GAZI UNİVERSITY

CHEMICAL ENGINEERING DEPARTMENT

CHE392 CHEMICAL ENGINEERING LABORATORY I

1B. DETERMINATION OF SURFACE TENSION OF LIQUIDS

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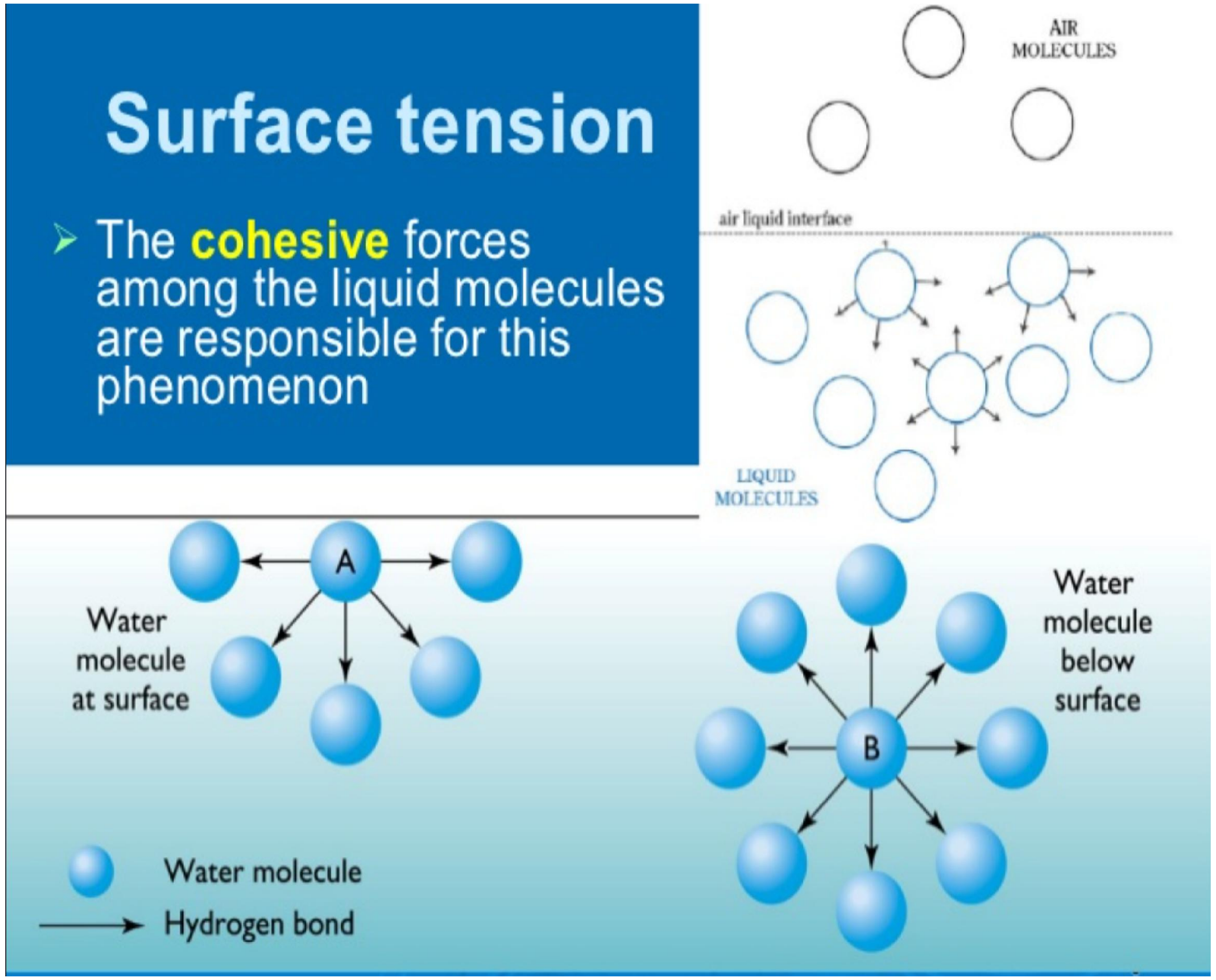
CONTENT

