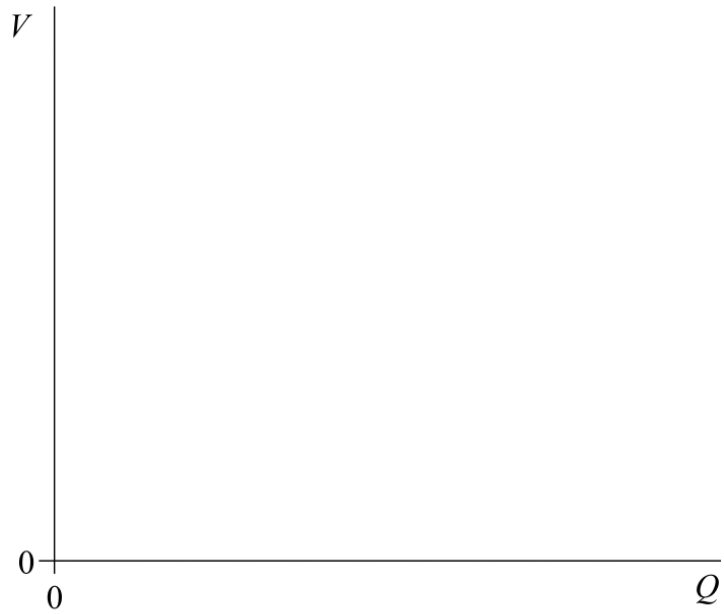
Capacitor Past Paper Questions
Jan 2002—Jan 2010 (old spec)

3 (a) A 2.0 μF capacitor is charged through a resistor from a battery of emf 4.5 V. Sketch a graph on the axes below to show how the charge stored, Q, varies with the potential difference, V, across the capacitor during the charging process. Mark appropriate values on the axes of the graph.

Q3 Jan 2002



(2 marks)

(b) (i) Show that the energy stored by a charged capacitor is given by $E = \frac{1}{2}QV$.

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(ii) Calculate the energy stored by the capacitor in part (a) when the potential difference across it is 1.5 V.

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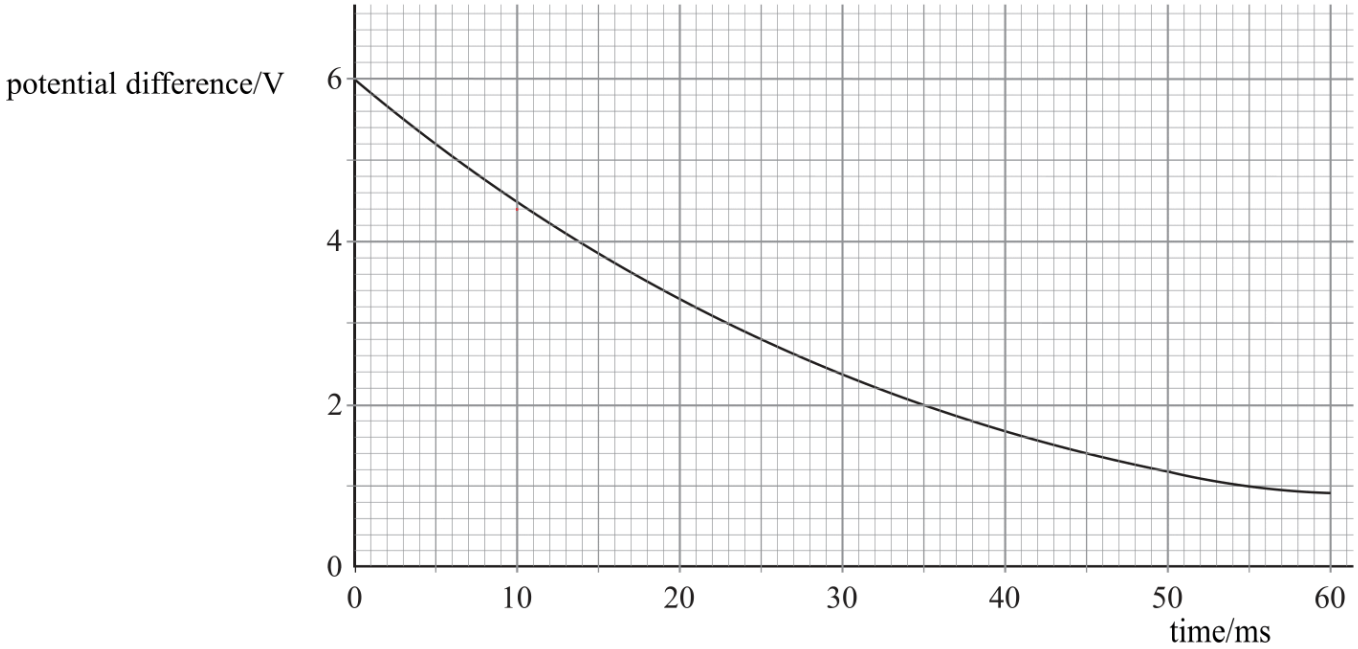
(5 marks)

