Q1.(a) (i) Describe how you would make a direct measurement of the emf ε of a cell, stating the type of meter you would use.

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(1)

(ii) Explain why this meter must have a very high resistance.

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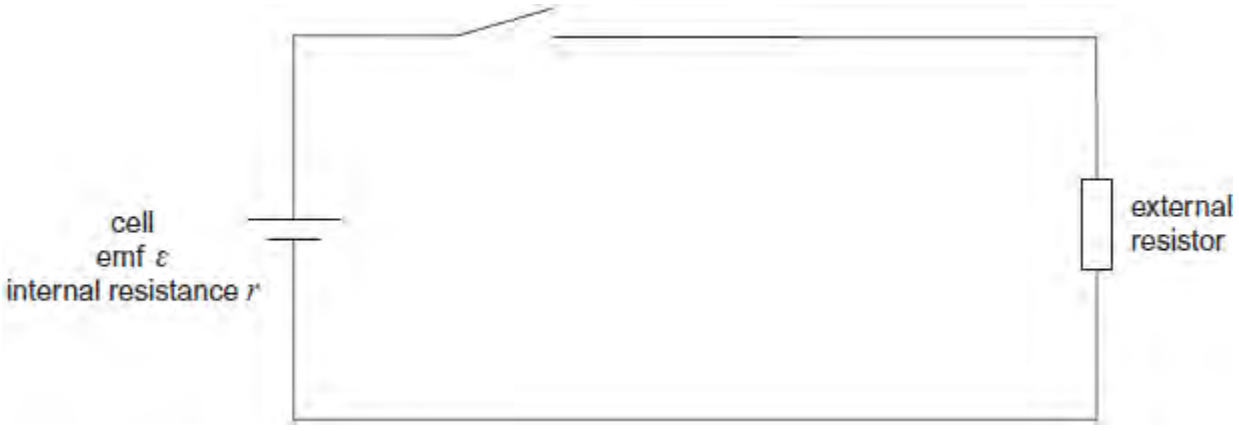
(1)

(b) A student is provided with the circuit shown in the diagram below.



The student wishes to determine the efficiency of this circuit.

In this circuit, useful power is dissipated in the external resistor. The total power input is the power produced by the battery.

$$\text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

The efficiency can be determined using two readings from a voltmeter.

(i) Show that the efficiency = $\frac{V}{\varepsilon}$ where ε is the emf of the cell

and V is the potential difference across the external resistor.

(1)

(ii) Add a voltmeter to the diagram and explain how you would use this new circuit to take readings of ε and V.

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(2)

(c) Describe how you would obtain a set of readings to investigate the relationship between efficiency and the resistance of the external resistor. State any precautions you would take to ensure your readings were reliable.

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(2)

(d) State and explain how you would expect the efficiency to vary as the value of R is increased.

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.....

(2)
(Total 9 marks)

Q2. A student has a diffraction grating that is marked 3.5×10^3 lines per m.

(a) Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

percentage uncertainty = ... %

(1)

(b) Determine the grating spacing.

grating spacing = ... mm

(2)

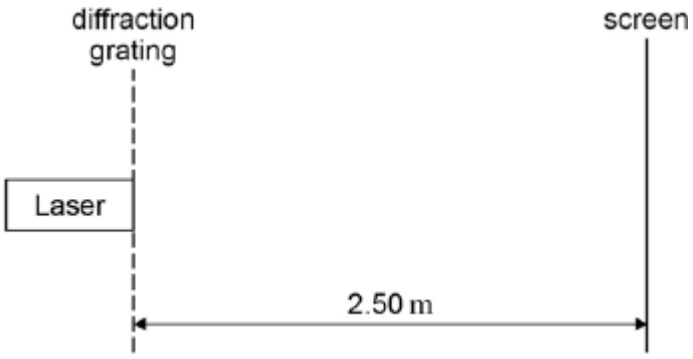
(c) State the absolute uncertainty in the value of the spacing.