- Purpose
- What is surface tension?
- The measurement of the surface tension
- Derivation of surface tension formula
- Experimental Procedure
- Experimental Data

The purpose of the experiment

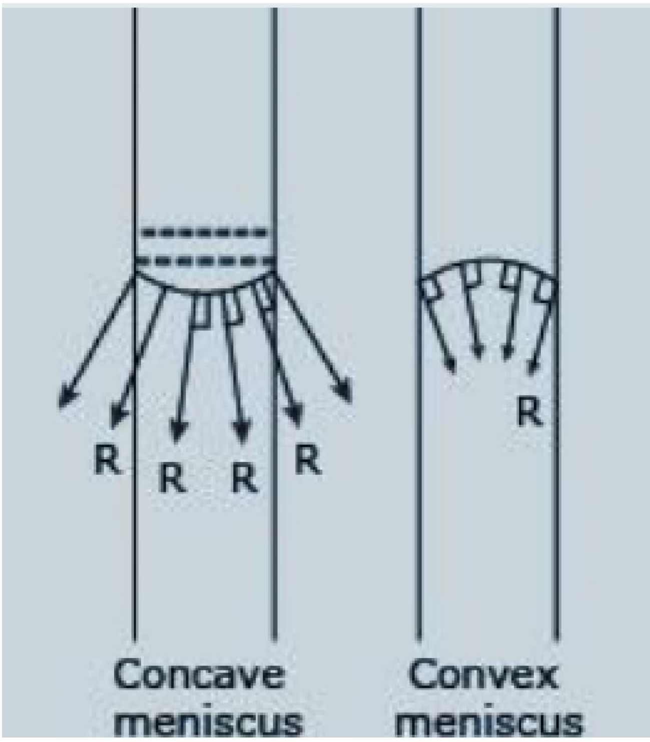
- Aim: To determine the surface tension of given liquid by drop count or drop-weight method using stalagmometer