Q2 Jun 2002

2 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,

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(2 marks)

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

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(3 marks)

(c) the time constant for the circuit,

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(3 marks)

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

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(2 marks)

4 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.

Q4 Jan 2004

Calculate

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

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(2 marks)

(b) the time constant of the discharging circuit,

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(1 mark)

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

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(3 marks)

3 (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. **Q3 Jun 2005**

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

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

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(3 marks)

(b) The student then connected the capacitor as shown in **Figure 4** to carry out an investigation into the discharge of the capacitor.

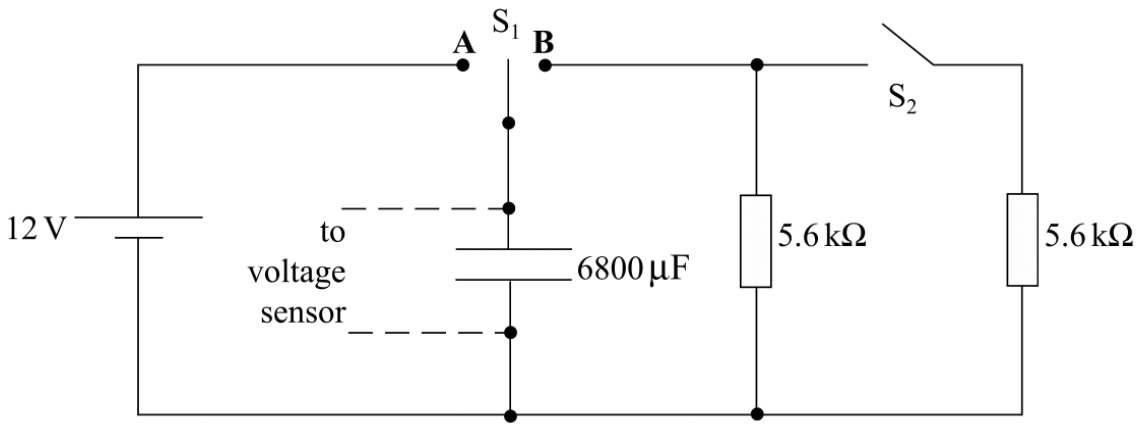

Figure 4

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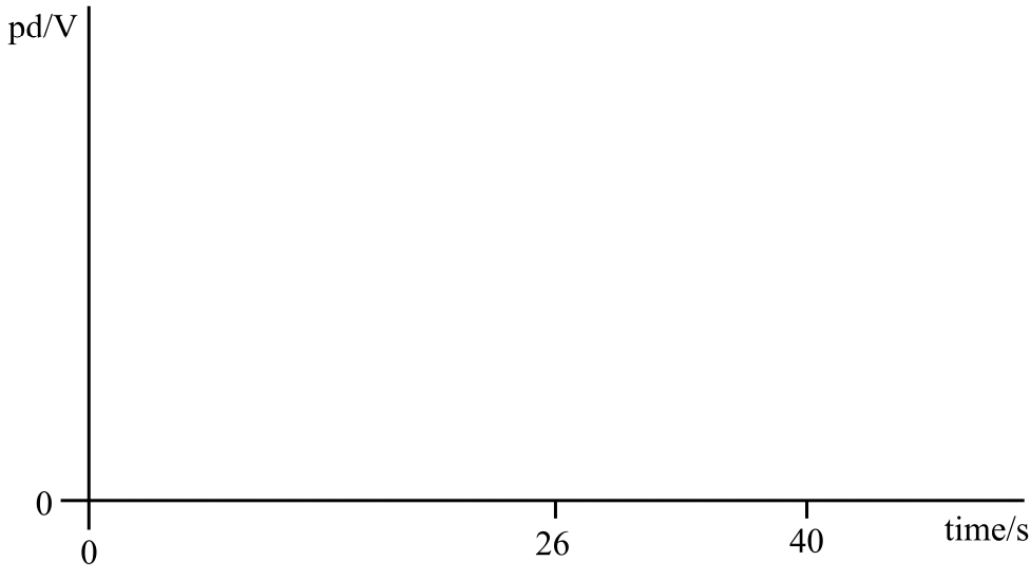
(iii) Sketch a graph of pd against time for the student's experiment described in parts (b)(i) and (b)(ii).



