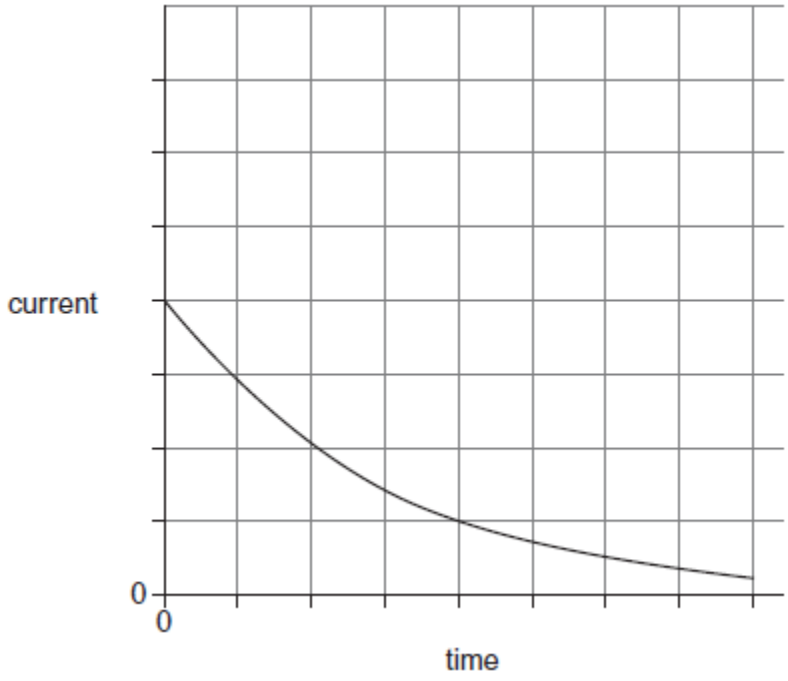
Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 (a) The graph shows how the current varies with time as a capacitor is discharged through a 150 Ω resistor.



(i) Explain how the initial charge on the capacitor could be determined from a graph of current against time.

_____

_____

_____

_____

(1)

(ii) The same capacitor is charged to the same initial potential difference (pd) and then discharged through a 300 kΩ resistor. Sketch a second graph on the same axes above to show how the current varies with time in this case.

(3)

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(b) In an experiment to show that a capacitor stores energy, a student charges a capacitor from a battery and then discharges it through a small electric motor. The motor is used to lift a mass vertically.

(i) The capacitance of the capacitor is 0.12 F and it is charged to a pd of 9.0 V.
The weight of the mass raised is 3.5 N.
Calculate the maximum height to which the mass could be raised.
Give your answer to an appropriate number of significant figures.

maximum height _____ m

(4)

(ii) Give **two** reasons why the value you have calculated in part (i) would not be achieved in practice.

1. _____

_____

_____

_____

2. _____

_____

_____

_____

(2)

(Total 10 marks)