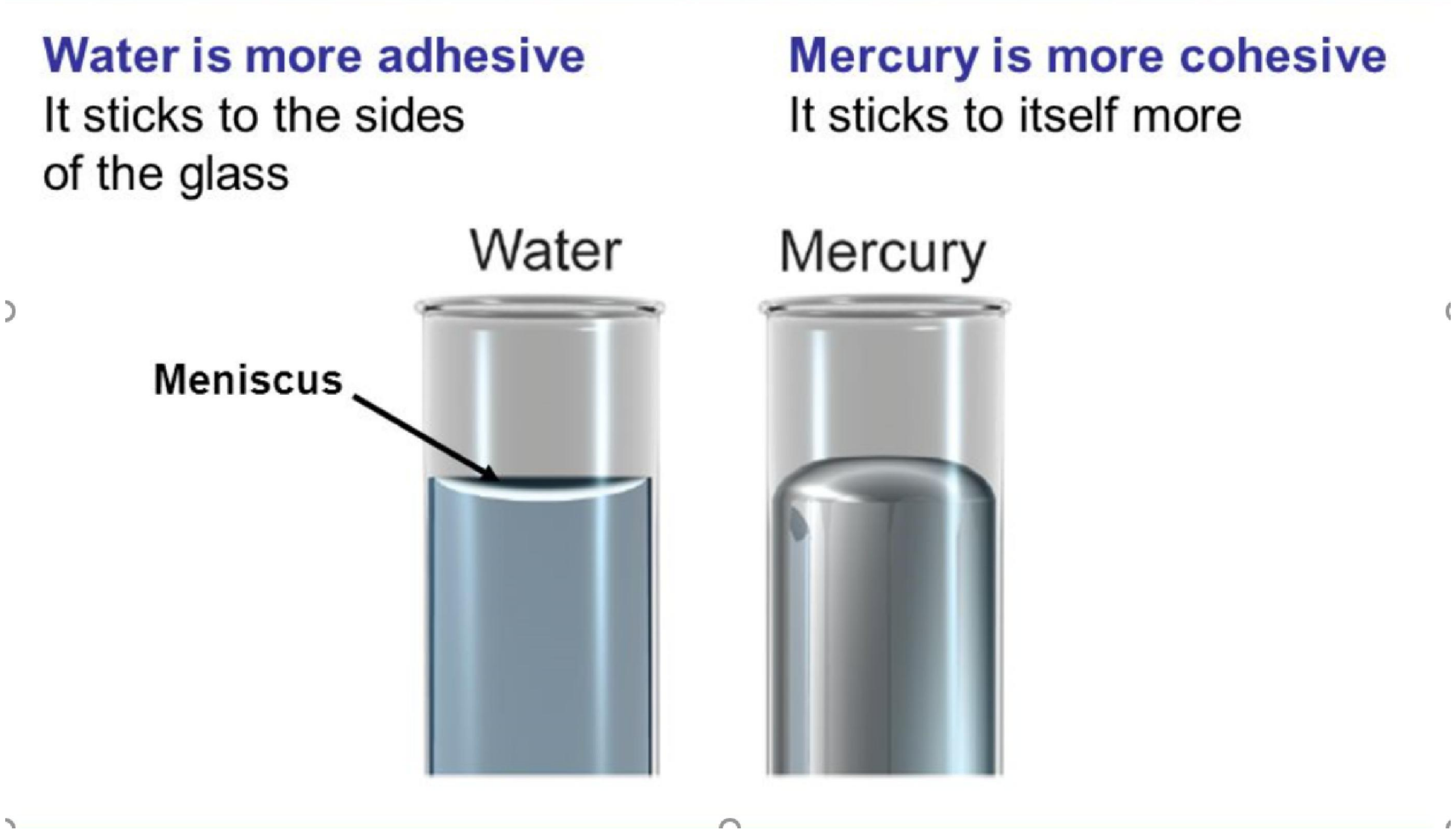
What is the surface tension?



- ✓ The attractive force exerted upon the surface molecules of a liquid by the molecules beneath that tends to draw the surface molecules into the bulk of the liquid and makes the liquid assume the shape having the lest surface area.
- ✓ Surface tension (γ) is a property of the surafce of a liquid that allows it to resist an external force.
- ✓ It is due to the phenomena of surface tension that the drops of water tend to assume a spherical shape to attain mimimum surface area

Cohesion or adhesion?