(7 marks)

2 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.

Q2 Jan 2006

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

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(2 marks)

(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 marks)

3 **Figure 2** shows a circuit used to determine the capacitance of a capacitor C. Switch S is held in position **X** until C is fully charged. It is then switched to position **Y**, so that C discharges through the microammeter and the variable resistor R. While discharging, R is adjusted continuously to keep the current constant until C has been fully discharged. Measurements taken during the discharge allow the initial charge stored by C to be determined.

Q3 Jan 2007

Figure 2

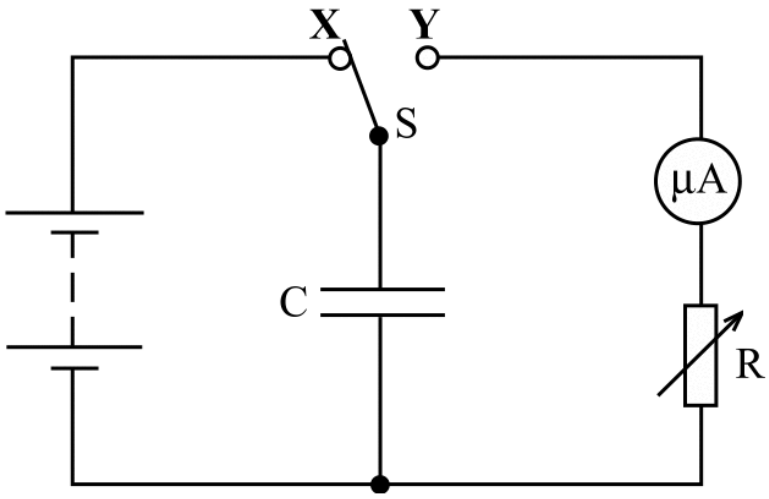
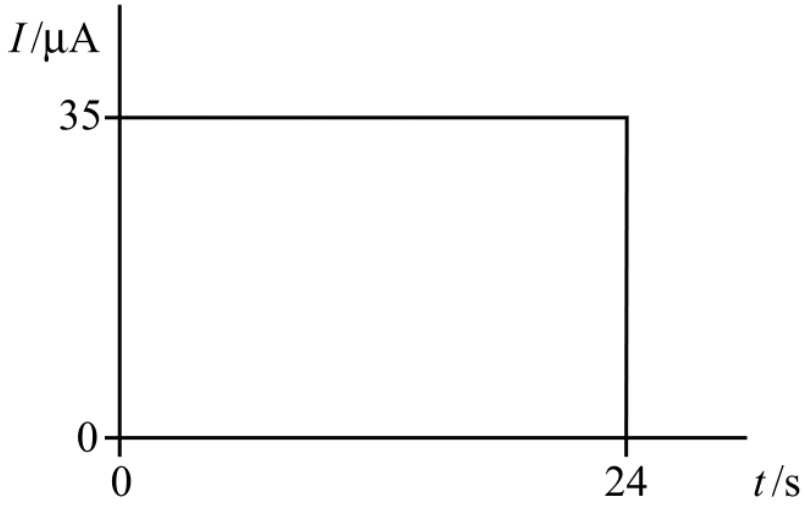


Figure 3 shows a graph of current, *I*, against time, *t*, obtained in such an experiment.

Figure 3



(a) Calculate

(i) the initial charge stored by the capacitor,

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(ii) the capacitance of the capacitor, if the emf of the battery used was 6.0 V.

