AQA Examination-style questions

n an experiment to measure the capacitance C of a capacitor, the circuit in **Figure 1** 'as used to charge the capacitor then discharge it through a resistor of known resistance R.

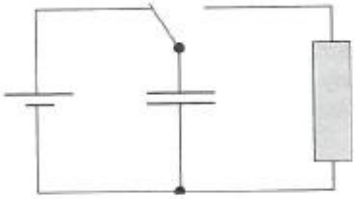

Figure 1

a) The capacitor pd V at time t after the discharge commenced is given by $V = V_0 e^{-t/CR}$. Show that this equation can be rearranged into an equation of the form $\ln V = a - bt$, where a and b are constants, and determine expressions for a and b. *(4 marks)*

b) As the capacitor discharged, its pd was measured every 30 seconds using a digital voltmeter. The measurements were repeated twice as shown in Table 1.

Table 1

t/s	0	30	60	90	120	150	180	210	240	270	300
V/V	4.50	3.82	3.26	2.78	2.33	2.00	1.70	1.43	1.23	1.04	0.89
	4.51	3.81	3.25	2.77	2.35	2.10	1.72	1.43	1.25	1.02	0.90
	4.50	3.83	3.25	2.76	2.34	1.98	1.69	1.42	1.22	1.04	0.87
mean V/V	4.503	3.820	3.253	2.760	2.340	2.027	1.703				
ln V	1.505	1.340	1.180	1.017	0.850	0.707	0.532				

(i) Complete the missing entries in Table 1.

(ii) Use the measurements to plot a graph of ln V on the y-axis against t on the x-axis.

(iii) Use your graph to determine the time constant of the discharge circuit.

(iv) The resistance R of the resistor was 68 kΩ. Determine the capacitance C of the capacitor. *(10 marks)*

(c) (i) Discuss the reliability of the measurements.

(ii) Estimate the accuracy of your value of capacitance, given the resistor value is accurate to within 1%. *(4 marks)*

Figure 2 shows a 2.0 μF capacitor connected to 150 V supply.

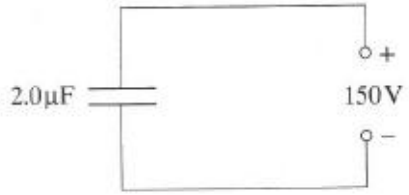

Figure 2

(a) Calculate the charge on the capacitor. *(2 marks)*

(b) (i) Suggest a graph that could be drawn in order to calculate the energy stored in the capacitor by finding the area under the graph.

(ii) Calculate the energy stored by the capacitor when it has a pd of 150 V across it. *(3 marks)*

(c) The charged capacitor is removed from the power supply and discharged by connecting a 220 kΩ resistor across it.

(i) Calculate the maximum discharge current.

(ii) Show that the current will have fallen to 10% of its maximum value in a time of approximately 1 s. *(5 marks)*

AQA, 2002

3 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, *(2 marks)*

(b) the time constant of the discharging circuit, *(1 mark)*

(c) the pd across the capacitor 60 s after the discharge has begun. *(3 marks)*

AQA, 2004

4 A student used a voltage sensor connected to a data logger to plot the discharge curve for a 4.7 μF capacitor. **Figure 3** shows the graph she obtained.

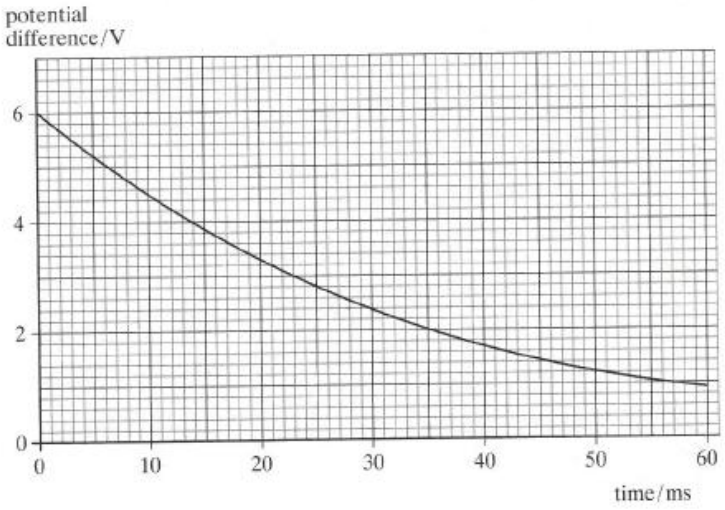

Figure 3

Use data from the graph to calculate:

(a) the initial charge stored, *(2 marks)*

(b) the energy stored when the capacitor had been discharging for 35 ms, *(3 marks)*

(c) the time constant for the circuit, *(3 marks)*

(d) the resistance of the circuit through which the capacitor was discharging. *(2 marks)*

AQA, 2002

5 **Figure 4** shows a circuit that may be used to investigate the capacitance of a capacitor. The switch moves rapidly between **X** and **Y**, making contact with each terminal 400 times per second. When it makes contact with **X** the capacitor **C** charges, when it makes contact with **Y** the capacitor discharges through the resistor **R**.