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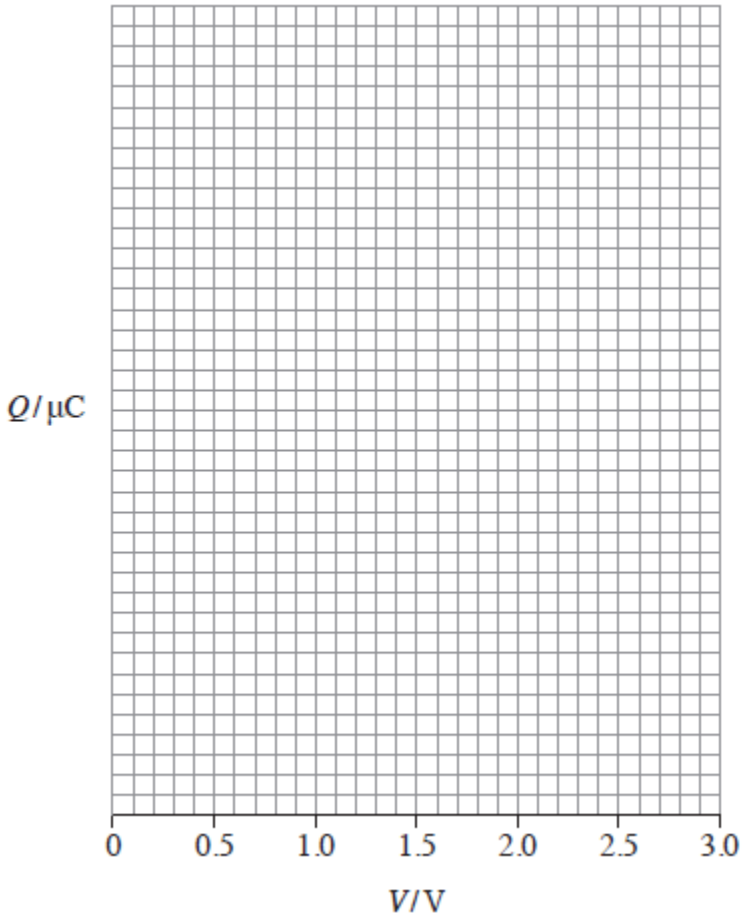
2 The specification for a pacemaker requires a suitable charge to be delivered in 1.4 ms. A designer uses a circuit with a capacitor of capacitance 3.0 μF and a 2.5 V power supply to deliver the charge. The designer calculates that a suitable charge will be delivered to the heart as the capacitor discharges from a potential difference (pd) of 2.5 V to a pd of 1.2 V in 1.4 ms.

(a) (i) Calculate the charge on the capacitor when it is charged to a pd of 2.5 V.

charge _____ C

(1)

(ii) Draw a graph showing how the charge, Q, on the capacitor varies with the pd, V, as it discharges through the heart.
Include an appropriate scale on the charge axis.



(3)

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(b) Calculate the energy delivered to the heart in a single pulse from the pacemaker when the capacitor discharges to 1.2 V from 2.5 V.

energy _____ J

(3)

(c) (i) Calculate the resistance of the heart that has been assumed in the design.

resistance _____ Ω

(3)

(ii) Explain why the rate of change of pd between the capacitor plates decreases as the capacitor discharges.

_____

_____

_____

_____

_____

(2)

(Total 12 marks)

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3 (a) When an uncharged capacitor is charged by a **constant** current of 4.5 μA for 60 s the pd across it becomes 4.4 V.

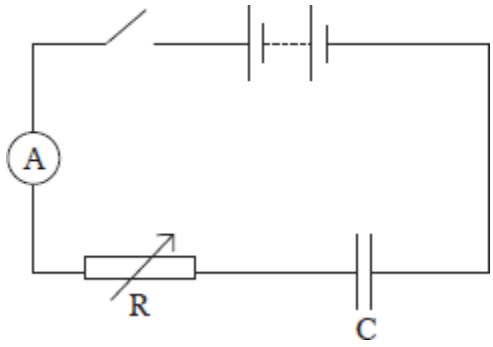
(i) Calculate the capacitance of the capacitor.

capacitance _____ F

(3)

(ii) The capacitor is charged using the circuit shown in **Figure 1**. The battery emf is 6.0 V and its internal resistance is negligible. In order to keep the current constant at 4.5 μA, the resistance of the variable resistor R is decreased steadily as the charge on the capacitor increases.

Figure 1



Calculate the resistance of R when the uncharged capacitor has been charging for 30 s.

resistance _____ Ω

(3)

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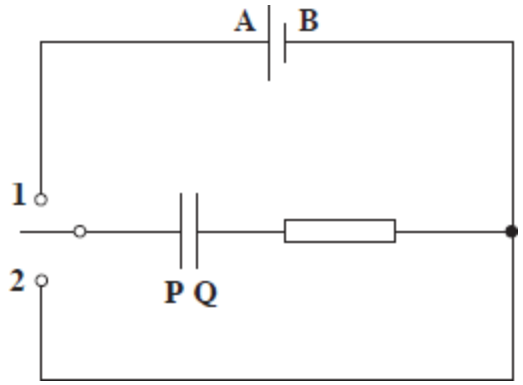
(b) The circuit in **Figure 2** contains a cell, an uncharged capacitor, a fixed resistor and a two-way switch.