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(2 marks)

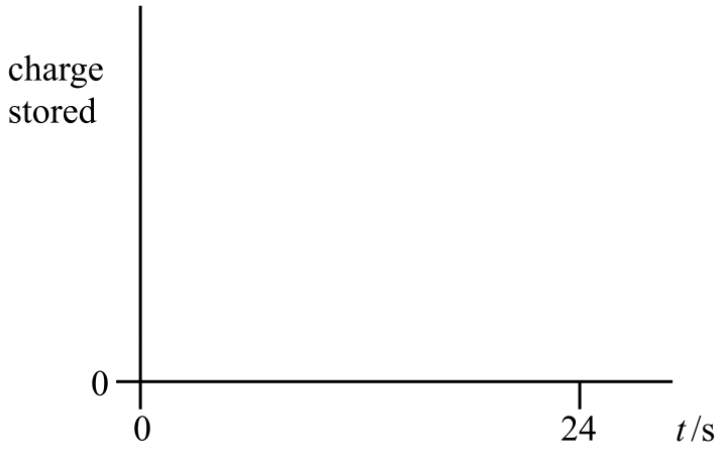
(b) Sketch graphs on the axes below to show, for the capacitor, how

(i) the charge stored
(ii) the energy stored

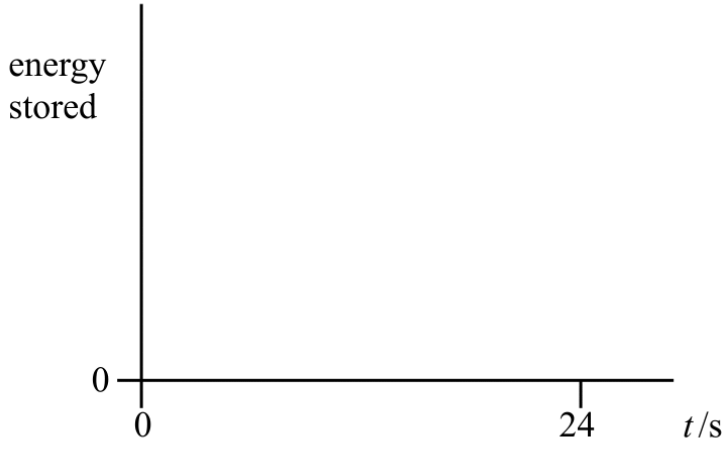
varied with time during the experiment.

You do not need to show any values on the vertical axes.

(i)



(ii)



(4 marks)

2 (a) An experiment is to be carried out to determine the capacitance of a capacitor by measuring the potential difference V across it at various times t as it discharges through a resistor. The timing is to be carried out using a stopwatch. If the capacitance is known to be about 30 μF, suggest a suitable value for the resistance of the resistor, and explain why you have chosen this value.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer. **Q2 Jan 2008**

