Determining the density of air

Objects of the experiments
- Measuring the mass of the open glass sphere filled with air.
- Measuring the mass of the evacuated glass sphere.
- Determining the density of air from the mass difference and the volume of the glass sphere.

Principles

Depending on the state of aggregation of a homogeneous substance, different methods are applied to determine its density

\[ \rho = \frac{m}{V} \]  
\( \text{II.} \)

\( m \): mass, \( V \): volume

In most cases, the mass and the volume are measured separately.

In this experiment, the density of air in a glass sphere of known volume \( V \) is determined. The mass \( m \) of the air enclosed in the sphere is determined from the mass difference between the total mass \( m_1 \) of the sphere filled with air and the mass \( m_2 \) of the empty (evacuated) sphere:

\[ m = m_1 - m_2 \]  
\( \text{II.} \)

Setup and carrying out the experiment

The experimental setup is illustrated in Fig. 1.

- Connect the hand vacuum and pressure pump, and evacuate the sphere with 2 cocks as far as possible (see Fig. 1 middle, the hand vacuum and pressure pump displays the differential pressure \( \Delta p \) relative to the outside air pressure).
- Close the open cock \( \text{(a)} \), and remove the hand vacuum and pressure pump.
- Put the sphere with 2 cocks on the scale pan again, and determine the mass \( m_2 \) of the empty sphere (see Fig. 1 right).

Measuring example

Total mass : \( m_1 = 253.94 \, \text{g} \)
Mass of the empty sphere * : \( m_2 = 252.83 \, \text{g} \)

* measured at \( p = 1000 \, \text{mbar} - \Delta p = 50 \, \text{mbar} \)

Evaluation

Mass of the enclosed air : \( m = 1.11 \, \text{g} \)
Volume of the enclosed air : \( V = 1000 \, \text{ml} = 1000 \, \text{cm}^3 \)

From Eq. (I) we obtain \( \rho = 0.0011 \, \frac{\text{g}}{\text{cm}^3} = 1.1 \, \frac{\text{kg}}{\text{m}^3} \)

Value quoted in the literature:

\( \rho = 1.29 \, \frac{\text{kg}}{\text{m}^3} \) (density of dry air under normal conditions)

Results

Air, too, has a density. Under normal conditions it is approximately one thousandth the density of water.

Fig. 1  Experimental setup for determining the density of air