LONDON SCIENCE COLLEGE

Name:

Date:

CAPACITORS
TEST 2

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

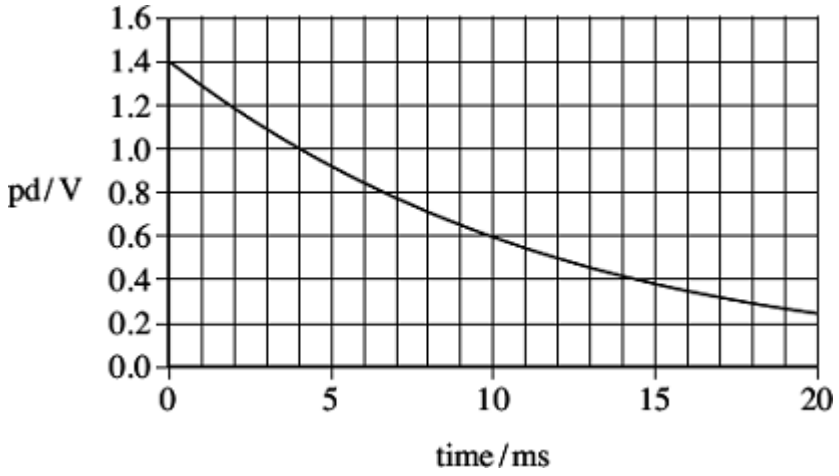
Instructions

- 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 The figure below shows part of the discharge curve for a capacitor that a manufacturer tested for use in a heart pacemaker.



The capacitor was initially charged to a potential difference (pd) of 1.4 V and then discharged through a 150 Ω resistor.

(a) Show that the capacitance of the capacitor used is about 80 μF.

(3)

(b) Explain why the rate of change of the potential difference decreases as the capacitor discharges.

(3)

(c) Calculate the percentage of the initial energy stored by the capacitor that is lost by the capacitor in the first 0.015 s of the discharge.

energy lost _____%

(3)

(d) The charge leaving the capacitor in 0.015 s is the charge used by the pacemaker to provide a single pulse to stimulate the heart.

(i) Calculate the charge delivered to the heart in a single pulse.

charge _____C

(1)

(ii) The manufacturer of the pacemaker wants it to operate for a minimum of 5 years working at a constant pulse rate of 60 per minute.
Calculate the minimum charge capacity of the power supply that the manufacturer should specify so that it will operate for this time.
Give your answer in amp-hours (Ah).

minimum capacity _____Ah

(2)

(Total 12 marks)

2 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 _____

_____

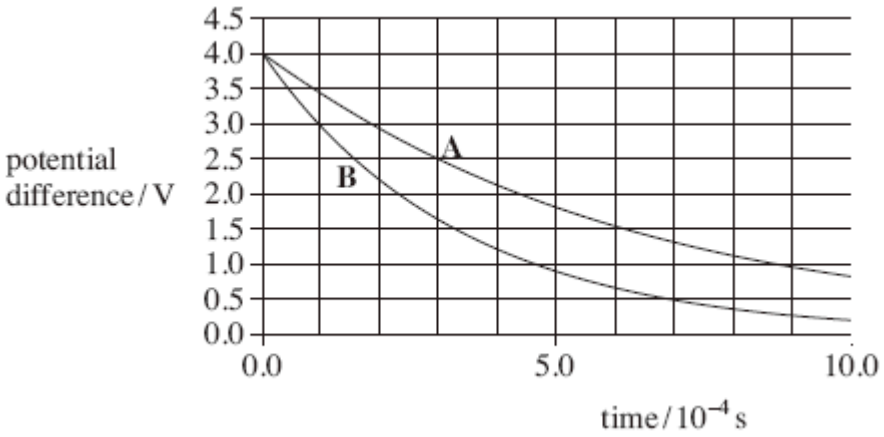
(2)

(Total 7 marks)

3 (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*.

(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.

