

Name of the Student: _____

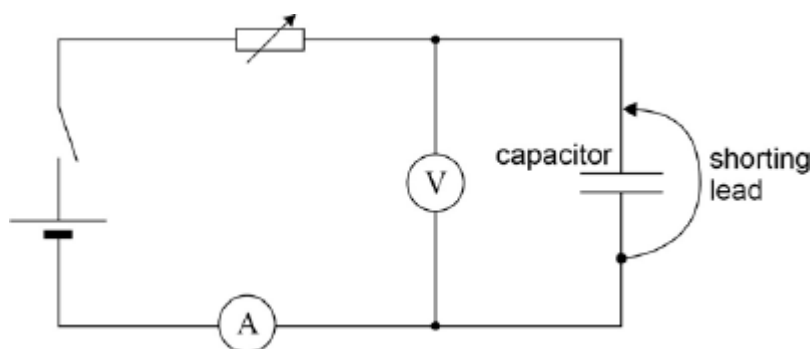
Max. Marks : 24 Marks

Time : 24 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 k Ω .

- (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.

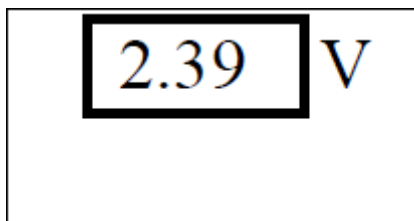
(1)

- (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 $680\ \mu\text{F}$ and a manufacturing tolerance of $\pm 5\%$. In this experiment the charging current is maintained at $65\ \mu\text{A}$. 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 $98\ \text{mV s}^{-1}$.

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.

(4)

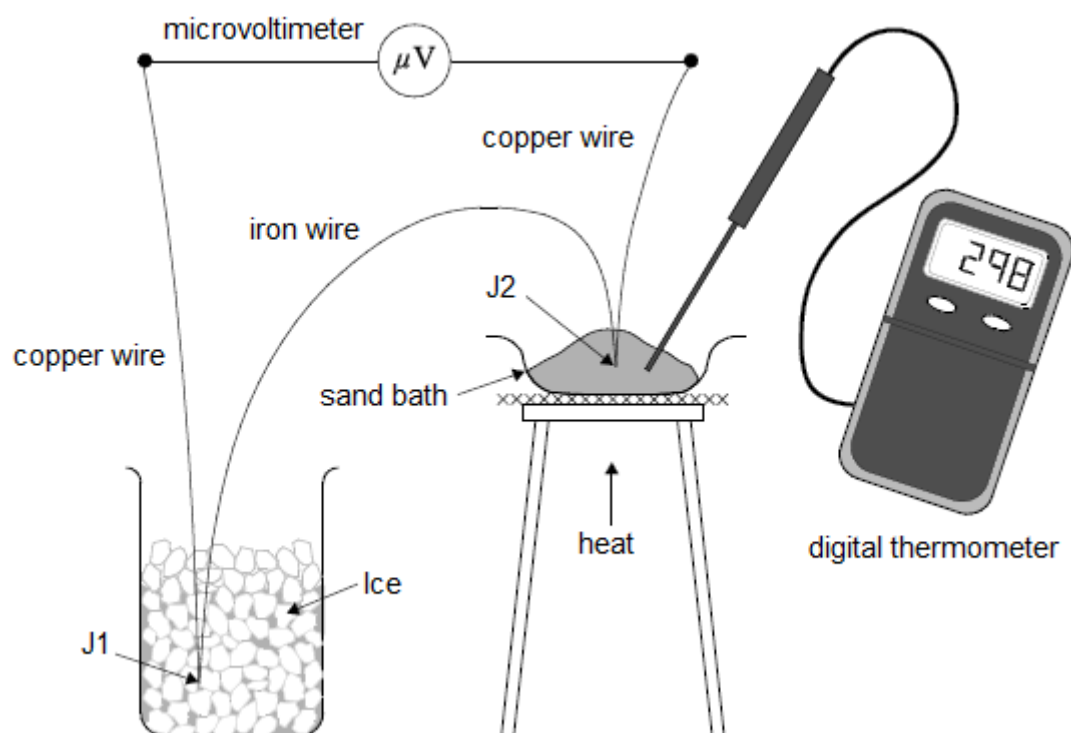
(Total 15 marks)

Q2.

