UE2010301 WATER ANOMALY

EXPERIMENT PROCEDURE

- **Measure the thermal expansion of water over a temperature range between 0°C and 15°C.**
- **Demonstrate the thermal anomaly.**
- **Determine the temperature when the density is at a maximum.**

OBJECTIVE

Determine the temperature where water reaches its maximum density.

SUMMARY

When temperature is raised from 0°C to about 4°C the volume of a mass of water initially becomes smaller and only begins to expand thermally at higher temperatures. The density of water is therefore at its greatest at around 4°C.

REQUIRED APPARATUS

Quantity	Description	Number
1	Device for Demonstrating the Anomaly of Water	**1002889**
1	Plastic Trough	**4000036**
1	Magnetic Stirrer	**1002808**
1	Digital Thermometer, 1 Channel	**1002793**
1	K-Type NiCr-Ni Immersion Sensor, -65°C – 550°C	**1002804**
Additionally recommended:		
1	Funnel	**1003568**
1	Tubing, Silicone 6 mm	**1002622**
1	Stainless Steel Rod 470 mm	**1002934**
1	Clamp with Jaw Clamp	**1002829**
1	Tripod Stand 150 mm	**1002835**

BASIC PRINCIPLES

Water is unlike most other materials in that up to a temperature of about 4°C it initially contracts and only starts expanding at higher temperatures. Since the density is inversely related to the volume of a mass, water thus reaches its maximum density at about 4°C.

The experiment involves measuring the expansion of water in a vessel with a riser tube. The height h to which water rises up the tube is measured as a function of the water temperature ϑ. Neglecting the fact that the glass vessel also expands at higher temperatures, the total volume of the water in the vessel and in the tube is given by:

(1) $$V(\vartheta) = V_0 + \pi \cdot \frac{d^2}{4} \cdot h(\vartheta)$$

d: Internal diameter of tube, V_0: Volume of vessel

If the expansion of the vessel is taken into account, equation (1) becomes

(2) $$V(\vartheta) = V_0 \cdot (1 + 3 \cdot \alpha \cdot \vartheta) + \pi \cdot \frac{d^2}{4} \cdot h(\vartheta)$$

$\alpha = 3.3\ 10^{-6}\ K^{-1}$: Linear expansion coefficient of glass

EVALUATION

Water density ρ is derived from equations (1) and (2) as follows:

$$\frac{\rho(\vartheta)}{\rho(0°C)} = \frac{V_0 + \pi \cdot \frac{d^2}{4} \cdot h(0°C)}{V_0 \cdot (1 + 3 \cdot \alpha \cdot \vartheta) + \pi \cdot \frac{d^2}{4} \cdot h(\vartheta)}$$

The maximum for this expression is at ϑ = 3.9°C.

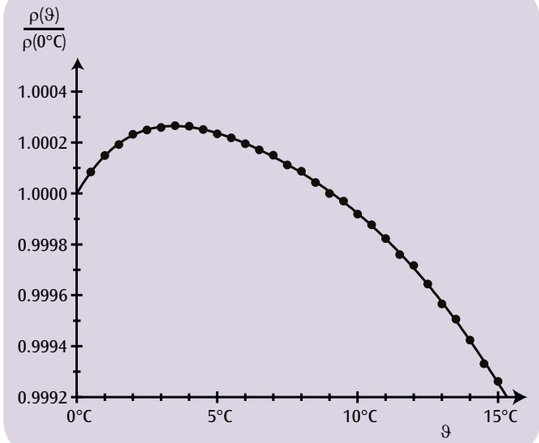

Fig. 1: Relative density of water as a function of temperature

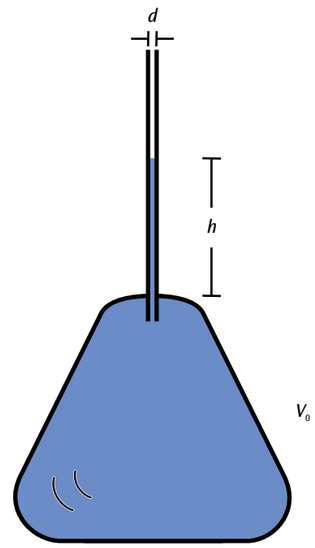

Fig. 2: Vessel with riser tube