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Report

EXERCISE 8	DETERMINATION OF VISCOSITY OF FLUID BY STOKES' LAW

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Date and signature of the teacher …………………………………….

1. Introduction: A brief description of the physical phenomena covered by the exercise, including basic formulas and definitions. Purpose of the exercise.

2. Measurement results and calculations

2.1 Wide cylindrical glass tank

a) Enter the results of the measurement of the distance between the rings (h) and the density of the tested liquid (ρ_c) and their uncertainty in Table 1. Determine the measurement uncertainty of the distance $u(h)$ and the density of the tested liquid $u(\rho_c)$ based on the accuracy of the measurement.

Note: For a single measurement of x, the measurement uncertainty $u(x)$ results from the accuracy of the instrument (Δx) and is expressed as:

$$u(x) = \frac{\Delta x}{\sqrt{3}} .$$

b) Enter the results of the measurement of the mass m and its uncertainty $u(m)$ and the diameter of the ball d in Table 1. Calculate the mean value of the diameter and its uncertainty $u(d)$ and the density of the balls ρ_k and its uncertainty $u(\rho_k)$ using the formulas below. Enter the results in Table 1.

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i$$

$$u(\bar{d}) = \sqrt{\frac{\sum_{i=1}^{n}(d_i - \bar{d})^2}{n(n-1)}}$$

$$u\,(d) = \sqrt{u^2(\bar{d}) + \frac{(\Delta d)^2}{3}} .$$

Sample calculations:

$\bar{d}_1 =$

$u(\bar{d}_1) =$

$u\,(d_1) =$

$\rho_{k1} = \frac{6m}{\pi d^3} =$

$u_c(\rho_{k1}) = \sqrt{\left|\frac{\partial \rho_k}{\partial m}\right|^2 u^2(m) + \left|\frac{\partial \rho_k}{\partial d}\right|^2 u^2(d)} = \sqrt{\left|\frac{6}{\pi d^3}\right|^2 u^2(m) + \left|\frac{18m}{\pi d^4}\right|^2 u^2(d)} =$

c) Enter the results of the measurement of the falling time t in Table 1. Calculate the average value of time $\bar{t}$ and its uncertainty $u(t)$ using the formulas given. Enter the results in Table 1.

Sample calculations:

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_i =$$

$$u(\bar{t}) = \sqrt{\frac{\sum_{i=1}^{n}(t_i - \bar{t})^2}{n(n-1)}} =$$

$$u\,(t) = \sqrt{u^2(\bar{t}) + \frac{(\Delta t)^2}{3}} =$$

d) Based on the measurement data, calculate the viscosity coefficient η for each ball and its uncertainty u_c(η); enter the data in Table 1.

$$\eta = \frac{d^2 g t(\rho_k - \rho_c)}{18h}$$

$\eta_1 =$

$\eta_2 =$

$$u_c(\eta) = \sqrt{\left|\frac{dgt(\rho_k - \rho_c)}{9h}\right|^2 u^2(d) + \left|\frac{d^2 g(\rho_k - \rho_c)}{18h}\right|^2 u^2(t) + \left|\frac{d^2 gt}{18h}\right|^2 u_c^2(\rho_k) + \left|\frac{d^2 gt}{18h}\right|^2 u^2\,(\rho_c) + \left|\frac{d^2 gt(\rho_k - \rho_c)}{18h^2}\right|^2 u^2(h)}$$

$u_c(\eta_1) =$

$u_c(\eta_2) =$

$$\bar{\eta} = \frac{\eta_1 + \eta_2}{2} =$$

$$u(\bar{\eta}) =$$

Table 1

no.	***m*** 10^{-3}[kg]	***d*** 10^{-3}[m]	***h*** [m]	***t*** [s]	ρ_k [kg/m^3]	ρ_k [kg/m^3]	η [Ns/m^2]
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
$\bar{X}$							
$\Delta_p X$							
u(X)							
$u_c(X)$							

$\bar{\eta} =$ $u(\bar{\eta}) =$

2.2 Höppler's viscometer

a) Enter the results of the falling time t of the ball and the values of the density of the ball ρ_k , of the liquid ρ_c and their uncertainty $u(\rho_k)$, $u(\rho_c)$ in the table.
b) Calculate the average time of the ball falling $\bar{t}$ and its uncertainty $u(t)$. Enter the results into the table.

Sample calculations:

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_i =$$

$$u(\bar{t}) = \sqrt{\frac{\sum_{i=1}^{n}(t_i - \bar{t})^2}{n(n-1)}} =$$

$$u\,(t) = \sqrt{u^2(\bar{t}) + \frac{(\Delta t)^2}{3}} =$$

c) Calculate the viscosity coefficient η and its uncertainty $u(\eta)$. Enter the calculation results into the table.

$$\eta = k(\rho_k - \rho_c)t =$$

$$\boldsymbol{u_c(\eta) = \sqrt{|kt|^2 . u^2(\rho_k) + |kt|^2 . u^2(\rho_c) + |k(\rho_k - \rho_c)|^2 . u^2(t) + |(\rho_k - \rho_c)t|^2 . u^2(k)}} =$$

no.	***t*** [s]	***k*** [m²/s²]	ρ_κ [kg/m³]	ρ_χ [kg/m³]	η [Ns/m²]
1					
2					
3					
4					
5					
$\bar{X}$					
$\Delta_p X$					
$u(X)$					
$u_c(X)$					

3. Conclusion