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

Q1.

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

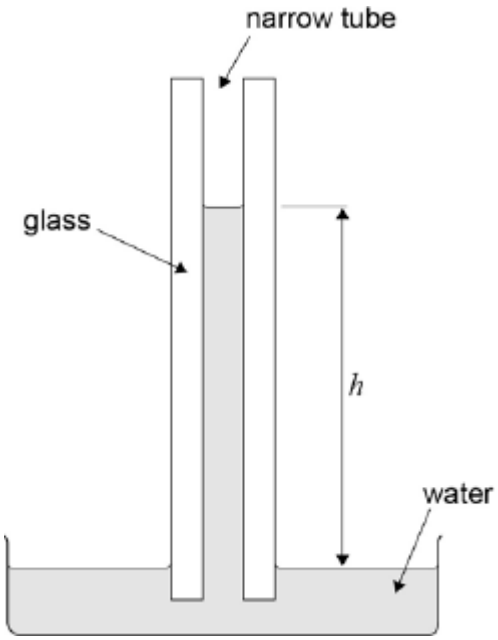

Figure 2 shows the variation of h with temperature θ for this particular tube.

Figure 2

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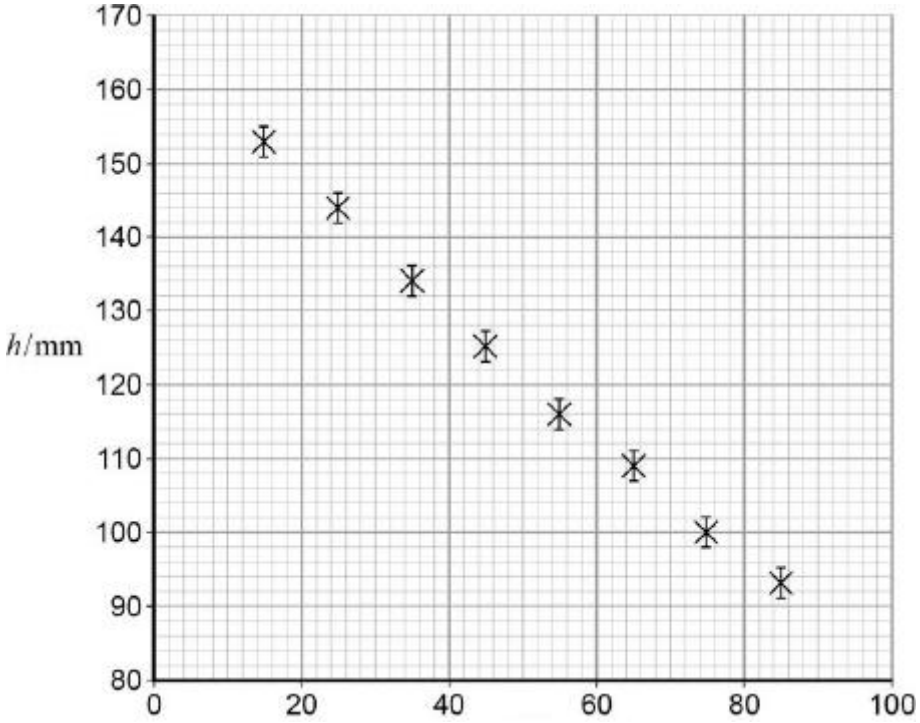

The uncertainty in the measurement of h is shown by the error bars. Uncertainties in the measurements of temperature are negligible.

(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)