The measurement of the surface tension of liquids by using stalagmometer

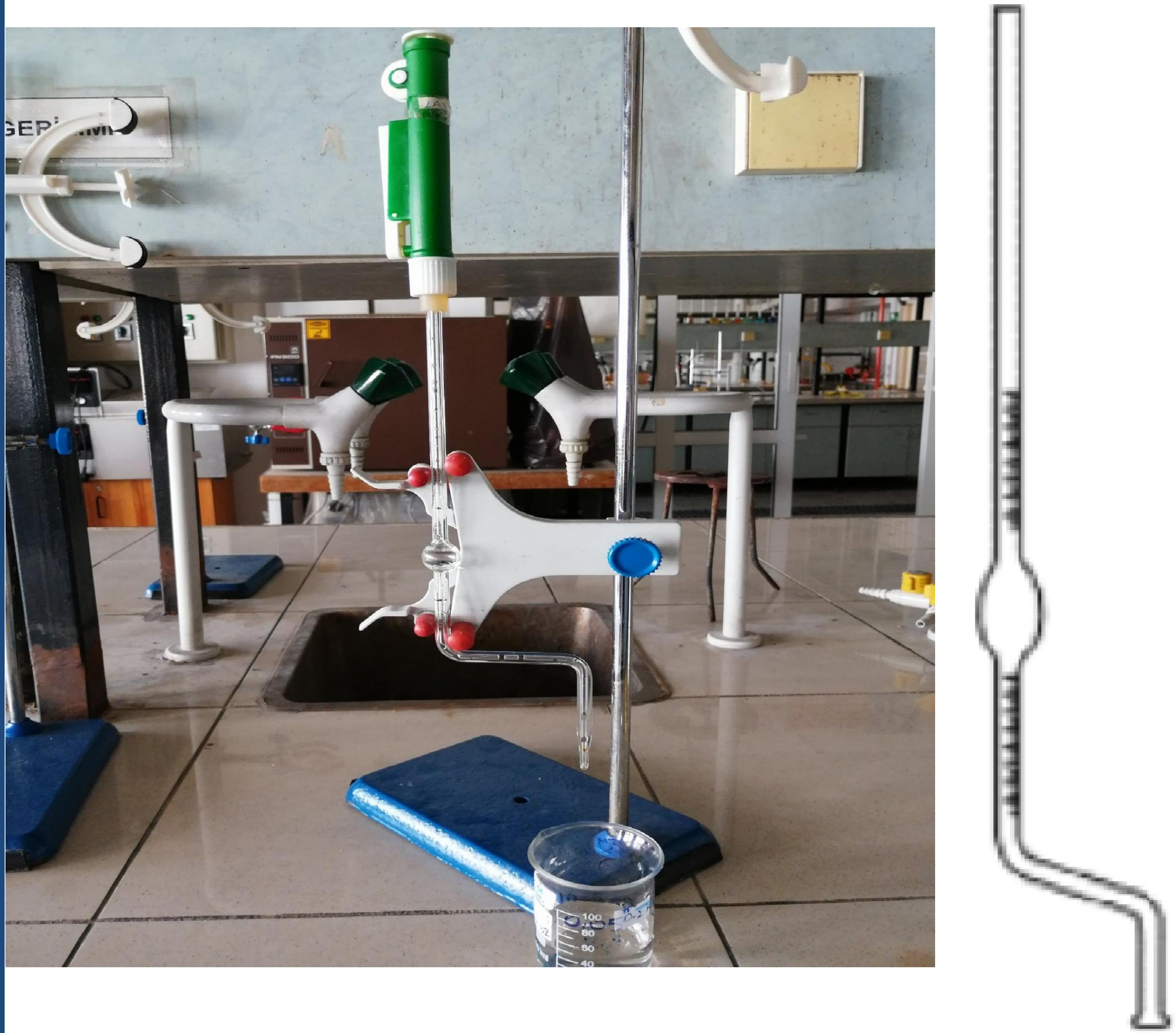


Figure 1.Traube Stalogmometre

Stalagmometer is a glass tube, widened in the middle part (Figure 1). Its volume is calibrated by the scale shown on the tube, or by the top and bottom lines. The bottom part of stalagmometer is modified such that the liquid flowing through its smaller diameter forms drops.

The principle is to measure the weight of drops (which are counted) of a fluid falling from a capillary, and thereby calculate the surface tension of the fluid.

The drop of a mass m gets released when its weight G= mg is equal or greater than the surface force at the end of tube:$2\pi r\gamma$

Equation suggests, that the surface tension (γ) can be calculated from the known water mass (m) and the radius of stalagmometer tube (r).

$$\boxed{2\pi r\gamma = mg}$$

Two methods by using stalagmometer

I. Drop-weight method

II. Drop-count method

Derivation of Surface Tension Formula

With respect to ;drop-weight

$$\frac{\cancel{2\pi r}\gamma_1}{\cancel{2\pi r}\gamma_2} = \frac{m_1\cancel{.g}}{m_2\cancel{.g}}$$

$$\boxed{\frac{\gamma_1}{\gamma_2} = \frac{m_1}{m_2}}$$

With respect to; drop-count

$$\frac{\gamma_1}{\gamma_2} = \frac{m_1}{m_2} \rightarrow \frac{p_1.v_1}{p_2.v_2}$$