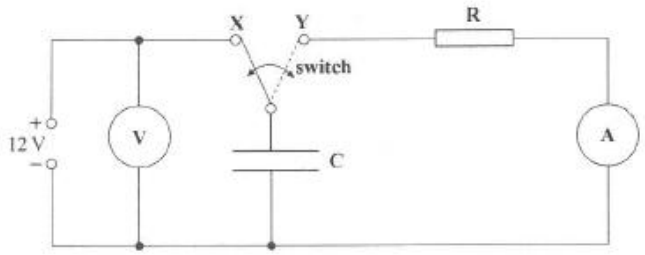

Figure 4

(a) **R** has a value of 220 Ω. The time constant for the circuit is 2.2×10^{-4}s. Calculate the value of capacitor **C**. *(1 mark)*

(b) Calculate the periodic time, *T*, for the oscillation of the switch. *(2 marks)*

(c) The switch makes contact with **Y** for time ½. The capacitor discharges from 12 V during this time.

(i) Calculate the voltage across the charged capacitor after a time ½.

(ii) Explain whether or not it is reasonable to assume that the capacitor has completely discharged in the time ½. *(4 marks)*

AQA, 2007

6 (a) Explain what is meant by a capacitance of 1 farad (F). *(1 mark)*

(b) The capacitance of a capacitor is 2.3×10^{-11}F. When the potential difference across it is 6.0 V, calculate:

(i) the charge it stores,

(ii) the energy it stores. *(4 marks)*

(c) A student charged the capacitor and then tried to measure teh potential difference between the plates using an oscilloscope. The student observed the trace shown in **Figure 5** and concluded that the capacitor was discharging through the oscilloscope.

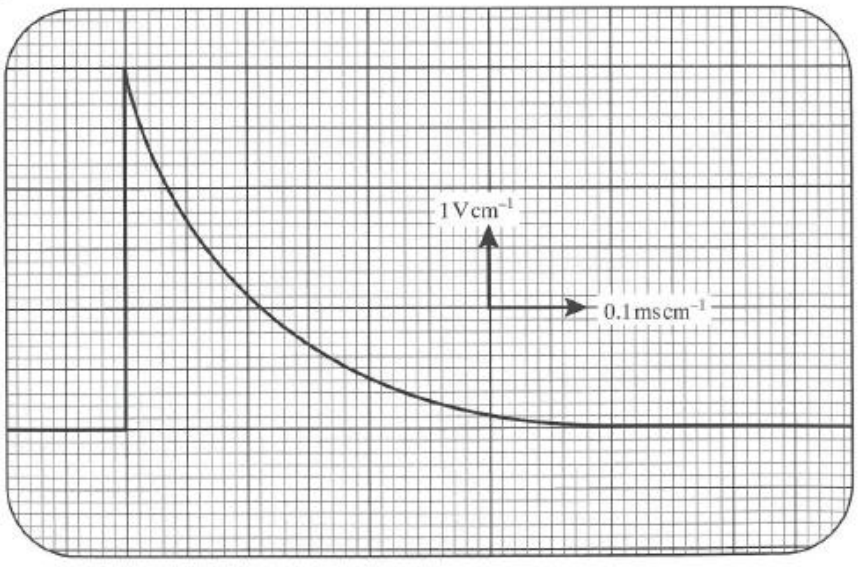

Figure 5

Calculate the resistance of the oscilloscope. *(3 marks)*

AQA, 2003

7 A torch bulb produces a flash of light when a 270 μF capacitor is discharged across it.

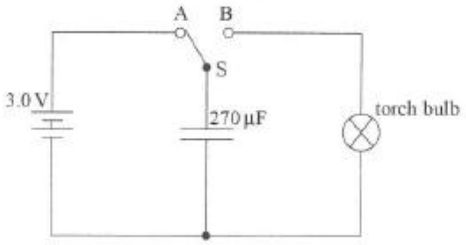

Figure 6

(a) The capacitor is charged to a pd of 3.0 V from the battery, as shown in **Figure 6**. Calculate:

(i) the energy stored in the capacitor,

(ii) the work done by the battery. *(3 marks)*

(b) The capacitor is discharged by moving switch **S** in the diagram from **A** to **B**. The discharge circuit has a total resistance of 1.5 Ω.

(i) Show that almost all of the energy stored in the capacitor is released when the capacitor pd has decreased from 3.0 V to 0.3 V.

(ii) Emission of light from the torch bulb ceases when the pd falls below 2.0 V. Calculate the duration of the light flash.

(iii) Assuming that the torch bulb produces photons of average wavelength 500 nm, estimate the number of photons released during the light flash. *(8 marks)*

AQA, 2006

8 A student uses a system shown in **Figure 7** to measure the contact time of a metal ball when it bounces on a metal block.

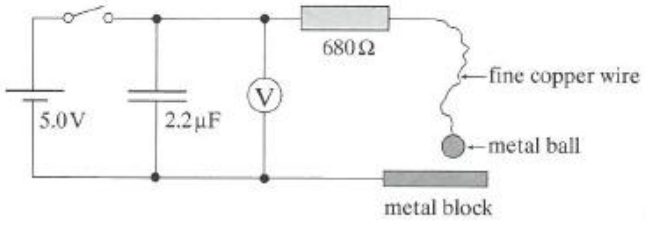

Figure 7

The student charges the capacitor by closing the switch, records the voltmeter reading and then opens the switch. The student then releases the ball and measures the voltage after the ball has rebounded from the metal block.

In one test the student records an initial voltage of 5.0 V and a final voltage of 2.2 V.

(a) Calculate the time for which the ball is in contact with the block. *(3 marks)*

(b) (i) Calculate the energy lost by the capacitor during the discharge.

(ii) State where this energy is dissipated and the form it will take. *(4 marks)*

AQA, 2002