Figure 2



The switch is moved to position **1** until the capacitor is fully charged. The switch is then moved to position **2**.

Describe what happens in this circuit after the switch is moved to position **1**, and after it has been moved to position **2**. In your answer you should refer to:

- the direction in which electrons flow in the circuit, and how the flow of electrons changes with time,
- how the potential differences across the resistor and the capacitor change with time,
- the energy changes which take place in the circuit.

The terminals of the cell are labelled **A** and **B** and the capacitor plates are labelled **P** and **Q** so that you can refer to them in your answer.

The quality of your written communication will be assessed in your answer.

(6)

(Total 12 marks)

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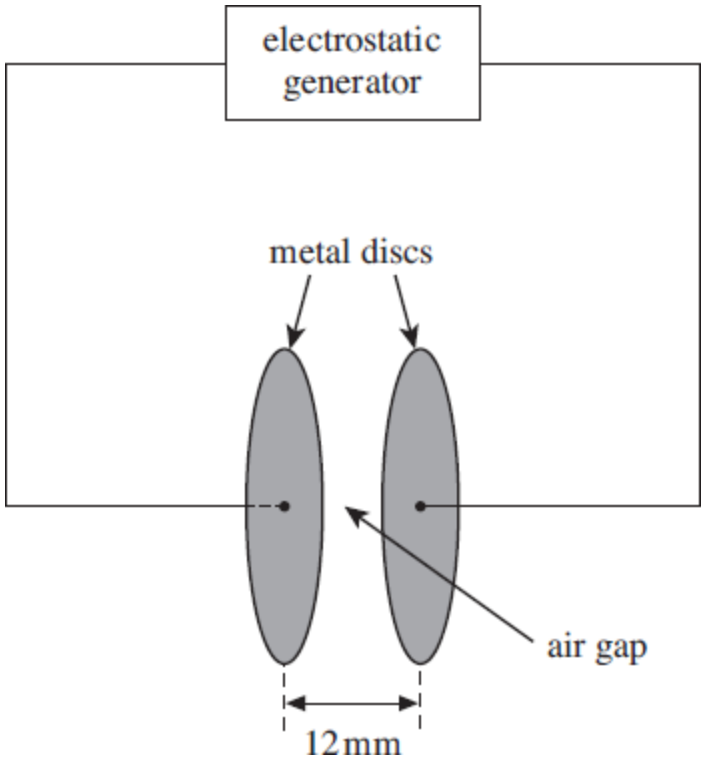
4 The diagram below shows an arrangement to demonstrate sparks passing across an air gap between two parallel metal discs. Sparks occur when the electric field in the gap becomes large enough to equal the breakdown field strength of the air. The discs form a capacitor, which is charged at a constant rate by an electrostatic generator until the potential difference (pd) across the discs is large enough for a spark to pass. Sparks are then produced at regular time intervals whilst the generator is switched on.



(a) The electrostatic generator charges the discs at a constant rate of 3.2×10^{-8} A on a day when the minimum breakdown field strength of the air is 2.5×10^{6} V m^{-1}. The discs have a capacitance of 3.7×10^{-12} F.

(i) The air gap is 12 mm wide. Calculate the minimum pd required across the discs for a spark to occur. Assume that the electric field in the air gap is uniform.

pd _____ V

(1)

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(ii) Calculate the time taken, from when the electrostatic generator is first switched on, for the pd across the discs to reach the value calculated in part (a)(i).

time _____ s

(2)

(b) The discs are replaced by ones of larger area placed at the same separation, to give a larger capacitance.

State and explain what effect this increased capacitance will have on:

(i) the time between consecutive discharges,

_____

_____

_____

_____

_____

(2)

(ii) the brightness of each spark.