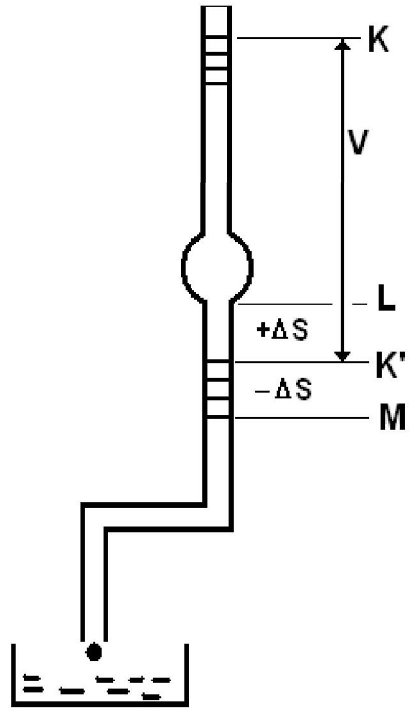
$$v_1 \rightarrow \frac{V_T}{n_1} \qquad v_2 \rightarrow \frac{V_T}{n_2}$$

$$\frac{\gamma_1}{\gamma_2} = \frac{{}^{V_T}\!/_{n_1}.p_1}{{}^{V_T}\!/_{n_2}.p_2}$$

$$\boxed{\frac{\gamma_1}{\gamma_2} = \frac{n_2.p_1}{n_1.p_2}} \xrightarrow{*} \boxed{\frac{\gamma_1}{\gamma_2} = \frac{n_2}{n_1}}$$

! The **surface tension is directly proportional** to the **weight** of the **drop, and inversely proportional to the number of the droplets**

* For lower liquid concentration : $p_1 \cong p_2$



Experimental Procedure

- Chose the three different liquids (ethyl alcohol, butyl alcohol, acetic asit, acetone, ethanol, and etc.) and three different concentrations of each liquids (0.2M, 0.15M, 0.10M, 0.05M, and etc.)
- Mount the clean and dry stalagmometer on the vertical stand and immerse the bottom end of stalagmometer into water and fill it up
- Weigh the mass of the empty weighing beaker located at the bottom end of the stalagmometer.
- Concerning the **experimental** procedure by **constant volume** methods, set the base levels at the top (K-level) and bottom part (K'-level) of the stalagmometer.
- Drop the one droplet into the beaker and find the equivalent notch number for one droplet.
- Continue dropping between specified range (K-K') and do not forget the count all droplets.
- After the dropping the latest droplets, count how many notches are left to reach to specified K' level (It could be upper or below of the specified K' level)
- Find the how many droplets (ΔS) are required to balance the real specified volume. If the liquid level is above the K' level, taken as the positive sign of the +ΔS. If the liquid level is below the K' level, taken as the negative sign of the -ΔS.
- Weigh the mass of the weighing beaker and find the total drop-weight.
- Calculate the mass of one droplets: $\frac{total\ mass\ of\ droplets}{total\ number\ of\ droplets}$
- After completing all step for reference water, repeat the above steps for unknown liquids
- Calculate the surface tension of the unknown liquids by using reference value.