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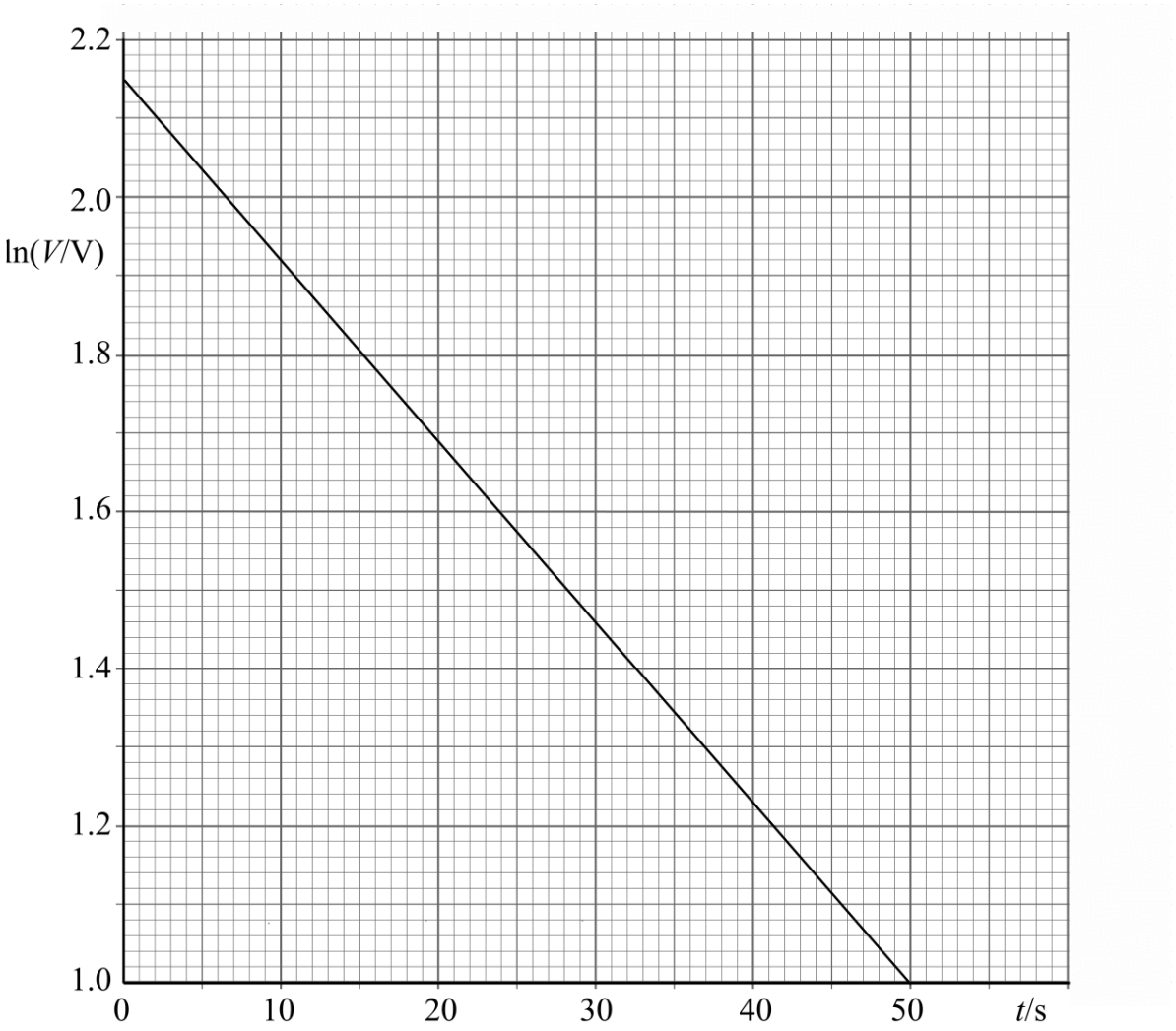
(3 marks)

(b) A similar experiment, in which the resistor had a resistance of 91 kΩ, gave the graph of ln V against t shown on the opposite page.



Use this graph to calculate

(i) the pd across the capacitor when $t = 0$,

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(ii) the time constant for the discharging circuit,

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(iii) the capacitance of the capacitor used in this experiment.

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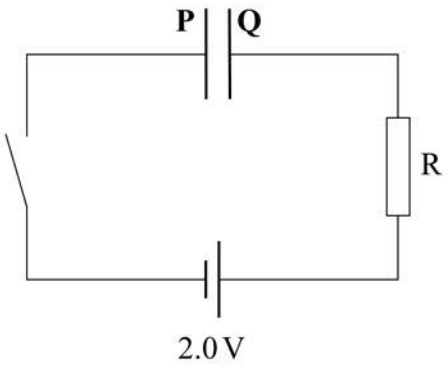
(5 marks)

3 (a)

Figure 3

Q3 Jan 2009



You may be awarded additional marks to those shown in brackets for the quality of written communication in your answers.

Figure 3 shows a circuit containing a capacitor connected in series with a fixed resistor R, a cell of emf 2.0 V, and a switch. Initially the capacitor is uncharged. The switch is closed at time $t = 0$, causing the capacitor plates **P** and **Q** to begin charging.

Describe what happens in the circuit from $t = 0$ until the capacitor becomes fully charged, in terms of

3 (a) (i) electron flow round the circuit,

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3 (a) (ii) the potential differences across the capacitor and the resistor.

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(5 marks)

3 (b) (i) Calculate the final energy stored by the capacitor if its capacitance is 50 μF.