(4)

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

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

_____

_____

energy _____ J

(3)

(Total 11 marks)

4 **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

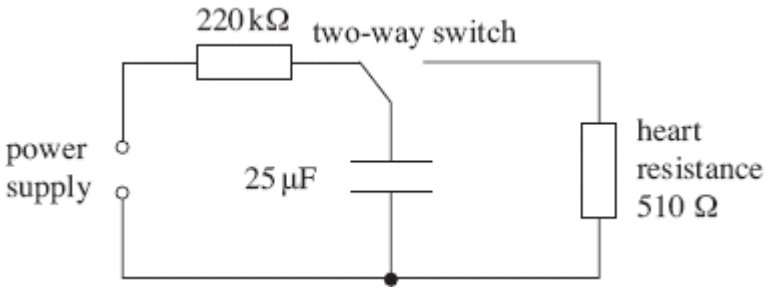
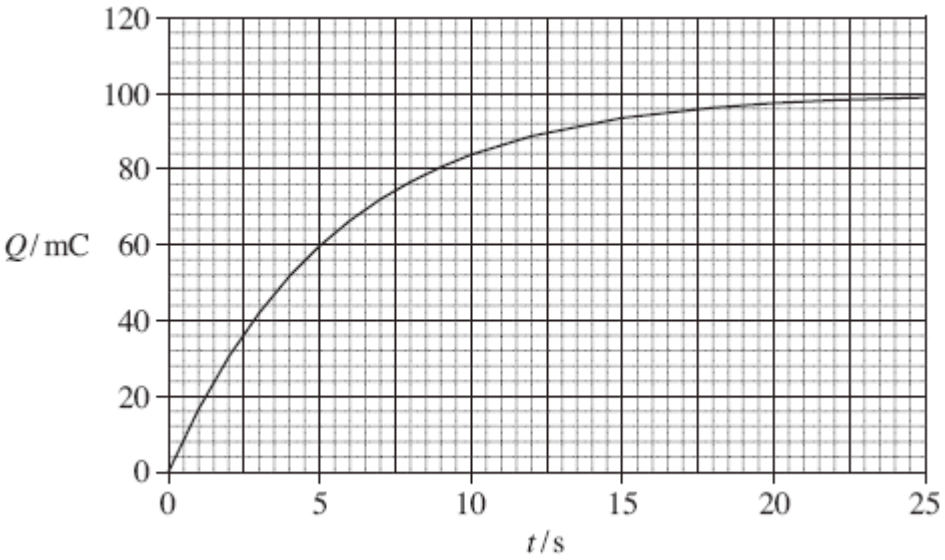


Figure 2



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

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.

emf of the supply _____ V

(2)

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

(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.

(2)

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

average power _____ W

(1)

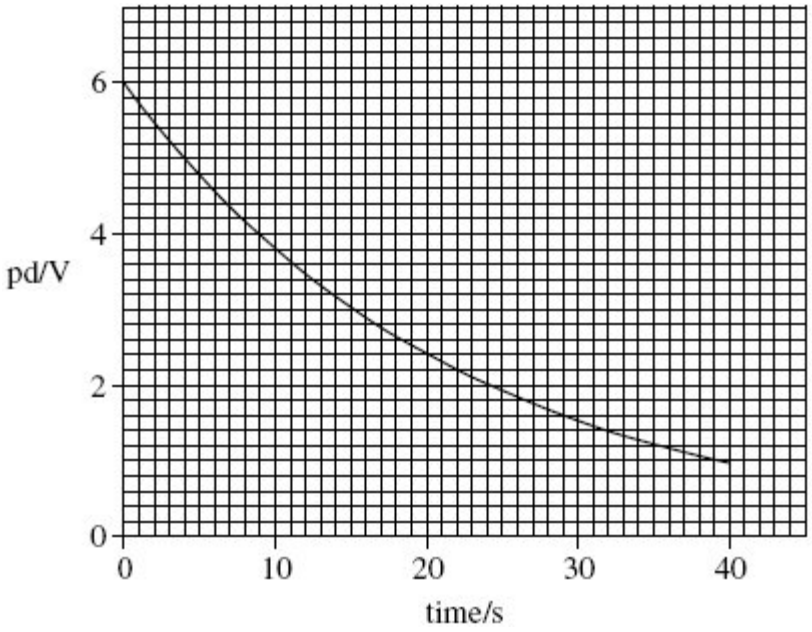
(c) The circuit designer suggests that the capacitor can be used successfully after a charging time equal to 1.5 time constants of the charging circuit shown in **Figure 1**.