Experimetal Data

- The mass of the empty weighing beaker for ethanol and Butyl alcohol: 50.1212 g
- The mass of the empty weighing beaker for ethanol and Isobutyl alcohol : 36.4880 g
- Surface tension of the water at 20 ^{o}C:72.8 dyn/cm

Solution	Notch number of a drop	Drop Number	∆S	The weight of the beaker after the dropping is completed (g)
Su	12	42	-7	52.4319
0.2 M Butyl Alcohol	7	73	-1	52.4280
0.1 M Butyl Alcohol	8	60	-2	52.4415
0.05 M Butyl Alcohol	11	53	-1	52.4415
0.02 M Butyl Alcohol	13	48	-9	52.4732
0.2 M Isobutyl Alcohol	10	58	-3	38.3782
0.1 M Isobutyl Alcohol	7	54	4	38.3555
0.05 M Isobutyl Alcohol	13	49	-3	38.3819
0.02 M Isobutyl Alcohol	13	40	-10	38.4223
0.2 M Ethanol	12	48	0	52.4156
0.1 M Ethanol	9	45	-1	52.4432
0.05 M Ethanol	8	44	-3	52.4532
0.02 M Ethanol	12	42	-4	52.4648

Table for experimental data

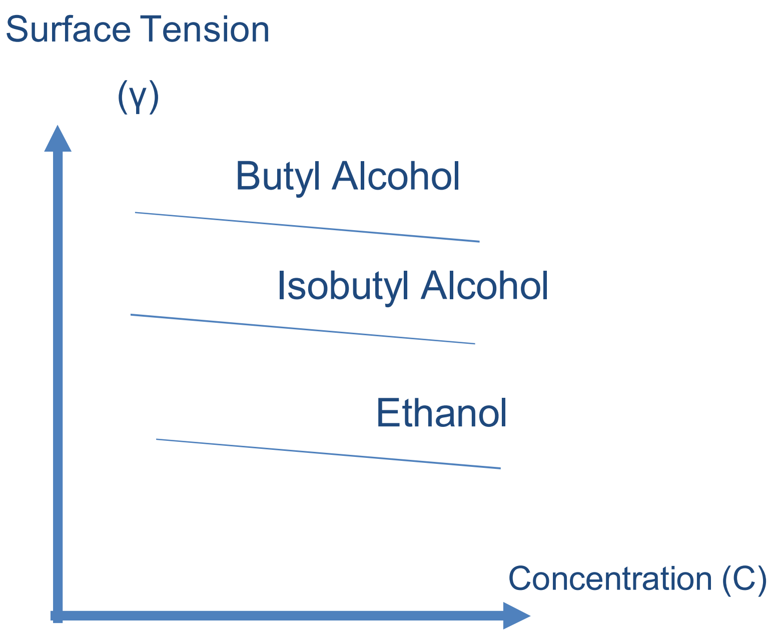
DATA TABLE FOR SURFACE TENSION EXPERIMENT

GROUP NUMBER: DATE:

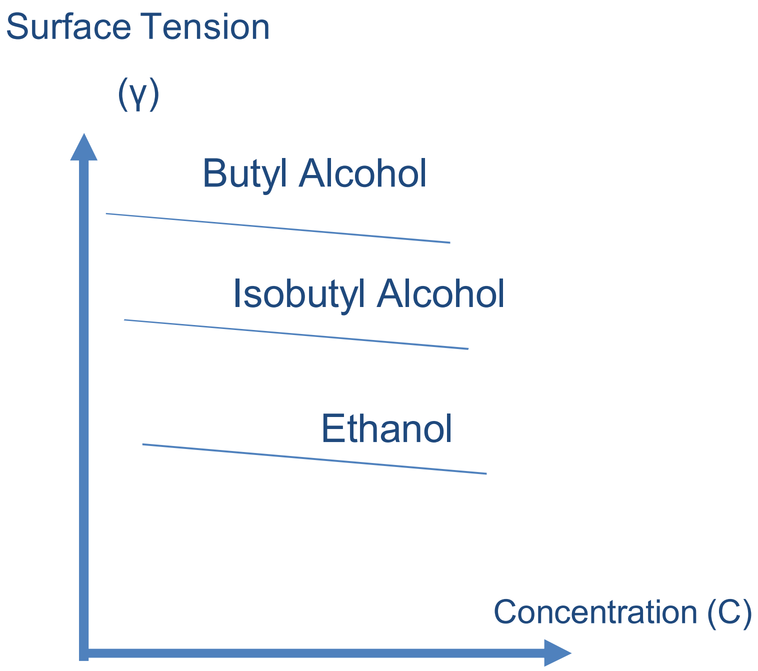
Solution	Notch Number of a drop	Drop Number	$\pm\Delta S$	Real Drop Number	Drop mass (g)	Surface tension according to the number of drops	Surface tension according to the mass of drops

