Task II. Properties of liquids

Required knowledge: Physical properties of liquids

1. Viscosity

Main tasks:
Measuring and calculation of kinematic viscosity of unknown liquid.

Measurement aids and implements:
The Ostwald viscometer, electric heater with electromagnetic stirrer, stirring bar, stand, stopwatch, thermometer, water (vacuum) pump, beaker, pipettes, distilled water, liquid of unknown viscosity.

Procedure:
1) Fill fully the largest beaker with tap water and put it on the electric heater (The red stirring bar should be placed on the bottom of the beaker). Move the stand and immerse the Ostwald viscometer and thermometer into this water bath. The measuring part of the Ostwald viscometer (wider part with marked lines on the upper and lower part) should be just above the level of water. A rubber tube of the viscometer keep outside the water bath and join to glass end of the green vacuum pipette (pump).
2) Fill 9 ml of unknown liquid into the wider arm of the viscometer by pasteur pipette, switch on the stirrer without heating and wait about one minute for the temperature stabilization of both of the liquids. Test the working process of the viscometer by the green pump. The level of studied liquid has to move up and down by pressing buttons on the pump.
3) Turn ON the heating to about half range and measure the temperature T_1. At the same time measure the time t_1 of dropping of the studied liquid from the upper gauge mark to the lower one (it is necessary to use? the vacuum pump: press and hold the white button). Repeat the measurement three times and calculate average time of the liquid drop from top to bottom line (gauge mark).
4) Repeat the measurement with increasing the temperature of the water bath gradually by 5 °C (T_2=T_1+5 °C; T_3=T_2+5 °C; T_4=T_3+5 °C).
6) Empty the viscometer (put the unknown liquid back to the vessel). Prepare a new water bath with cold tap water and again immerse the viscometer in it. Rinse and fill the viscometer with 10 ml of distilled water and repeat the experiment. If it is possible, start the experiment with the same temperature of the water bath as during the measurement with unknown liquid.
8) **Make a table of results.** Calculate kinematic viscosity of studied liquid (**ν, nu**) at temperatures T_1, T_2 T_3 and T_4. (For the calculation of kinematic viscosity of distilled water (**ν_0**) use the values for the density **ρ** (rho) and dynamic viscosity **η (eta)** of distilled water found in enclosed table using the equation **$\nu_0 = \eta/\rho$**). Plot the dependence of kinematic viscosity of distilled water and studied liquid on temperature into in the same graph.

$$\nu = t\,\nu_0/t_0$$

t – average time of studied liquid
t_0 – average time of water

Table of temperature dependence of density ρ, and dynamic viscosity η of distilled water

t [°C]	ρ [kg·m^{-3}]	$\eta 10^{-3}$ [N·s·m^{-2}]
0	999.84	1.79
5	999.97	1.52
10	999.70	1.31
12	999.50	1.24
14	999.24	1.18
16	998.94	1.10
18	998.60	1.05
20	998.21	1.00
22	997.77	0.96
24	997.30	0.91
25	997.05	0.89
30	995.65	0.80
35	994.03	0.72
40	992.10	0.65
45	990.10	0.60
50	988.05	0.55
55	985.70	0.51
60	983.20	0.47
65	980.56	0.44
70	977.75	0.41
75	974.82	0.38
80	971.80	0.36

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2. The surface tension of liquids

Main tasks:
Determine the surface tension of variously concentrated solutions of bile acid and compare it with the surface tension of water.
Verify the surface tension for variously concentrated solutions of bile acid by means of stalagmometer

Measurement aids and implements:
Digital tensiometer K9, stalagmometer, distilled water, bile acid, thermometer.

Task 1
Determine the surface tension of variously concentrated solutions of bile acid and compare it with the surface tension of distilled water

Procedure:
1) Measurement is provided by the digital tensiometer K9. Switch on the tensiometer – press ON.
2) Set mode PLATE (by button MODE, if it isn`t already set).
3) Start measurement with distilled water. Pour distilled water into the **glass** vessel of tensiometer (fill ca ½ of the vessel volume).
4) Move the table upwards, almost to the lower edge of measuring lamella by means of the screw for general shift on right side. (You can watch reflection of the lower edge of the lamella on surface of the liquid for better setting).
WARNING- if you use roller for general setting the screw button on left side must be open
5) Lock the table by screw on left side. Calibrate the system for measurement of force by pressing button ZERO.
6) Drive up with the table to fully immerse the lamella into studied liquid.
7) By rotation of the right screw go slowly down with the table and at the same time follow display of tensiometer. Just before separation of the lamella from the water surface the value of the surface tension force will at the greatest value. Write down this value.
8) Repeat the measurement in the same way for all accessible concentrations of bile acids. Write down the results into a table. **After the measurement put back bile acid into the vessel**.

Task 2
Verification of the surface tension for variously concentrated solutions of bile acid by means of a stalagmometer

Procedure:
1) Check the mass of every of **four** dry weighing vessels by analytical scales (they are prepared in front of bile acids). The container **under** the stalagmometer is used **only** for avoiding liquid spilling! Every vessel is prepared for the specific liquid (50%, 80% and 100% bile acid, distilled water).
2) Pipette the distilled water into the stalagmometer. After dropping of several drops place the weighing vessel below the outlet part of the stalagmometer and count 50 drops of studied liquid.

3) Check the mass of weighing vessel with 50 drops of studied liquid and determine mass of 50 drops.

4) Repeat the measurements for all solutions of bile acids (**After the measurements put back bile acids into the vessels**).

5) Calculate the surface tension of the solutions of the acid by using the equation

$$\frac{\gamma}{\gamma_{ref}} = \frac{m}{m_{ref}},$$

where the index *ref* represents value for reference (comparative) liquid (distilled water), which surface tension is presented in the table. m represents the mass of 50 drops and γ represents surface tension.

Compare measured values of distilled water with values of variously concentrated solutions of bile acid in the discussion. Compare values measured by the stalagmometer and tensiometer K9. Write down why and how are the values different. Try to specify mistakes made in measurement.

Table of the surface tension of pure water

temperature (°C)	ST (mN/m)	temperature (°C)	ST (mN/m)	temperature (°C)	ST (mN/m)
1	75.50	31	71.05	61	66.06
2	75.36	32	70.89	62	65.88
3	75.23	33	70.73	63	65.71
4	75.09	34	70.57	64	65.53
5	74.94	35	70.41	65	65.36
6	74.80	36	70.25	66	65.18
7	74.66	37	70.09	67	65.00
8	74.52	38	69.93	68	64.83
9	74.38	39	69.76	69	64.65
10	74.23	40	69.60	70	64.47
11	74.09	41	69.44	71	64.29
12	73.94	42	69.27	72	64.11
13	73.79	43	69.11	73	63.93
14	73.65	44	68.94	74	63.75
15	73.50	45	68.78	75	63.57
16	73.35	46	68.61	76	63.39
17	73.20	47	68.44	77	63.21
18	73.05	48	68.28	78	63.03
19	72.90	49	68.11	79	62.85
20	72.75	50	67.94	80	62.66
21	72.60	51	67.77	81	62.48
22	72.45	52	67.60	82	62.30
23	72.29	53	67.43	83	62.11
24	72.14	54	67.26	84	61.93
25	71.99	55	67.09	85	61.74
26	71.83	56	66.92	86	61.56
27	71.67	57	66.75	87	61.37
28	71.52	58	66.58	88	61.19
29	71.36	59	66.40	89	61.00
30	71.20	60	66.23	90	60.81

Source: N.B. Vargaftik et al.:International tables of the surface tension of water.J. Phys. Chem. Ref. Data, 12, 817,1983