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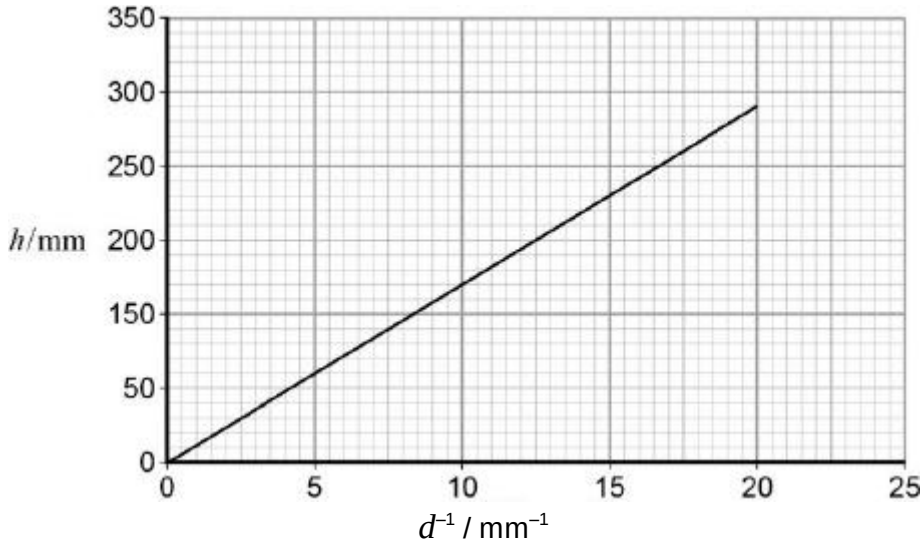
(d) Determine k. State a unit for your answer.

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)

Q2.

The term **ultrasound** refers to vibrations in a material that occur at frequencies too high to be detected by a human ear. When ultrasound waves move through a solid, both longitudinal and transverse vibrations may be involved. For the longitudinal vibrations in a solid, the speed c of the ultrasound wave is given by

$$c = \sqrt{\frac{E}{\rho}}$$

where E is the Young modulus of the material and ρ is the density. Values for c and ρ are given in the table below.

Substance	c / m s^{-1}	ρ / kg m^{-3}
glass	5100	2500
sea water	1400	1000

Ultrasound waves, like electromagnetic radiation, can travel through the surface between two materials. When all the energy is transmitted from one material to the other, the materials are said to be **acoustically matched**. This happens when ρc is the same for both materials.

(a) Calculate the magnitude of the Young modulus for glass.

Young modulus = _____

(1)

(b) State your answer to (a) in terms of SI fundamental units.

(1)

(c) The passage states that 'when ultrasound waves move through a solid both longitudinal and transverse vibrations may be involved'.

State the difference between longitudinal and transverse waves.

_____

_____

_____

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_____

(2)

(d) Show that when two materials are acoustically matched, the ratio of their Young moduli is equal to the ratio of their speeds of the ultrasound waves.

(2)

(e) The wave speed in a material X is twice that in material Y. X and Y are acoustically matched.

Determine the ratio of the densities of X and Y.

X = _____ Y = _____

(1)

(f) Ultrasound waves obey the same laws of reflection and refraction as electromagnetic waves.

Using data from **Table 1**, discuss the conditions for which total internal reflection can occur when ultrasound waves travel between glass and sea water.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

Q3.

Figure 1 shows data for the variation of the power output of a photovoltaic cell with load resistance. The data were obtained by placing the cell in sunlight. The intensity of the energy from the Sun incident on the surface of the cell was constant.

Figure 1

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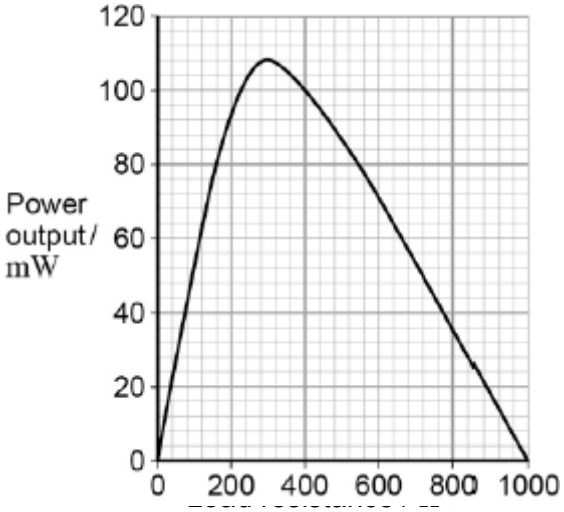

(a) Use data from **Figure 1** to calculate the current in the load at the peak power.

(3)

(b) The average wavelength of the light incident on the cell is 500 nm. Estimate the number of photons incident on the active area of the cell every second.

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(2)

(Total 5 marks)

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