EXERCISE 33C	MEASUREMENT OF SURFACE TENSION: STALAGMOMETRIC METHOD

Measurement procedure

1. List of equipment

- Stalagmometer
- Tested liquids
- Weighing vessel
- Calliper
- Thermometer

2. Goal

Determination of surface tension of several different liquids.

3. Measurement setup

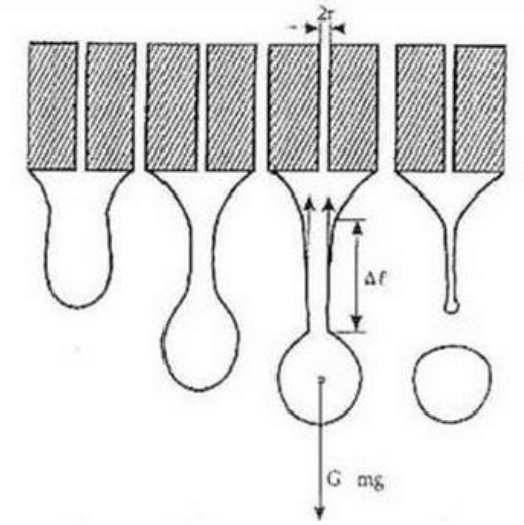


Fig. 1.
Presentation of the formation of drops at the end of the stalagmometer's capillary. The time of detachment of the drop is determined by the force of gravity and the surface tension force, the value of which depends on the diameter of the capillary, among other things.

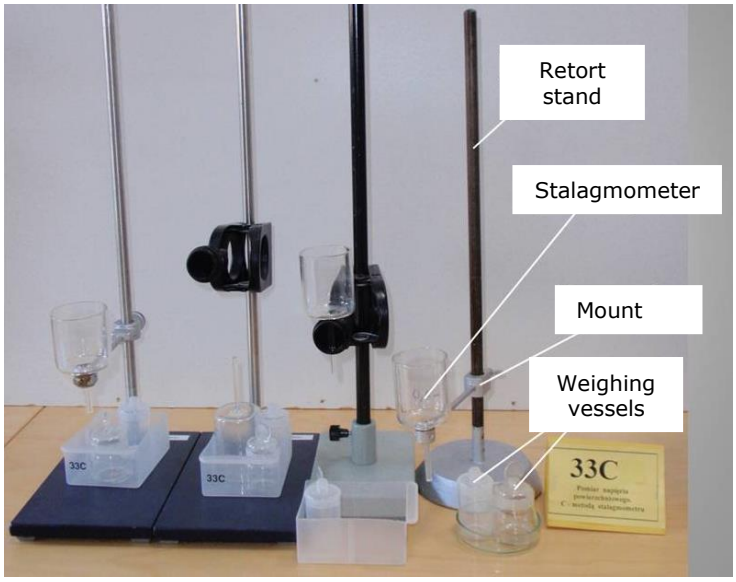


Fig. 2. Measurement setup.

4. Measurements plan

a) Using laboratory scale, weigh the washed and dried vessel along with its lid (m_{nw}).
b) Measure the temperature of the liquid (ambient temperature) and the outer radius *R* of the stalagmometer's tube.
c) Ensure that the thin tube (capillary) of the stalagmometer is not clogged.
d) Fill the stalagmometer with test liquid. During measurements the liquid level should not be subject to large fluctuations.
e) Catch tens (eg. 50) drops of the liquid into the weighing vessel.

f) Weigh the covered vessel with a liquid (m_N).
g) Repeat the measurement three times and determine the average weight m of one drop of liquid.
h) Write down the results in the table (Tab.2.).

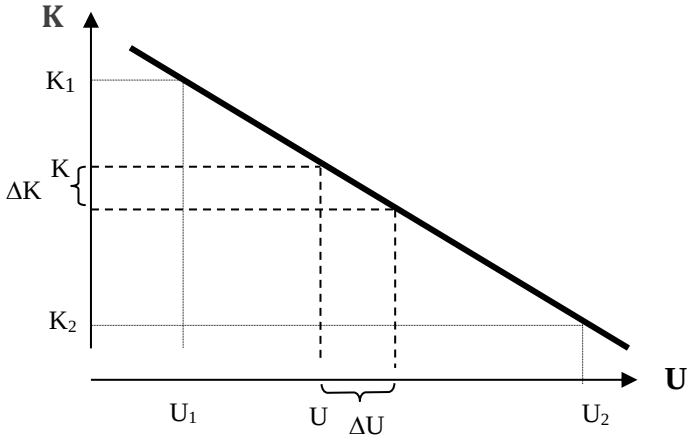
5. Analysis of results

a) Calculate the value of the expression

$$U = \frac{m}{\rho \cdot R^3} \qquad (1)$$

where: m - the mass of a single drop of liquid
ρ - liquid density at the measurement temperature
R - the outer radius of stalagmometer's tube.
and its uncertainty $u_c(U)$.