_____

_____

_____

_____

_____

(2)

(Total 7 marks)

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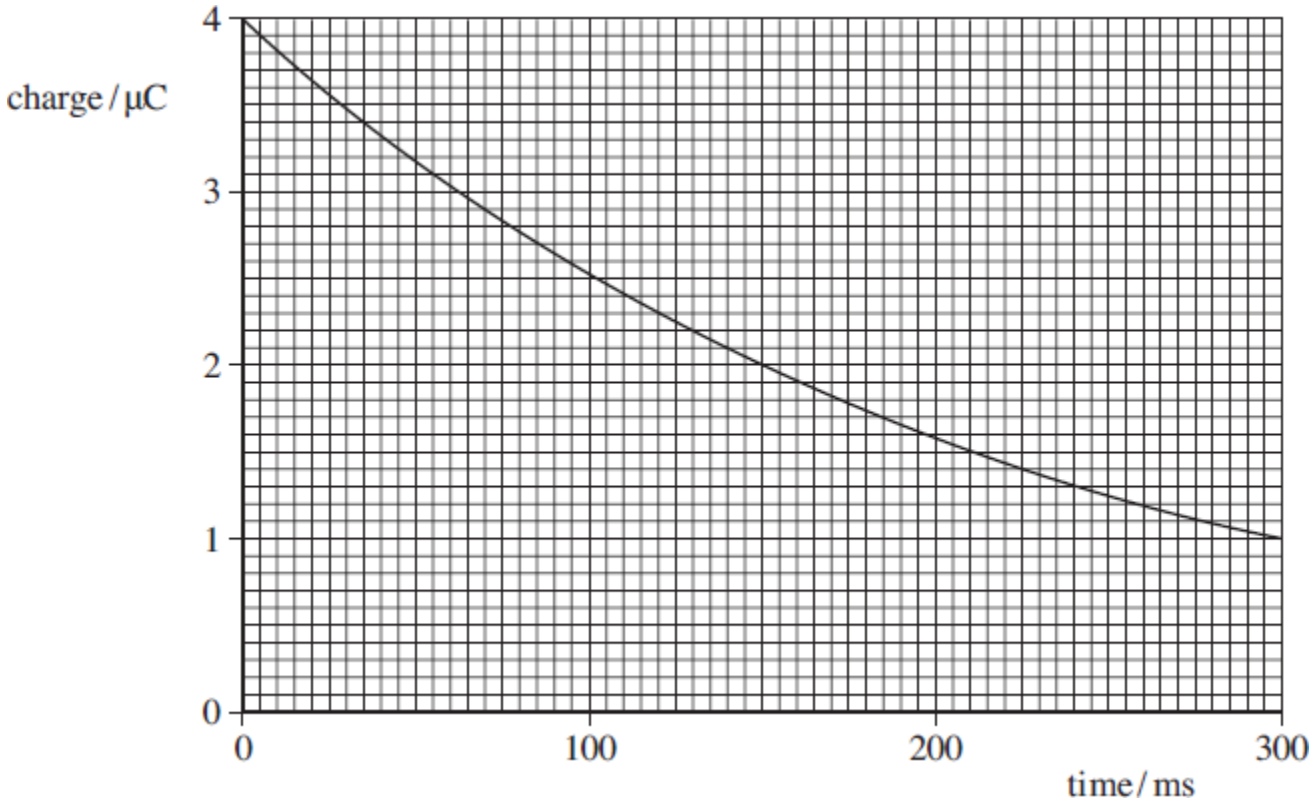
5 The graph below shows how the charge stored by a capacitor varies with time when it is discharged through a fixed resistor.



(a) Determine the time constant, in ms, of the discharge circuit.

time constant _____ ms

(3)

(b) Explain why the rate of discharge will be greater if the fixed resistor has a smaller resistance.

_____

_____

_____

_____

_____

(2)

(Total 5 marks)

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6 (a) Define the capacitance of a capacitor.