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

(3)

(Total 13 marks)

5 (a) A capacitor, initially charged to a pd of 6.0V, was discharged through a 100 kΩ resistor. A datalogger was used to record the pd across the capacitor at frequent intervals. The graph shows how the pd varied with time during the first 40 s of discharge.



(i) Calculate the initial discharge current.

answer = _____ A

(1)

(ii) Use the graph to determine the time constant of the circuit, giving an appropriate unit.

answer = _____

(4)

(iii) Hence calculate the capacitance of the capacitor.

answer = _____ μF

(1)

(iv) Show that the capacitor lost 90% of the energy it stored originally after about 25 s.

(3)

(b) In order to produce a time delay, an intruder alarm contains a capacitor identical to the capacitor used in the experiment in part (a). This capacitor is charged from a 12 V supply and then discharges through a 100 kΩ resistor, similar to the one used in the experiment.

(i) State and explain the effect of this higher initial pd on the energy stored by this capacitor initially.

_____

_____

_____

(2)

(ii) State and explain the effect of this higher initial pd on the time taken for this capacitor to lose 90% of its original energy.

_____

_____

_____

(1)

(Total 12 marks)

6 (a) (i) Define the capacitance of a capacitor.

_____

_____

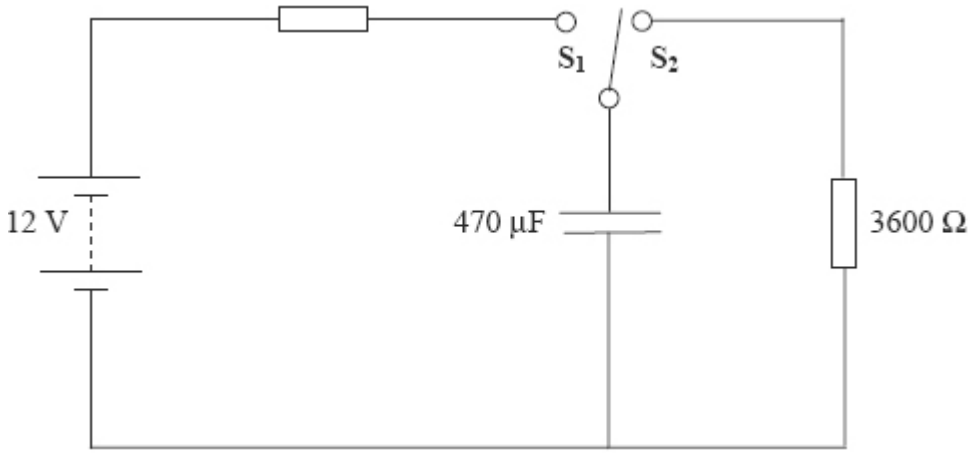
(1)

(ii) Calculate the charge, in C, stored on a 470 μF capacitor which has a potential difference of 2.3×10^2 V across it.

(1)

(b) A 470 μF capacitor is connected in a circuit which enables it to charge when the switch is in position $\mathbf{S_1}$ and discharged when the switch is in position $\mathbf{S_2}$. The arrangement is shown in **Figure 1.**

