Determine the coefficient of volumetric expansion of a liquid using a density vial

Purpose of the experiment

Determination of the volumetric coefficient of a liquid

Equipment used

Density bottle with stopper, glycerin, Becker, thermometer that reads up to 110°C, heating device

Theory

Let us assume that the mass of a bottle with its cap empty is empty (Mo) and that its mass when filled with glycerin and at temperature $\mathbf{t_1}$ is $\mathbf{M_1}$. If the density of glycerin at temperature $\mathbf{t_2}$ is $\boldsymbol{\rho}$ and the internal volume of the bottle, i.e. the volume of glycerin, is

$$V_0 = \frac{M_1 - M_2}{\rho_1} \text{---------(1)}$$

If the tube filled with glycerin is heated to the boiling point of water ($\mathbf{t_2}$) the volume of the glycerin and the volume of the tube will expand and the excess portion will pour out through the capillary tube fixed in the stopper. If it is left to cool ($\mathbf{t_1}$) and its mass in this case is ($\mathbf{M_2}$) then the volume of the glycerin at temperature ($\mathbf{t_2}$) will be:

$$V = \frac{M_2 - M_0}{\rho_1} \text{--------(2)}$$

We must not forget that the increase in the volume of glycerin is in fact the increase in the total volume of glycerin minus the increase in the volume of the bottle. It is only an apparent increase. Therefore, the expansion coefficient that we will obtain now is the apparent expansion coefficient and not the real one. The apparent expansion coefficient is defined as the

amount of apparent change in the unit volume when we change one degree Celsius, i.e.

Where (β) represents the apparent coefficient of expansion of the liquid and since

$$\Delta V = V_0 - V = \frac{M_1 - M_2}{\rho_1}$$

$$\Delta t = t_2 - t_1$$

$$\beta = \frac{M_1 - M_2}{(M_2 - M_\circ)(t_2 - t_1)} \text{------(3)}$$

Where ($M_1 - M_2$) represents the mass of the spilled glycerin, ($M_2 - M_\circ$) represents the mass of the remaining glycerin, and ($t_2 - t_1$) represents the change in temperature. To obtain the true coefficient of expansion of glycerin, we must add the true coefficient of expansion of glass to the apparent coefficient.

Scientific part

1-The density bottle is cleaned, dried, then weighed and sealed

2-Fill it with glycerin and cover it with a stopper so that the excess glycerin is drained through the capillary tube. The bottle is cleaned, the outside is dried with filter paper, and it is weighed again .

3-Tie the neck of the bottle with a string and attach it to a stand so that it is immersed up to the neck in the water of the heating pot

5-Raise the temperature of the heating pot until the water boils for a period of approximately a quarter of an hour

6-The temperature of boiling water is measured

7-Remove the bottle into the heating pot, dry it, leave it to cool, and weigh it for the third time

8- The readings are arranged as follows

Mass of vial with stopper at laboratory temperature=$M_{\circ|}(gm)$

The mass of vial with stopper filled with liquid at laboratory temperature= $M_1(gm)$

The mass of the bottle with the stopper after it cools= M_2(gm)

Glycerine temperature when filling the bottle $= t_1$ ℃

Boiling water temperature $= t_2$℃

This is replaced in the previously derived relationship by Equation No. 3, in which the apparent coefficient of expansion is calculated. To find the real coefficient of expansion (**α**) the relationship is used ($\boldsymbol{\alpha = \beta + g}$) where (**g**) represents the volumetric expansion coefficient of the glass and is equal to(**0.000026**)

Questions

1- Why must the bottle be clean inside and out, as well as the stopper, before starting to weigh?

2- Why must the string that connects the bottle to it be weighed in all three cases?