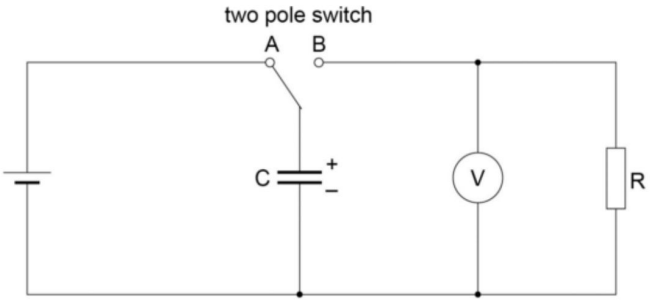
AQA Physics A-level

Required Practical 9

Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC

Discharging capacitor

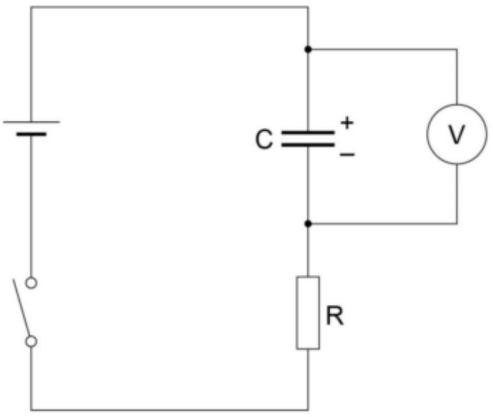
- Equipment:
  - Electrolytic capacitor
  - Resistor
  - Battery
  - Voltmeter
  - Switch



- Method:
  - Set up the apparatus as shown in the diagram.
  - Set the switch to the A position to allow the capacitor to fully charge.
  - Move the switch to the B position and start the stopwatch. Observe and record the voltage reading V at time t=0 and at 5s intervals as the capacitor discharges until about 120s have passed.
  - Repeat the experiment twice more and obtain the average V at each t.
  - (Note that the experiment can be repeated for different resistors or capacitors to investigate how the time constant varies with resistance and capacitance).
- Graphs and calculations:
  - Calculate the natural logarithm of V at each t and tabulate this. Plot a graph of ln(V) against t and draw a line of best fit. This should yield a straight line graph with negative gradient, showing that the decay of voltage across the capacitor is exponential. The gradient will equal -1/RC (or -1/time constant).
  - $V = V_0 e^{\frac{-t}{RC}} \Rightarrow ln(V) = \frac{-1}{RC}t + ln(V_0) = \frac{-1}{\tau}t + ln(V_0)$ where τ is the time constant of the RC circuit.
  - If C is known, you can find the time constant using RC and also using the graph and check if they are the same. If C is not known, you can find it using the graph.
- Safety:
  - Ensure the capacitor is connected with the correct polarity and that its voltage rating exceeds the voltage of the battery used to prevent it from exploding and releasing harmful chemicals.
- Improvements and notes:
  - You can also plot a graph of V against t which will give an exponential decay curve. The time constant can be found from this by finding t when the voltage is approximately 37% of the original voltage (the voltage of the battery).

Charging capacitor

- Equipment:
  - Electrolytic capacitor
  - Resistor
  - Battery
  - Voltmeter
  - Switch



- Method:
  - Set up the apparatus as shown in the diagram.
  - Close the switch and observe and record the voltage reading V at time t=0 and at 5s intervals as the capacitor charges until about 120s have passed.
  - Repeat the experiment twice more and obtain the average V for each t.
  - (Like the discharging experiment, this experiment can also be repeated with different resistors or capacitors).
- Graphs and calculations:
  - Plot a graph of V against t. This graph will show an exponential growth curve.
  - $V = V_0(1 - e^{\frac{-t}{RC}})$
- Safety:
  - Ensure the capacitor is connected with the correct polarity and that its voltage rating exceeds the voltage of the battery used to prevent it from exploding and releasing harmful chemicals.
- Improvements and notes:
  - The time constant can be found from the exponential growth curve by finding t when the voltage is approximately 63% of the maximum voltage (the voltage of the battery).