Lengths of copper and iron wire are joined together to form junctions J1 and J2. When J1 and J2 are at different temperatures an emf ε is generated between them. This emf is measured using a microvoltmeter.

Figure 1 shows J1 kept at 0 °C while J2 is heated in a sand bath to a temperature θ measured by a digital thermometer.

Figure 1

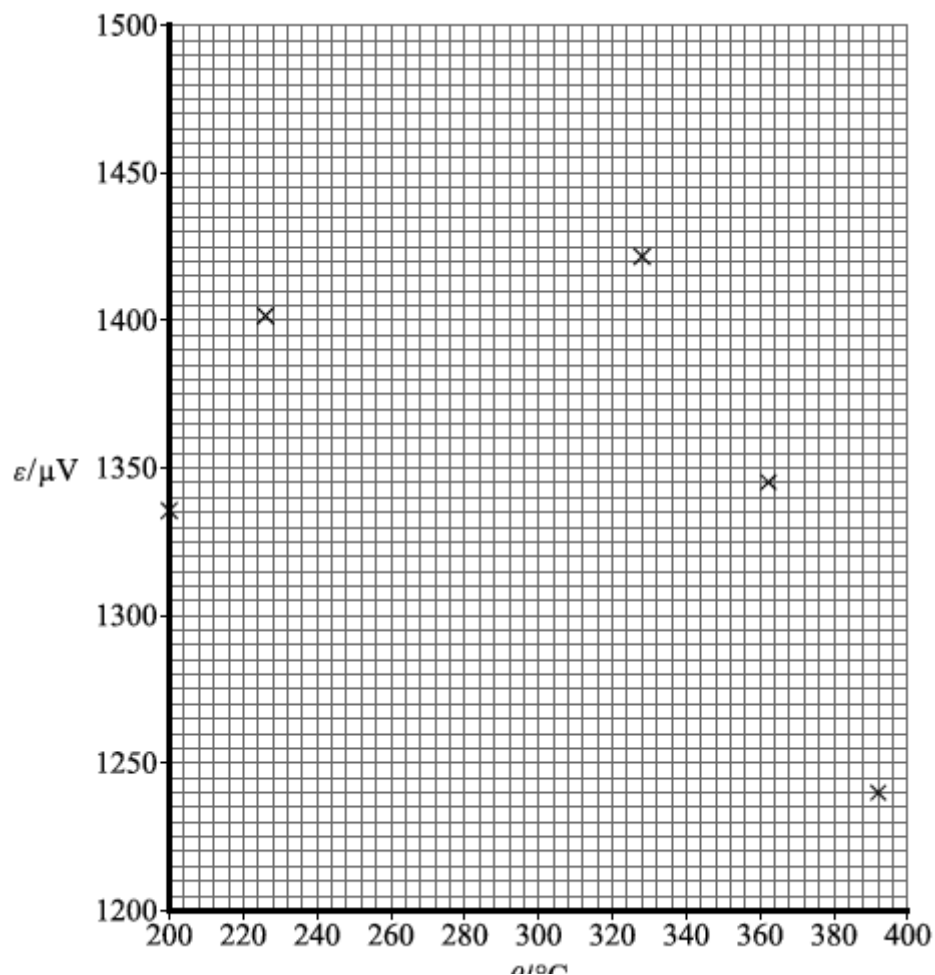


An experiment is carried out to determine how ε depends on θ .

The results of the experiment are shown in the table below and a graph of the data is shown in **Figure 2**.

$\theta / ^\circ\text{C}$	$\varepsilon / \mu\text{V}$
200	1336
226	1402
258	1450
298	1456
328	1423
362	1345
392	1241

Figure 2



(a) Plot the points corresponding to $\theta = 258^\circ\text{C}$ and $\theta = 298^\circ\text{C}$ on **Figure 2**.

(1)

(b) Draw a suitable best fit line on **Figure 2**.

