Wroclaw University of Science and Technology

GENERAL PHYSICS
LABORATORY REPORT

Theme of class: DETERMINATION OF SOLID STATE DENSITY

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Date of class: 2023-03-14

Submission Date: 2023-03-07

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1 Introduction

1.1 Theory

Density can be measure using weight and volume. To calculate errors we can use two methods: direct and indirect.

Direct

For direct measurements we can calculate: A, B, A + B uncertainties for diameter and mass.

Indirect

For Indirect measurements such as density and volume we can calculate uncertainties using parameters of the object and its weight.

1.2 Equipment

The following devices were used during the laboratory:

- Micrometer screw
- Calliper
- Lab Balances
- Measurement element

2 Experiment

2.1 Measuring the parameters of the object with Calliper

For the first measurement we were using Calliper and Lab Balances. First of all we measured all parameters of the given metal object. To be more precise we repeated the measurement 5 times. Then we used uncertainties specified on the instruments to calculate uncertainties for our measurements.

No	ϕ_{in} $[mm]$	$\Delta\phi_{in}$	ϕ_{out} $[mm]$	$\Delta\phi_{out}$
1	11.95	0.05	15.9	0.05
2	11.9	0.05	15.9	0.05
3	11.9	0.05	15.85	0.05
4	11.95	0.05	15.95	0.05
5	11.9	0.05	15.9	0.05
	h $[mm]$	Δh	m $[g]$	Δm
1	32.8	0.05	7.92	0.01
2	32.75	0.05	7.93	0.01
3	32.75	0.05	7.93	0.01
4	32.8	0.05	7.93	0.01
5	32.85	0.05	7.95	0.01
No	ϕ_{in} $[mm]$	ϕ_{out} $[mm]$	h $[mm]$	m $[g]$
mean	11.92	15.9	32.79	7.932
u_A	0.00075	0.00125	0.00175	0.00012
u_B	0.3441007604	0.458993464	0.9465657663	0.04579542335
u_{A+B}	0.3441015778	0.4589951661	0.946567384	0.04579558057

V	2851.487655			
ρ	2.781705888			
c $(\bar{V})$	431.2854846			

Table 1: Dimensions measurements, uncertainties

Example calculations for ϕ_{in} are shown in the equations below.

$$u_B(\phi_{in}) = \sqrt{\frac{(\Delta\bar{\phi}_{in})^2}{3}} = \sqrt{\frac{(0.05 \cdot 11.92)}{3}} = 0.3441007604 \tag{1}$$

$$u(\phi_{in}) = \sqrt{u_A^2(\bar{\phi}_{in}) + u_B^2(\bar{\phi}_o)} = \sqrt{0.00075^2 + 0.3441007604^2} = 0.3441015778 \tag{2}$$

2.2 Measuring the parameters of the object with Micrometer screw

In this experiment we were using micrometer screw instead of calliper.

No	ϕ_{in} $[mm]$	$\Delta\phi_{in}$	ϕ_{out} $[mm]$	$\Delta\phi_{out}$
1	11.95	0.05	16.01	0.01
2	11.9	0.05	16.01	0.01
3	11.9	0.05	16.01	0.01
4	11.95	0.05	16.01	0.01
5	11.9	0.05	16.01	0.01
	h $[mm]$	Δh	m $[g]$	Δm
1	32.8	0.05	7.92	0.01
2	32.75	0.05	7.93	0.01
3	32.75	0.05	7.93	0.01
4	32.8	0.05	7.93	0.01
5	32.85	0.05	7.95	0.01
No	ϕ_{in} $[mm]$	ϕ_{out} $[mm]$	h $[mm]$	m $[g]$
mean	11.92	15.9	32.79	7.932
u_A	0.00075	0	0.00175	0.00012
u_B	0.3441007604	0.0924337781	0.9465657663	0.04579542335
u_{A+B}	0.3441015778	0.0924337781	0.946567384	0.04579558057

$\bar{V}$ $[mm^3]$	2941.883983			
ρ $[g/cm^3]$	2.69623141			
c (V)	224.7720491			

Table 2: Dimensions measurements, uncertainties

Formulas used in the calculations

- $\frac{\delta V}{\delta h} = \pi \frac{d^2}{4}$
- $\frac{\delta V}{\delta d} = 2\pi \frac{h}{4}$
- $(\frac{\delta \rho}{\delta M})^2 = (\frac{1}{V_t})^2$
- $(\frac{\delta \rho}{\delta v_t})^2 = (-\frac{M}{V_t^2})^2$
- $dx = \frac{0.05_{mm}}{2} = 0.025_{mm}$
- $\mu_a(h) = \sqrt{\frac{(h_{tot}-h_1)^2+(h_{tot}-h_2)^2+(h_{tot}-h_3)^2+(h_{tot}-h_4)^2+(h_{tot}-h_5)^2}{5(5-1)}}$
- $\mu_b(h) = \frac{dx}{2\sqrt{3}}$
- $\mu_c(h) = \sqrt{\mu_a^2(h) + \mu_b^2(h)}$
- $\mu(V_n) = \sqrt{(\frac{\delta V}{\delta h})^2 \cdot \mu^2(h) + (\frac{\delta V}{\delta d})^2 \cdot \mu^2(d)}$
- $\mu(V_{total}) = \sqrt{\mu^2(V_1) + \mu^2(V_2) + \mu^2(V_3) + \mu^2(V_4) + \mu^2(V_5) - \mu^2(V_6)}$
- $\mu_a(d) \sqrt{\frac{(d_{tot}-d_1)^2+(d_{tot}-d_2)^2+(d_{tot}-d_3)^2+(d_{tot}-d_4)^2+(d_{tot}-d_5)^2}{5(5-1)}}$

- $\mu_b(d) = \frac{0{,}05_{mm}}{2\sqrt{3}}$
- $\mu_c(d) = \sqrt{\mu_a^2(d) + \mu_b^2(d)}$
- $\mu_a(M) = \sqrt{\frac{(m_{tot}-m_1)^2+(m_{tot}-m_2)^2+(m_{tot}-m_3)^2+(m_{tot}-m_4)^2}{4(4-1)}}$
- $\mu_b(M) = 0.1_g$
- $\mu_c(M) = \sqrt{\mu_a^2(M) + \mu_b^2(M)}$
- $\mu(\rho) = \sqrt{(\frac{\delta\rho}{\delta M})^2 \cdot \mu^2(M) + (\frac{\delta\rho}{\delta V_t})^2 \cdot \mu^2(v_t)}$

3 Conclusion

In conclusion, this experiment allowed us to determine the density of a solid sample using basic engineering tools and measurement techniques. Our results demonstrated the importance of accurate measurements and proper error analysis in scientific and engineering applications, as our calculations relied heavily on precise and reliable data.

Through the use of a micrometer screw, calliper, and lab balances, we were able to measure the dimensions and weight of the sample with an appropriate level of uncertainty. This data allowed us to accurately calculate the volume and density of the sample.

From our experiments we can conclude that micrometer screw is more precise because overall error is less while using this experiment.

Overall, this experiment provided valuable practical experience in using basic engineering tools and measurement techniques. We gained a deeper understanding of the importance of reliable measurements and appropriate error analysis in scientific and engineering applications, which will be beneficial for future experiments and projects.