1. Experimental Objectives

1) Understand the Poiseuille law.

2) Learn how to measure viscous and surface tension coefficients of liquid using Ostwald viscometer.

3) Master the measurement principle of comparison method and recognize its application in practice.

2. Experimental Procedure

Measurement of viscosity coefficient of alcohol

1) Set up main unit
   a) Place the main unit on a stable table.
   b) Pour water into the glass beaker to the "Water Line" marked on the beaker.
   c) Place the magnetic rotor in the water, then put the beaker at the specific location on the main unit.
   d) Wire the sensor and heater to the main unit.
   e) Turn on power of the main unit.
   f) After adjusting the "Adj." knob of the motor in clockwise direction to maximum, turn on motor switch. Now, the magnetic rotor rotates with a relatively high speed. Next, turn the "Adj." knob in count-clockwise direction to near minimum to get a proper rotation speed of the rotor.
   g) Set temperature T above room temperature to heat the water in beaker (see next step).
2) Set up constant temperature controller
   a) After powered on, the digital meter displays "FdHC" initially, then "Axx.x" for the current temperature, and finally "b = =· =" for setting the control temperature.
   b) Press "Up" or "Down" button to increase or decrease temperature, then press "Set" button to set temperature to start heating.
   c) If necessary, press "Reset" button to reset temperature while waiting unill "b---" is displayed on the meter. Then repeat step b) to set temperature.
   d) During heating, press "Set" button to alternatively display preset temperature (meter displays with letter "b") and current temperature (meter displays with letter "A")
3) Clean Ostwald viscometer
   a) Inject 6-10 ml alcohol into ball *b* as seen in Figure 2.
   b) Open the valve of the rubber ball, squeeze with hand to expel internal air, and close the valve.
   c) Release hand slowly to suck alcohol from ball *b* into ball *c* by letting liquid surface slightly over line *m* (**Note**: do not suck alcohol into the rubber ball).
   d) Squeeze the rubber ball again to pressure alcohol back into the large tube.

e) Repeat the above steps 3 times. Then pour out alcohol into a recycle container.

4) Inject 6-8 ml alcohol into viscometer.
5) Place the viscometer into the beaker and fix it in vertical direction.
6) Suck alcohol from ball *b* into ball *c* by letting liquid surface slightly over line *m* (**Note**: do not suck liquid into the rubber ball).
7) Open the valve of rubber ball, liquid surface falls freely. Use a stopwatch to measure the time that the liquid surface takes to fall from line *m* to line *n*.
8) Repeat steps 6 and 7 to measure 3 - 5 sets of data.
9) Squeeze the rubber ball to pressure all alcohol into the large tube, and then pour it out.
10) Use 6-10 ml pure water to clean the viscometer per step 3) again.
11) Inject the same volume of water as in step 4) into the viscometer, and repeat steps 5), 6), 7) and 8).
12) Use formula (13) to derive the viscosity coefficient of alcohol at a certain temperature *T*.

<u>Measurement of surface tension using Ostwald viscometer</u>

1) Clean the Ostwald viscometer and pipette using distilled water. After they are dry, set the temperature controller at a certain temperature such as 30 °C and wait until the temperature is stabilized at this temperature.
2) Inject 10 ml liquid-under-test into the viscometer using the pipette. Use the rubber ball to suck the liquid from the top of ball *c* and let the liquid surface reach ball *c*. Then let it fall freely.
3) After liquid is stationary, measure the height difference between both sides using the scale lines on the outer wall of the beaker.
4) Pour out the liquid-under-test. Repeat steps 1) to 3) by injecting a standard liquid (pure water).
5) Use formula (16) to calculate the surface tension coefficient of the liquid-under-test.

3. Example of Data Recording and Processing

Note: the following data are for reference purposes only, not the criteria for apparatus performance.

<u>Measurement of viscosity coefficient of alcohol</u>

	Pure water				
T (°C)	t_1 (s)	t_2 (s)	t_3 (s)	Average t (s)	Density ρ_1 (kg/m^3)
30	63.56	63.57	63.69	63.61	995.67
32	61.21	61.16	61.12	61.16	995.05
34	58.87	58.85	58.85	58.86	994.40
36	56.78	56.72	56.75	56.75	993.71
38	54.69	54.78	54.72	54.73	992.99

	Alcohol				
T (℃)	t_1 (s)	t_2 (s)	t_3 (s)	Average t (s)	Density ρ_2 (kg/m^3)
30	99.75	99.81	99.94	99.83	780.97
32	96.4	96.66	96.65	96.57	779.27
34	93.56	93.34	93.53	93.48	777.56
36	90.44	90.34	90.41	90.40	775.85
38	87.44	87.56	87.62	87.54	774.14

	Pure water	Alcohol		
T (℃)	η_{ref} (10^{-7}Pa·s)	η_{mea} (10^{-7}Pa·s)	η_{ref} (10^{-7}Pa·s)	Error (%)
30	8007	9857	9885	0.29
32	7679	9496	9536	0.42
34	7371	9154	9204	0.55
36	7085	8812	8888	0.86
38	6814	8497	8586	1.04