General Certificate of Education
June 2003
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) **PHAP/TN**

Instructions to Supervisors for the Practical Examination (Units 5-9)

CONFIDENTIAL

OPEN ON RECEIPT

The examination will be held on Thursday 22 May 2003 Morning Session

- **These *Instructions* are provided to enable centres to make appropriate arrangements for the examination. Copies of the *Instructions* are to be kept at the centre under lock and key when not in use; they are not to be removed from the centre. The question paper packets must not be opened prior to the examination.**
- **These instructions explain how to set up the equipment for Question 2.**
- **Question 2 is printed on pages 4 to 5 of this instruction booklet.**
- **Centres are at liberty to make any reasonable minor modifications to the apparatus which may be required for the successful working of the experiment but a note of all such modifications must be forwarded to the Examiner with the scripts. However, any such modifications must permit the experiment to be carried out in the specified manner.**

Candidates are to investigate the discharge of a capacitor through different combinations of resistors.

Apparatus required for each candidate:

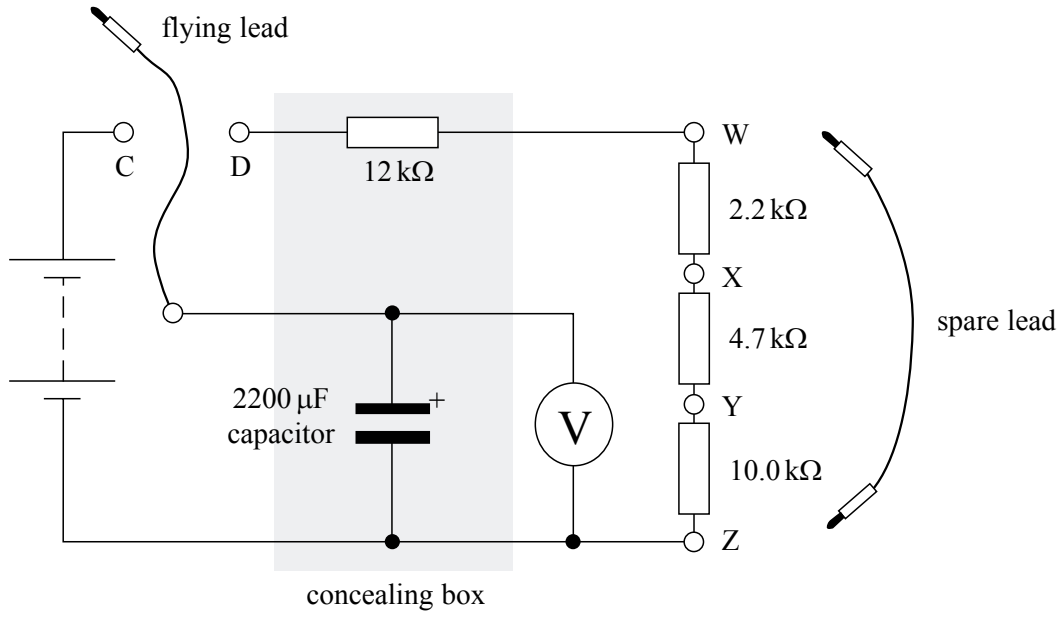
- ❒ stopwatch capable of reading to 0.1 s or better

for circuit (diagram below)

- ❒ digital voltmeter (or equivalent multimeter) capable of 0.1 V resolution or better
- ❒ d.c. supply with emf in range 50% to 90% of full-scale reading of available voltmeters, e.g. for 2000 mV digital meter, 1.5 V 'D-type' cell in good condition, in a suitable holder
- ❒ 2.2 kΩ, 4.7 kΩ, 10 kΩ, 12 kΩ resistor, 0.5 W or 0.6 W metal or carbon film
- ❒ one 2200 μF electrolytic capacitor
- ❒ 4 mm round sockets labelled 'C' and 'D' (see diagram) and lead terminated at one end with 4 mm plug, labelled 'flying lead'
- ❒ 4 mm round sockets labelled 'W', 'X', 'Y' and 'Z' and one connecting lead, ends terminated with 4 mm plugs, labelled 'spare lead'; as an alternative, centres may use solder pins for 'W', 'X', 'Y' and 'Z' and provide **one** 'spare lead' with ends terminated at crocodile clips
- ❒ stripboard if soldered circuit is used
- ❒ means of concealment for capacitor and 12 kΩ resistor (see diagram)

The supervisor should assemble the circuit shown in the diagram. The portion that is shaded should be concealed from the candidates, e.g. in a suitable box or using opaque tape.
Ensure that only one 'spare lead' is available per candidate.

The choice of power supply is at the discretion of the centre and rests on the type of voltmeter available. Voltmeters should be digital and offer a resistance of at least 50 kΩ.



If multimeters are to be used the attention of candidates can be drawn to the appropriate setting before the commencement of the experiment.