absolute uncertainty = ... mm

(1)

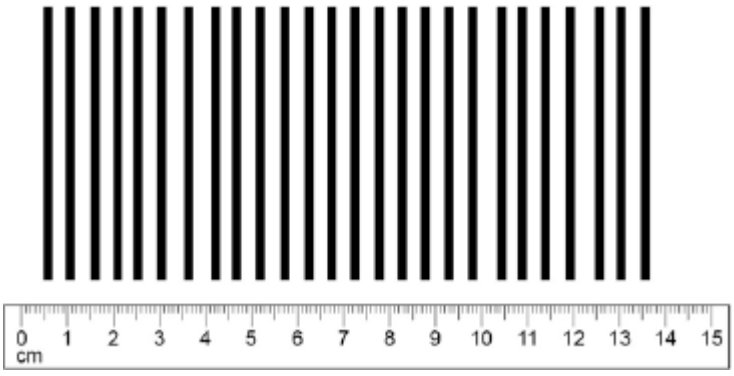
(d) The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

spacing = ... mm

(1)

(e) Calculate the number of lines per metre on the grating.

number of lines = ...

(2)

(f) State and explain whether the value for the number of lines per m obtained in part (e) is in agreement with the value stated on the grating.

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(2)

(g) State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

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(1)

(Total 10 marks)

Q3.Data analysis question

Capillary action can cause a liquid to rise up a hollow tube. **Figure 1** shows water that has risen to a height h in a narrow glass tube because of capillary action.

Figure 1

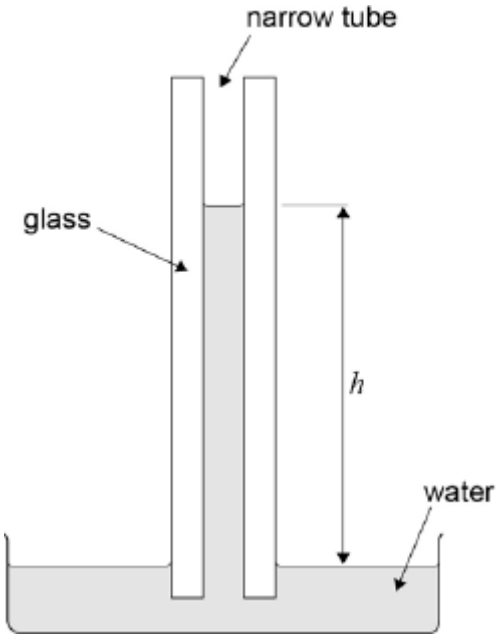
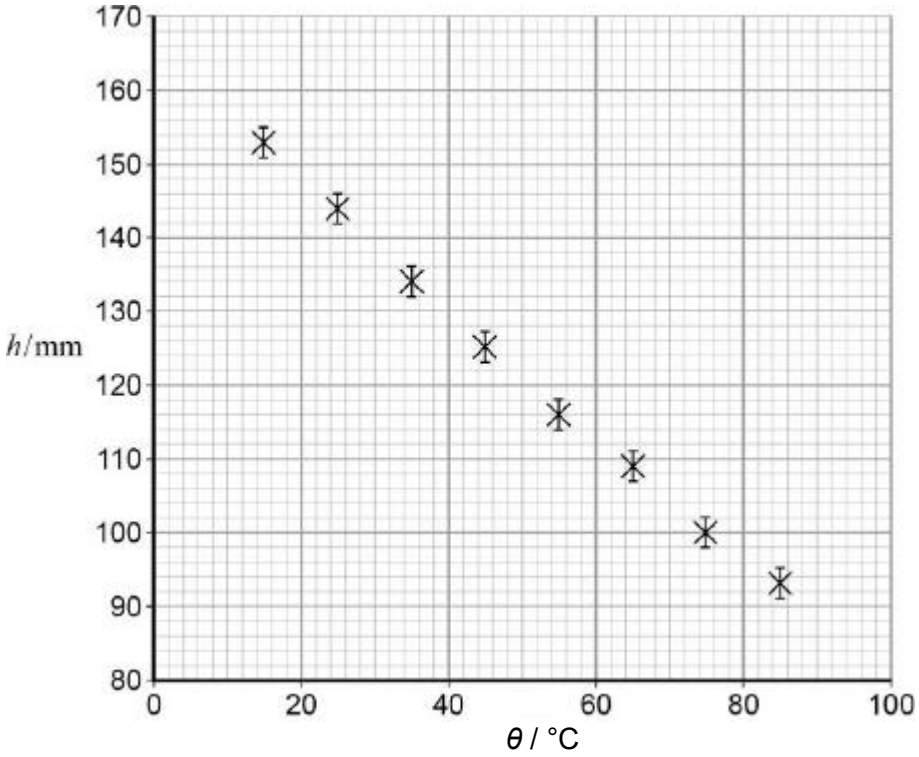