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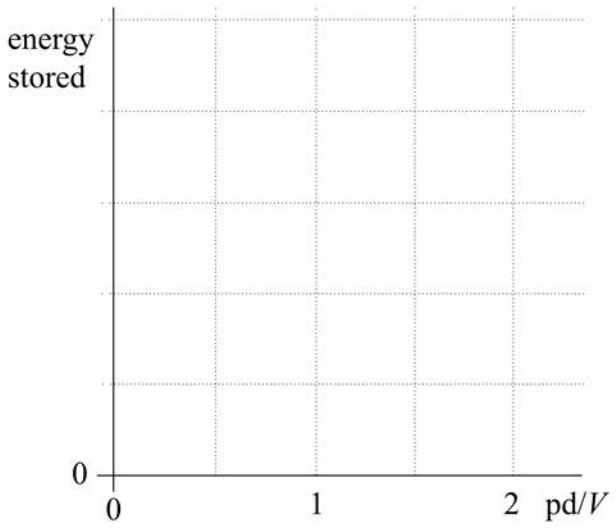
3 (b) (ii) On **Figure 4** sketch a graph to show how the energy stored by the capacitor varies with the pd across it whilst it is being charged during the process described in part (a).

Figure 4



(4 marks)

Q2 Jun 2009

2 (a) Define the *capacitance* of a capacitor.

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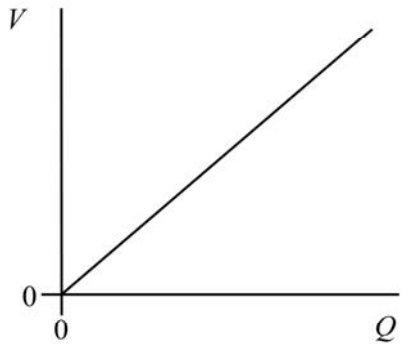
(2 marks)

2 (b) **Figure 2** shows how the pd, V, across a capacitor varies with the charge, Q, it stores.

Figure 2



By reference to **Figure 2**, show that the energy stored by a capacitor is given by

$$E = \tfrac{1}{2} Q V.$$

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(3 marks)

2 (c) A capacitor stores 9.0 μC of charge when the pd across it is 45 V.

Calculate

2 (c) (i) the capacitance of the capacitor,

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2 (c) (ii) the energy stored by the capacitor when the charge on it is 3.0 μC.

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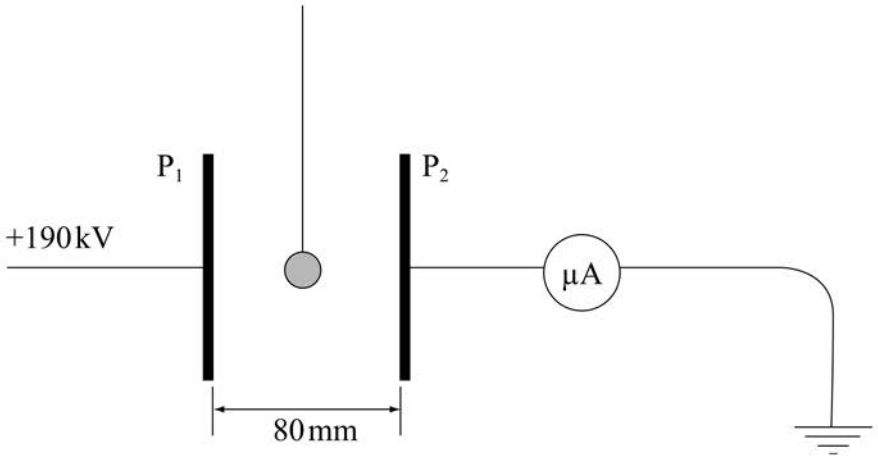
(4 marks)

Q4 Jan 2010

4 **Figure 5** shows two parallel metal plates, P_1 and P_2, placed 80 mm apart in air. P_1 is maintained at a potential of +190 kV, whilst P_2 is connected to earth through a microammeter. Suspended between the plates by an insulating thread is a light plastic sphere, the surface of which is coated with conducting paint so that it will store charge.

Figure 5



4 (a) Calculate the electric field strength between the plates.

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(1 mark)

4 (b) The sphere, whose capacitance is 5.6×10^{-13} F, shuttles back and forth between the plates 420 times per minute, contacting each plate alternately.

4 (b) (i) Calculate the magnitude of the charge it acquires every time it touches plate P_1 and state the sign of this charge.

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4 (b) (ii) Calculate the current in the microammeter.

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(6 marks)

4 (c) Explain why the sphere shuttles between the plates.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3 marks)