b) For the value of *U* assign value of *K*, using the table of dependency of *K* on *U*. Determine the exact value of *K* using linear interpolation. To this end, find in the table values of *U* underestimating U_1 and overestimating U_2 and read corresponding values of K_1 i K_2. The value of *K* can be read using a graph



c) Calculate the surface tension of the test liquid with the following formula
d)

$$\sigma = \frac{m \cdot g}{R} \cdot K \qquad (2)$$

Assume the gravitational acceleration $g = (9.81 \pm 0.01)\,[m/s^2]$.

e) Calculate the uncertainty $u_c(\sigma)$. Take into account the dispersion of measurements of mass of the liquid collected in the vessel.

f) Collect the results of measurements and calculations in a table. (Tab. 3.)

Table 1. The dependence of the parameter K on U

U	K	U	K	U	K
∞	0.15900	5.1	0.25273	1.50	0.26560
5000	0.17200	5.0	0.25306	1.45	0.26560
250	0.19900	4.9	0.25340	1.40	0.26536
58.1	0.21500	4.8	0.25373	1.38	0.26528
24.6	0.22560	4.7	0.25407	1.36	0.26520
17.7	0.23050	4.6	0.25448	1.34	0.26510
13.0	0.23546	4.5	0.25472	1.32	0.26500
12.0	0.23702	4.4	0.25509	1.30	0.26490
11.5	0.23780	4.3	0.25545	1.28	0.26474
11.0	0.23875	4.2	0.25583	1.26	0.26460
10.5	0.23940	4.1	0.25620	1.24	0.26438
10.0	0.24035	4.0	0.25659	1.22	0.26418
9.5	0.24117	3.9	0.25697	1.20	0.26396
9.0	0.24195	3.8	0.25734	1.18	0.26372
8.5	0.24324	3.7	0.25772	1.16	0.26350
8.0	0.24440	3.6	0.25810	1.14	0.26324
7.8	0.24490	3.5	0.25848	1.12	0.26296
7.6	0.24538	3.4	0.25892	1.10	0.26264
7.4	0.24590	3.3	0.25937	1.08	0.26230
7.2	0.24640	3.2	0.25980	1.06	0.26190
7.0	0.24700	3.1	0.26024	1.04	0.26154
6.9	0.24720	3.0	0.26068	1.02	0.26115
6.8	0.24750	2.9	0.26110	1.00	0.26070
6.7	0.24777	2.8	0.26154	0.95	0.25960
6.6	0.24804	2.7	0.26198	0.90	0.25815
6.5	0.24836	2.6	0.26241	0.85	0.25645
6.4	0.24867	2.5	0.26286	0.80	0.25460
6.3	0.24897	2.4	0.26327	0.75	0.25255
6.2	0.24925	2.3	0.26370	0.70	0.25030
6.1	0.24952	2.2	0.26410	0.65	0.24770
6.0	0.24984	2.1	0.26450	0.626	0.24640
5.9	0.25015	2.0	0.26488	0.597	0.24450
5.8	0.25047	1.9	0.26518	0.570	0.24300
5.7	0.25078	1.8	0.26543	0.541	0.24300
5.6	0.25110	1.75	0.26553	0.512	0.24410
5.5	0.25110	1.70	0.26563	0.483	0.24600
5.4	0.25174	1.65	0.26567	0.455	0.24910
5.3	0.25208	1.60	0.26568	0.428	0.25260
5.2	0.25240	1.55	0.26566	0.403	0.25590

6. Proposed tables (for approval by the teacher)

Table 2. Measurements of mass of 50 drops and of the diameter of stalagmometer. (Measurements documentation)

lp.	m_{nw} [g]	m [g]	ρ [kg/m^3]	D [mm]
1				
2				
3				
⋮				
N				

Table 3. Measurements of mass of 50 drops. radius of stalagmometer and calculations of surface tension. (Report)

lp.	m_{nw} [kg]	m [kg]	ρ [kg/m^3]	R [m]	$U = \frac{m}{\rho \cdot R^3}$	K	σ [N/m]
1							
2							
3							
⋮							
n							
$\bar{X}$							
ΔX							
$u(X)$							
$u_c(X)$							