Figure 2 shows the variation of h with temperature θ for this particular tube.

Figure 2



The uncertainty in the measurement of h is shown by the error bars. Uncertainties in the measurements of temperature are negligible.

(a) Draw a best-fit straight line for these data **(Figure 2)**.

(1)

(b) It is suggested that the relationship between h and θ is

$$h = h_0 - (h_0 k)\theta$$

where h_0 and k are constants.
Determine h_0.

h_0 = = ... mm

(1)

(c) Show that the value of $h_0 k$ is about 0.9 mm K^{-1}.

(3)

(d) Determine k. State a unit for your answer.

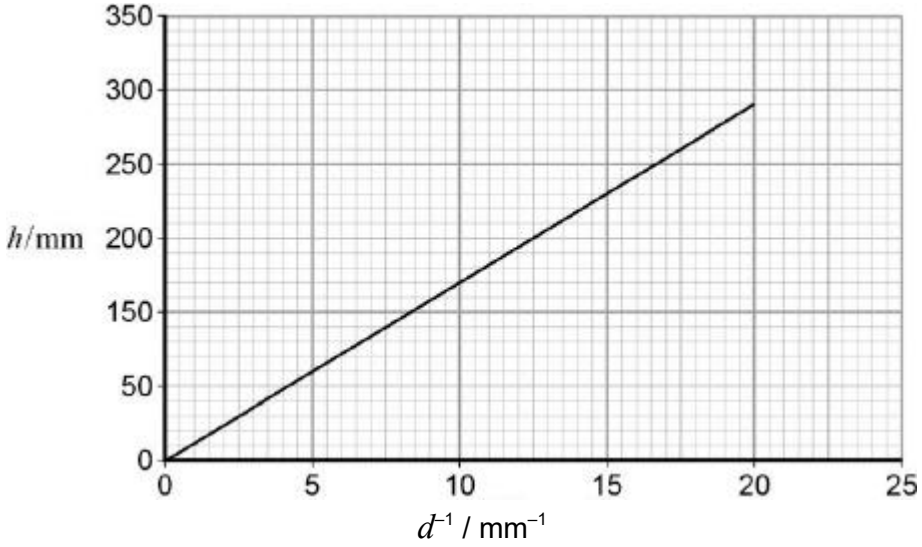
k = ... unit = ...

(2)

(e) A similar experiment is carried out at constant temperature with tubes of varying internal diameter d. **Figure 3** shows the variation of h with $\frac{1}{d}$ at a constant

temperature.

Figure 3



It is suggested that capillary action moves water from the roots of a tree to its leaves.

The gradient of **Figure 3** is 14.5 mm^2.

The distance from the roots to the top leaves of the tree is 8.0 m.

Calculate the internal diameter of the tubes required to move water from the roots to the top leaves by capillary action.

(2)

(f) Comment on the accuracy of your answer for the internal tube diameter in part (v).

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(1)

(Total 10 marks)