Determination of the density of air

Aims of the experiment

- To measure the mass of an open glass sphere filled with air
- To measure the mass of the evacuated glass sphere
- To calculate the density of air from the mass difference and the volume of the glass sphere

Principles

Air surrounds us, but it is invisible. Without air and its constituents, life on earth would not be possible. We take air for granted with every breath, however we are rarely consciously aware of it.

In a balloon there is not just air, but compressed air. The air is pressed together by the envelope; there is simply more air in it than in a balloon of the same size without pressure. You could also say: the density of the air in the balloon is greater than the density of the air outside the balloon. In this experiment, we want to determine the density of air.

The density of a substance is the quotient of mass and volume.

$$\text{Density} = \frac{\text{mass } m}{\text{volume } V}$$

$$\rho = \frac{m}{V}$$

Density is usually expressed in the units g/cm^3. Density is dependent on temperature. Substances expand with increasing temperature. The volume increases and the density becomes smaller. In the case of gases, the density depends not only on the temperature, but also on the pressure. In tables one usually finds values for 20 °C and normal atmospheric pressure of 1013 hPa.

Risk assessment

No hazardous chemicals will be used.

Be careful when using the glass taps on the gas weighing bulb. Breakage hazard! Lubricate the stop-cocks well

Equipment and chemicals

1 Sphere with 2 stop-cocks (gas weighing bulb).... 379 07
1 School laboratory balance 311 ..... 315 05
1 Support ring for 250 mL round bottom flask..... 667 072
1 Hand vacuum pump..... 375 58
1 Stopcock grease 661 082

Set-up and preparation of the experiment

Preparation

1. Lubricate the stopcocks of the sphere with stopcock grease.

2. Close all doors and windows as far as possible during the experiment, so that there is little air movement in the room.

Performing the experiment

1. Lay the sphere on the cork ring. Open the stopcocks of the sphere and connect the manual vacuum pump to the second stopcock.

2. Pump air through the sphere.

3. Leave both stopcocks of the sphere open.

4. Lay the sphere with the cork ring on the balance and determine the total mass m_1.

5. Note the value.

6. Take the sphere and cork ring off the balance, connect the manual vacuum pump and close the other glass stopcock.

7. Evacuate the sphere as far as possible.

8. Close the open stopcock, lay the sphere on the balance again and weigh it.

9. Note the measured value of the mass when empty m_2.

Result of the experiment

Total mass: m_1 = 294.03 g

Mass empty*: m_2 = 292.87 g

The mass empty was determined at a pressure of c. 50 mbar as displayed on the hand vacuum pump.

The mass difference is the result of the difference of both mass values, i.e. the mass of the enclosed air:

294.03 g - 292.87 g = 1.16 g

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The volume of the enclosed air:

$$V = 950 \text{ mL} = 950 \text{ cm}^3$$

$$\rho = \frac{m}{V}$$

$$\rho = \frac{1{,}16\ g}{950\ cm3} = 0.00122 \text{ g/cm}^3$$

The value in the literature is 1.20 kg/m^3 at 20 °C and 1 bar.

Cleaning and disposal

Open the stopcocks of the sphere and allow air to enter.

If the sphere is not to be used again for a long time, degrease the stopcocks with petroleum ether or benzine and replace them with a piece of paper inserted as a separator