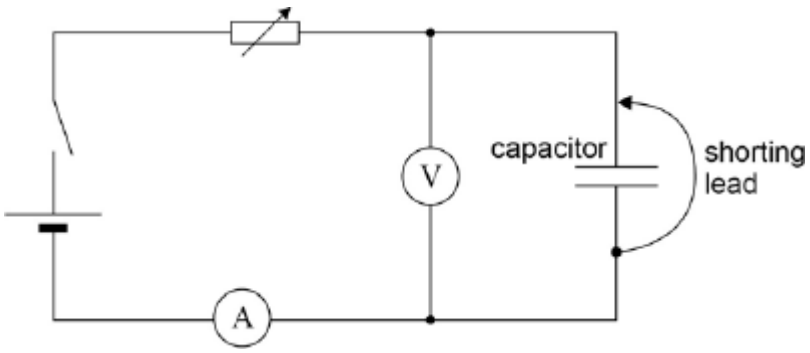
Name of the Student:_____
Max. Marks : 25 Marks **Time : 25 Minutes**

Q1.

This question is about capacitor charging and discharging.

A student designs an experiment to charge a capacitor using a constant current. The figure below shows the circuit the student designed to allow charge to flow onto a capacitor that has been initially discharged.



The student begins the experiment with the shorting lead connected across the capacitor as in the figure above. The variable resistor is then adjusted to give a suitable ammeter reading. The shorting lead is removed so that the capacitor begins to charge. At the same instant, the stop clock is started.

The student intends to measure the potential difference (pd) across the capacitor at 10 s intervals while adjusting the variable resistor to keep the charging current constant.

The power supply has an emf of 6.0 V and negligible internal resistance. The capacitor has a capacitance of 680 μF. The variable resistor has a maximum resistance of 100 kΩ.

(a) The student chooses a digital voltmeter for the experiment. A digital voltmeter has a very high resistance.

Explain why it is important to use a voltmeter with very high resistance.

_____

_____

_____

(1)

(b) Suggest **one** advantage of using an analogue ammeter rather than a digital ammeter for this experiment.

_____

_____

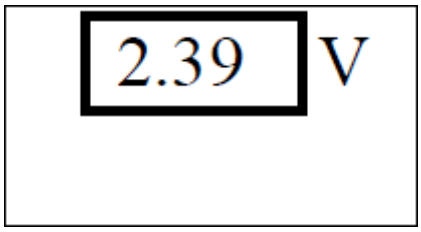
(1)

(c) Suggest a suitable full scale deflection for an analogue ammeter to be used in the experiment.

full scale deflection = _____

(2)

(d) The diagram shows the reading on the voltmeter at one instant during the experiment. The manufacturer gives the uncertainty in the meter reading as 2%.



Calculate the absolute uncertainty in this reading.

uncertainty = _____V

(1)

(e) Determine the number of different readings the student will be able to take before the capacitor becomes fully charged.

number = _____

(3)

(f) The experiment is performed with a capacitor of nominal value 680 μF and a manufacturing tolerance of ± 5 %. In this experiment the charging current is maintained at 65 μA. The data from the experiment produces a straight-line graph for the variation of pd with time. This shows that the pd across the capacitor increases at a rate of 98 mV s^{-1}.

Calculate the capacitance of the capacitor.

capacitance = _____μF

(2)

(g) Deduce whether the capacitor is within the manufacturer's tolerance.

_____

_____

_____

(1)

(h) The student decides to confirm the value of the capacitance by first determining the time constant of the circuit when the capacitor **discharges** through a **fixed** resistor.

Describe an experiment to do this. Include in your answer:

- a circuit diagram
- an outline of a procedure
- an explanation of how you would use the data to determine the time constant.

_____

_____

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(4)

(Total 15 marks)

Q2.

The concave mirrors used in some reflecting telescopes can suffer from spherical aberration.

(a) Draw a diagram to show what is meant by spherical aberration when produced by a concave mirror.

(2)

(b) The International Ultraviolet Explorer (IUE) and the Gran Telescopio Canarias (GTC) are two examples of reflecting telescopes.

The table below summarises some of the properties of the two telescopes.

Name	IUE	GTC
Objective Diameter	0.45 m	10.4 m
Location	Geosynchronous Earth orbit	Earth's surface, 2300 m above sea level
Spectrum detected	Ultraviolet	Visible and Infrared
Typical wavelength detected	2.0×10^{-7} m	1.0×10^{-6} m

Compare the two telescopes in terms of their location, collecting power and minimum angular resolution.

Include calculations to support your comparisons.

(6)

(c) The Charge Coupled Device (CCD) is an important part of the detection system of many modern telescopes due to its high quantum efficiency.

Explain what is meant by quantum efficiency and compare the quantum efficiency of a CCD with that of the eye.

(2)

(Total 10 marks)