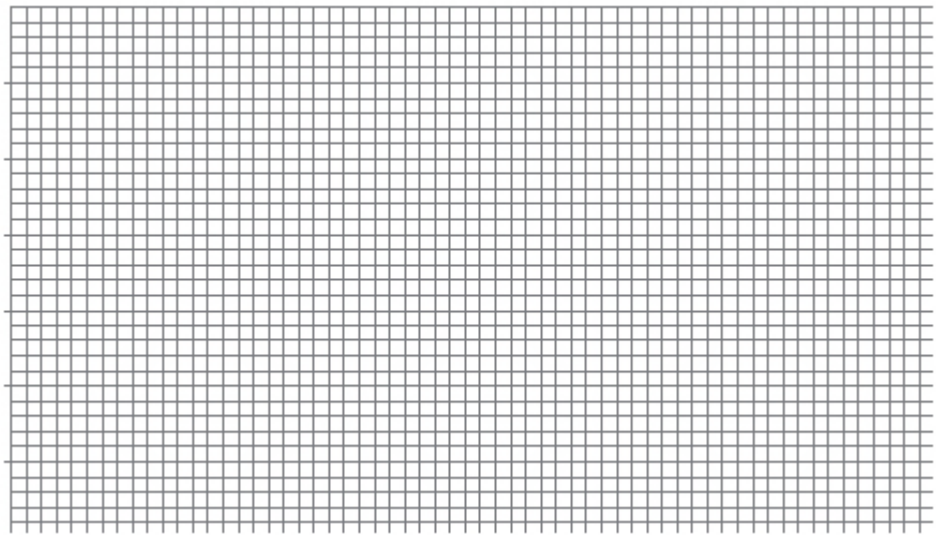
Figure 1



(i) Calculate the time constant of the discharge circuit when the switch is in position $\mathbf{S_2}$. Give your answer in s.

(1)

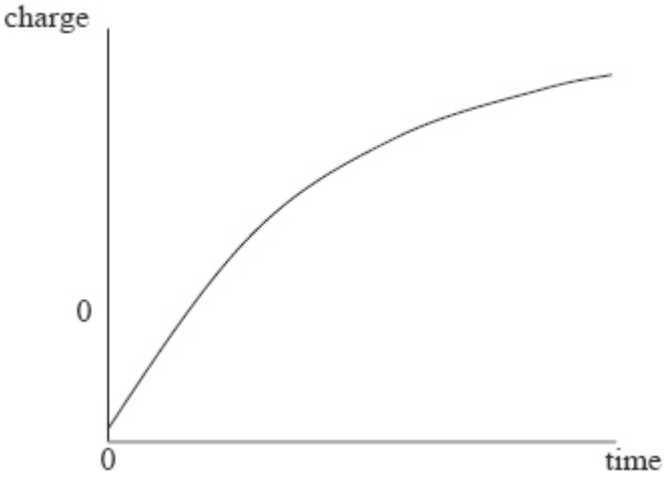
(ii) The capacitor is fully charged and then discharged. On the axes below, mark appropriate scales and draw a graph to show the variation of the potential difference across the capacitor with time for the discharge of the capacitor.



(3)

(c) **Figure 2** shows the variation of charge with time for the charging of the capacitor.

Figure 2



Explain why the charge across the capacitor changes in the way shown by the graph.

(3)

(Total 9 marks)

7 The separation of the plates of an isolated charged parallel−plate capacitor is increased.

What also increases?

A the capacitance of the capacitor ⬭

B the charge on the plates ⬭

C the strength of the electric field between the plates ⬭

D the pd between the plates ⬭

(Total 1 mark)

8 The initial charge stored by a capacitor of capacitance 0.50 μF is 2.0 μC. The capacitor is then discharged through a resistor.

How much energy is stored by the capacitor after a time equal to one time constant?

A 0.06 μJ ⬭

B 0.54 μJ ⬭

C 1.0 μJ ⬭

D 4.0 μJ ⬭

(Total 1 mark)

9 A 500 μF capacitor is charged to a pd of 10.0 V. It is then discharged through a 100 kΩ resistor.

What is the time taken for the pd to fall from 10.0 V to 5.0 V?

A 35 s ⬭

B 50 s ⬭

C 72 s ⬭

D 100 s ⬭

(Total 1 mark)

10 Which of the following statements about a parallel plate capacitor is **incorrect**?

A The capacitance of the capacitor is the amount of charge stored by the capacitor when the pd across the plates is 1 V. ⬭

B A uniform electric field exists between the plates of the capacitor. ⬭

C The charge stored on the capacitor is inversely proportional to the pd across the plates. ⬭

D The energy stored when the capacitor is fully charged is proportional to the square of the pd across the plates. ⬭

(Total 1 mark)