Thermal Expansion of Liquids

1 Objective

- Determine the volume V_0 of the dilatometer.
- Measure the volume expansion of distilled water with temperature.
- Find the coefficient of volume expansion γ for distileld water.

2 Prelab Questions

1. Find the density of pure water as it varies with temperature within the range of the experiment $[18 - 30]^{\circ}C$.
2. The volume of the liquid in the riser tube could be modelled as the volume of a cylinder. Write the cross-sectional area of a clinder, then find its volume.
3. The change in volume of the dilatometer ΔV_D will affect the apparent change in volume of the liquid in the riser tube. Explain that in few sentences.
4. From the mass of an empty dilatometer and that filled with distilled water, show how to find the volume (internal capcity) of dilatometer.
5. Obtain the following equation for the coefficient of liquid expansion $\gamma = \frac{1}{V_0}\frac{\Delta V}{\Delta \theta} + \gamma_D$.

3 Principles

- The flask will be filled with water up until the water is clearly visible through the riser tube.
- When the flask is heated both the flask and liquid will expand. This will effect the level of liquid in the riser tube.

4 Apparatus

- Dilatometer.
- Digital thermometer.
- 400ml beaker.
- Stand and two multiclamps.
- White plastic tape.
- Hot plate.

5 Precautions

1. Even after switching off the hot plate the heated liquid will continue to rise, spilling out of the riser tube.
2. The hot plate needs to be turned off early enough (before it reaches 8cm on the riser tube) so as not to lose any of the liquid from the dilatometer.

6 Experimental Steps

1. Fill the beaker with regular tap water. This is for the heat bath.
2. Measure the mass of the empty dilatometer m_{empty} without the riser tube.
3. Fill the dilatometer with distilled water up to its neck.

4. Measure the mass of the filled dilatometer m_{filled} without riser tube.
5. Find the mass of the water Δm_w.
6. Find the volume of dilatometer V_0 without riser tube, using the fact that the density of pure water at different temperatures is known to a very high accuracy. Do not use 1000 kg/m^3 as this is inaccurate.
7. Place the filled dilatometer without the riser tube in the heat bath.
8. Get rid of all the air bubbles by heating the water quickly, waiting about 30 minutes.
9. Allow the water-filled dilatometer to cool to room temperature and top it up with water. Only top it up if water spills out. Make sure to carefully add more water so as not to introduce extra bubbles.
10. Place the thermometer in the heat bath.
11. Insert the riser tube into the dilatometer and place it into the heat bath again.
12. Allow the water to rise, then stop heating it before it reaches the highest mark on the scale or when the temperature reaches about 35°.
13. Remove the heat bath away from the hot plate and turn the hot plate off.
14. Observe the cooling process, recording the temperature θ for every degree, and the height h of the water in riser tube.

7 Evaluation

1. Calculate the volume of the water in the riser tube for each h.
2. Plot a graph between ΔV in mm^3 and $\Delta\theta$ in K.
3. Find the slope of the graph.
4. Calculate the coefficient of volume expansion γ for water.

8 Postlab Questions

1. Knowing the Coefficient of Thermal Expansion of ethanol, in your opinion which liquid would make a better thermometer? Why?
2. Considering the phenomenon of water rising up capillarity tubes, calculate how high the will water rise in the riser tube at room temperature.
3. How could the gas bubbles effect the results?
4. What affects the density of a material? Write the density as a function of two varaibles then find its derivative.

9 Helpful Sites (clickable links)

- Determining the volumetric expansion coefficient of liquids.