2013 A/L Structured Essay Question No (01)

01. You are asked to determine the density of a given oil experimentally using Archimedes' principle. A set-up consisting of a thin walled glass test tube containing the oil, and a transparent glass vessel with water as shown in figure is provided to perform the experiment.

The test tube floats in up-right position in water as shown in the figure. A coloured ring is clearly marked around the wall of the tube at P and it can be used as a reference to measure heights. The following symbols are assigned to various parameters relevant to the set-up and use these symbols to answer the questions.

A - Area of cross-section of the tube above the ring

V - Volume of the tube below the ring

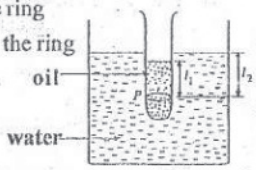
l_1 - Height of the oil column above the ring

l_2 - Height of the water column above the ring

M - Mass of the empty test tube

d - Density of the oil

d_w - Density of water (given)



(a) Write down an expression for the weight of the oil inside the tube in terms of V, A, l_1, d, and g.

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(b) Write down an expression for the total weight W of the test tube with the oil.

W = ...

(c) Write down an expression for the upthrust U acting on the test tube.

U = ...

(d) (i) What relationship holds between W and U?

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(ii) In the relationship you have given in (*d*) (*i*) above, arrange the parameters in W and U, to obtain a relationship in the form $l_2 = ml_1 + c$.

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(iii) If a suitable graph is plotted using the relationship obtained in (*d*) (*ii*) above, how would you determine the density of oil, d, using the graph?

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(e) The following measuring instruments are at your disposal.

A half metre ruler, a vernier calliper, and a travelling microscope.

(i) Of the given instruments what is the most suitable instrument to measure l_1 and l_2? You are not allowed to change the position of the test tube.

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(ii) How do you obtain the relevant readings to measure l_1 and l_2 using the instrument that you have mentioned under (*e*) (*i*)?

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(*f*) If the wall of the test tube is thick instead of thin, the corresponding expression for m in the expression that you have obtained in (d) (ii) above will yield $m = \dfrac{A_i d}{A_e d_w}$, where A_i and A_e are internal area of cross-section and external area of cross-section, respectively of the tube above the ring.

(i) To determine A_i and A_e what measurements do you have to take?

For A_i ..... (say x_i)

For A_e ..... (say x_e)

(ii) How do you use proper instrument selected out of the measuring instruments given in (*e*) above, to obtain the measurements x_i and x_e?

To measure x_i: .....

To measure x_e: .....