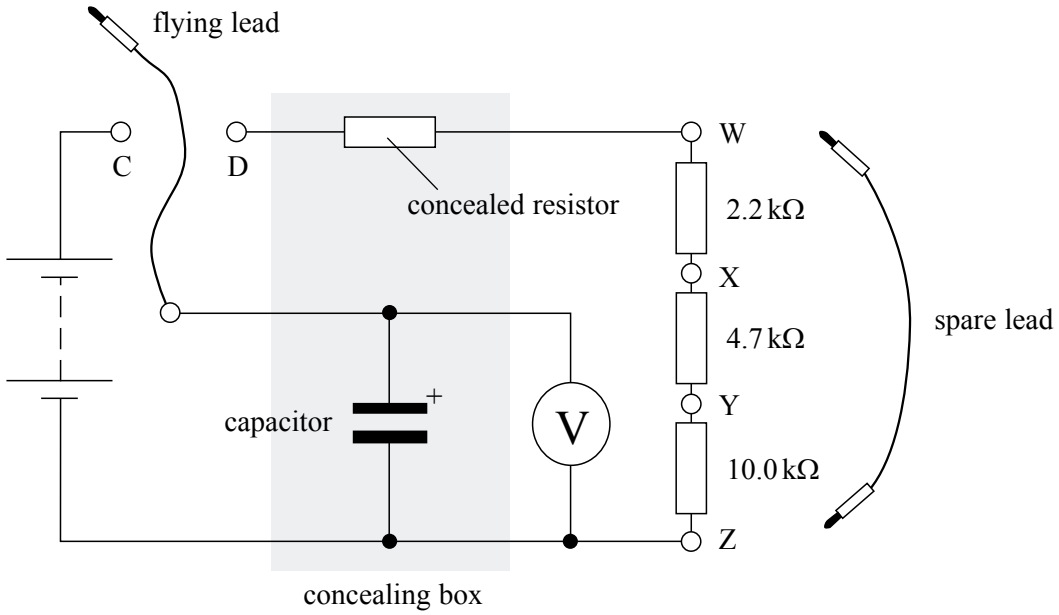
Testing the circuit:
Connect the spare lead between terminals 'W' and 'Z' then charge the capacitor by connecting the flying lead to the terminal marked 'C'. Discharge the capacitor through the 12 kΩ resistor and measure the time for the voltmeter reading to fall by 50%. The theoretical time obtained should be 18.3 s but given the tolerances of the components involved, a time in the range of 15 to 21 s is acceptable. If the procedure is repeated with the spare lead removed a theoretical time of 44.1s for the voltmeter reading to fall by 50% is expected (a time in the range 39 to 49 s is acceptable).

The examiners require no information for this question.

2 In this experiment you are to investigate the discharge of a capacitor through different combinations of resistors.
No description of the experiment is required.

You are provided with the circuit shown below, part of which is concealed, as shown by the shaded region on the diagram.

Different series combinations of the 2.2 kΩ, 4.7 kΩ and 10.0 kΩ resistors can be achieved in the circuit by using the spare lead to join any two of the terminals W, X, Y or Z, resulting in a resistance R.
If the spare lead is not used R has a **maximum** resistance. If the spare lead is used to join W to Z, R has **zero** resistance.



(a) With R set to zero resistance, charge the capacitor by connecting the flying lead to terminal C. The voltmeter will show a steady reading.
Discharge the capacitor by connecting the flying lead to terminal D. The voltmeter reading will start to fall exponentially.
Make suitable measurements to determine T_0, the time for the voltmeter reading to decrease by 50% when $R = 0$.

(b) Repeating the procedure for charging and discharging the capacitor, make suitable measurements to obtain values of T, the time for the voltmeter reading to decrease by 50%, corresponding to all possible **non-zero** values of R up to and including the maximum external resistance that can be included in the circuit.
Tabulate all your observations. *(7 marks)*

(c) Plot a graph of your results with T on the vertical axis and R on the horizontal axis.
Include the data set where $T = T_0$, $R = 0$. *(6 marks)*

(d) (i) Measure and record the gradient, G, of your graph.

(ii) Evaluate $\frac{T_0}{G}$.

(3 marks)

(e) (i) To enable the digital display on a certain voltmeter to be recognised, the read-out only changes twice per second. This presents a problem in knowing exactly when to start and stop the watch (to determine T).
Explain which readings of T that you made are likely to be affected most by this problem.

(ii) The problem identified in part (e)(i) could be eliminated if an analogue voltmeter (in which a needle moves across a fixed scale) was used: this type of meter makes judging a particular value easier. However most analogue voltmeters usually have a low resistance, often as small as 10 kΩ.
Explain, with the aid of a sketch, the change that would be produced in the graph if such a voltmeter were used for the experiment.

(6 marks)

END OF QUESTIONS

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