(1)

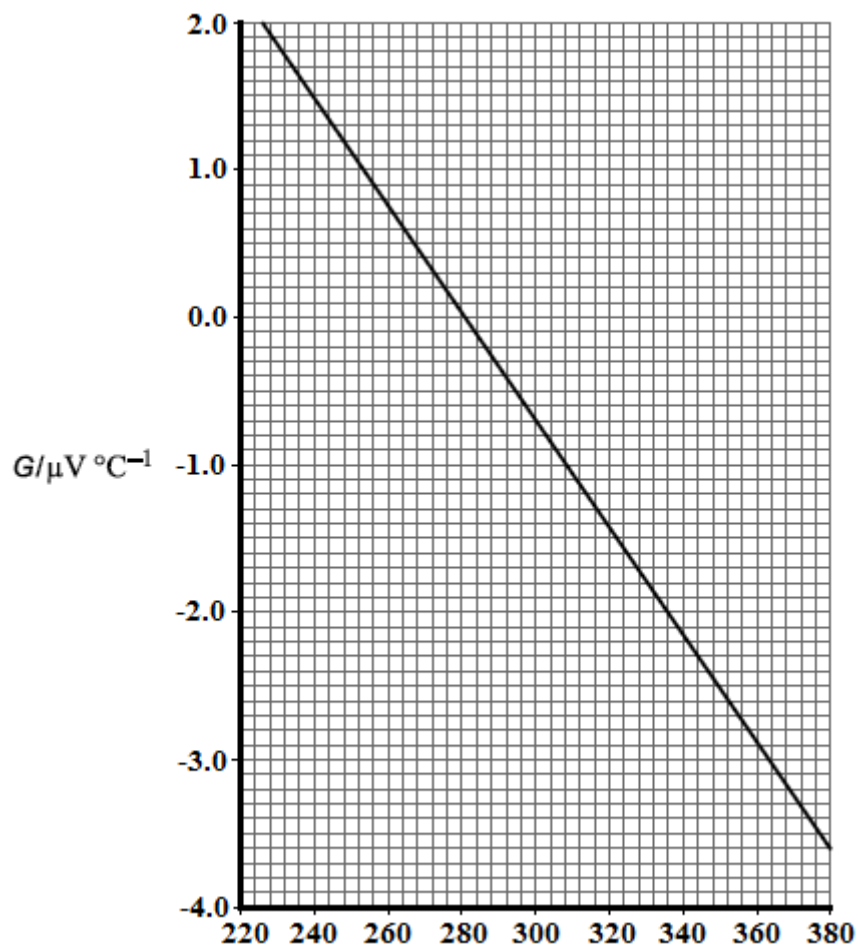
(c) Determine the maximum value of ε .

maximum value of $\varepsilon =$ _____ μV

(1)

(d) The gradient G of the graph in **Figure 2** is measured for values of θ between 220°C and 380°C . A graph of G against θ is plotted in **Figure 3**.

Figure 3



The neutral temperature θ_n is the temperature corresponding to the maximum value of ε . θ_n can be determined using either **Figure 2** or **Figure 3**.

Explain why a more accurate result for θ_n may be obtained using **Figure 3**.

(1)

(e) It can be shown that G is given by

$$G = \beta\theta + \alpha$$

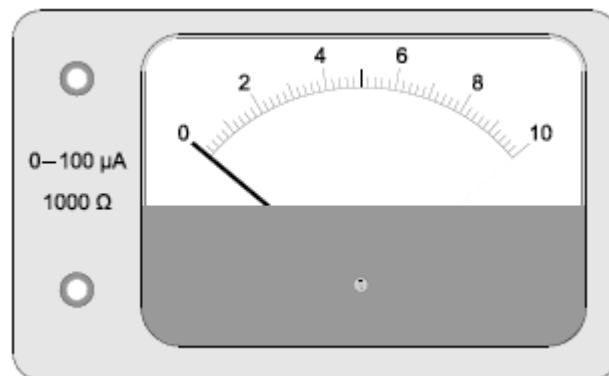
where α and β are constants.

Determine α .

$$\alpha = \text{_____} \mu\text{V } ^\circ\text{C}^{-1} \quad (2)$$

- (f) A student decides to carry out a similar experiment. The student thinks the meter in **Figure 4** could be used as the microvoltmeter to measure ε .

Figure 4



When this meter indicates a maximum reading and the needle points to the right-hand end of the scale (full-scale deflection), the current in the meter is $100 \mu\text{A}$. The meter has a resistance of 1000Ω .

Calculate the full-scale deflection of this meter when used as a microvoltmeter.

$$\text{full-scale deflection} = \text{_____} \mu\text{V} \quad (1)$$

- (g) The scale on the meter has 50 divisions between zero and full-scale deflection.

Discuss why this meter is not suitable for carrying out the experiment.

(2)
(Total 9 marks)