_____

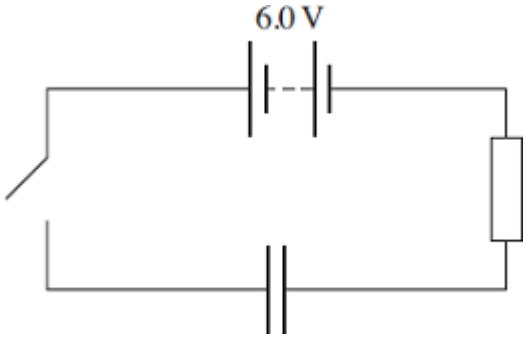
_____

_____

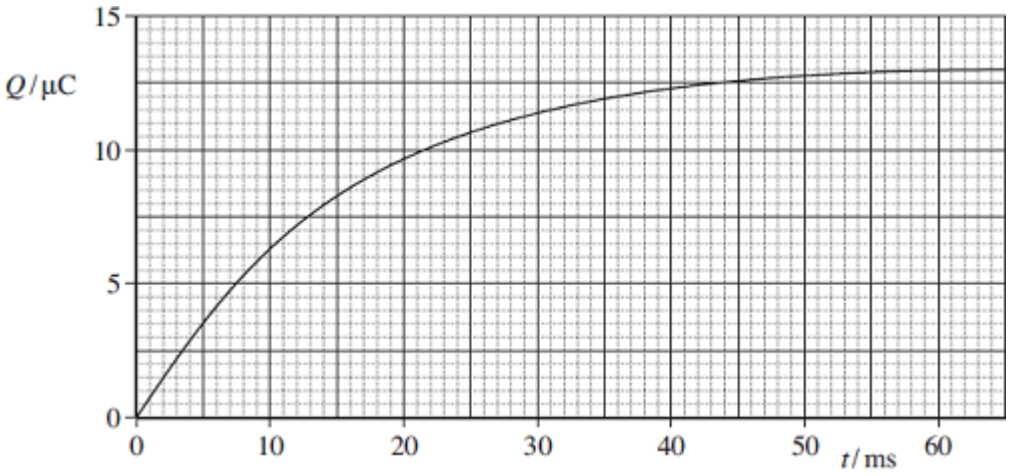
_____

(2)

(b) The circuit shown in the figure below contains a battery, a resistor, a capacitor and a switch.



The switch in the circuit is closed at time $t = 0$. The graph shows how the charge Q stored by the capacitor varies with t.



(b) (i) When the capacitor is fully charged, the charge stored is 13.2 μC. The electromotive force (emf) of the battery is 6.0 V. Determine the capacitance of the capacitor.

answer = _____ F

(2)

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(ii) The time constant for this circuit is the time taken for the charge stored to increase from 0 to 63% of its final value. Use the graph to find the time constant in milliseconds.

answer = _____ ms

(2)

(iii) Hence calculate the resistance of the resistor.

answer = _____ Ω

(1)

(iv) What physical quantity is represented by the gradient of the graph?

_____

_____

(1)

(c) (i) Calculate the maximum value of the current, in mA, in this circuit during the charging process.

answer = _____ mA

(1)

(ii) Sketch a graph on the outline axes to show how the current varies with time as the capacitor is charged. Mark the maximum value of the current on your graph.

(2)

(Total 11 marks)

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7 A capacitor of capacitance C has a charge of Q stored on the plates. The potential difference between the plates is doubled.

What is the change in the energy stored by the capacitor?

A $\frac{Q^2}{2C}$ ⬭

B $\frac{Q^2}{C}$ ⬭

C $\frac{3Q^2}{2C}$ ⬭

D $\frac{2Q^2}{C}$ ⬭

(Total 1 mark)

8 A capacitor consists of two parallel square plates of side l separated by distance d.
The capacitance of the arrangement is C.

What is the capacitance of a capacitor with square plates of side $2l$ separated by a distance $\frac{d}{2}$?

A C ⬭

B $2C$ ⬭

C $4C$ ⬭

D $8C$ ⬭

(Total 1 mark)

9 A capacitor of capacitance 120 μF is charged and then discharged through a 20 kΩ resistor.

What fraction of the original charge remains on the capacitor 4.8 s after the discharge begins?

A 0.14 ⬭

B 0.37 ⬭

C 0.63 ⬭

D 0.86 ⬭

(Total 1 mark)

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10 Initially a capacitor stores 600 μC of charge. When it loses half of this charge, the potential difference (pd) across it decreases by 50 V.

What is the capacitance of the capacitor?

A 1.5 μF ⬭

B 3.0 μF ⬭

C 6.0 μF ⬭

D 12 μF ⬭

(Total 1 mark)

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