- Fill in the above table with using the data given in the previous slide
- Include in your report

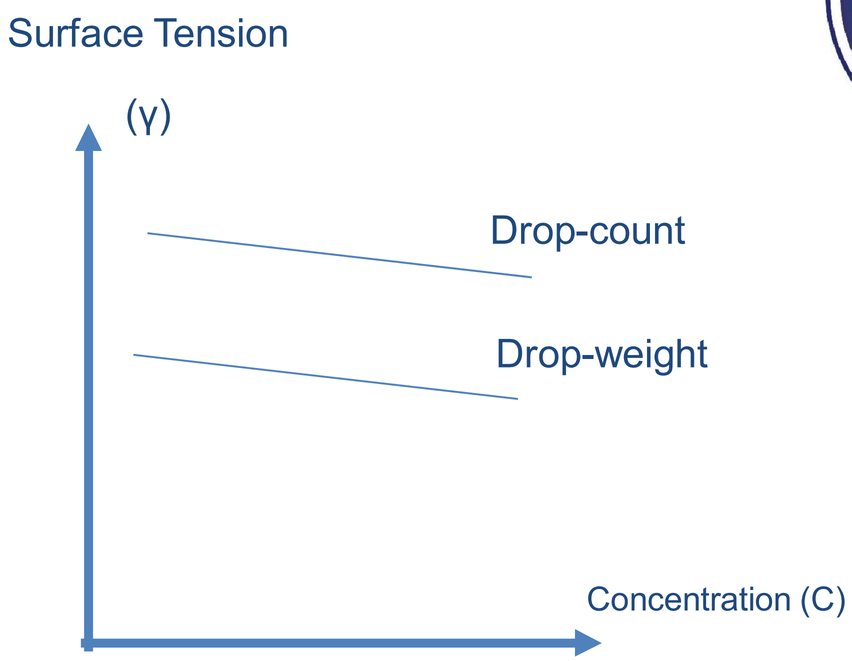
GRAPHS IN YOUR REPORTS



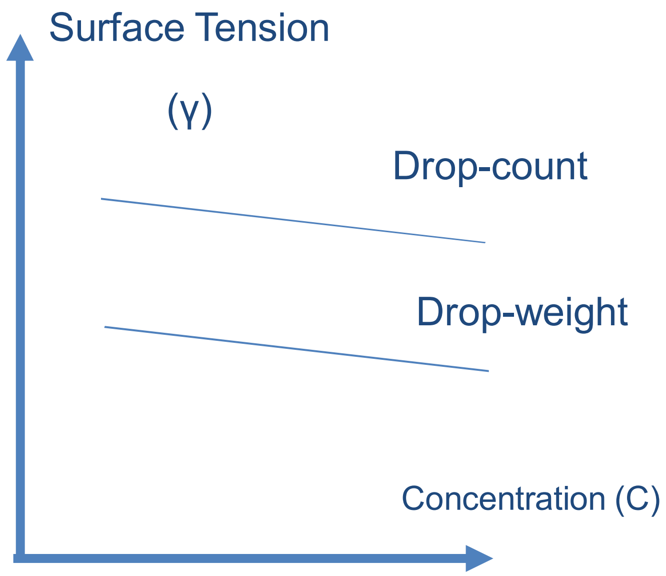
For Drop-count method



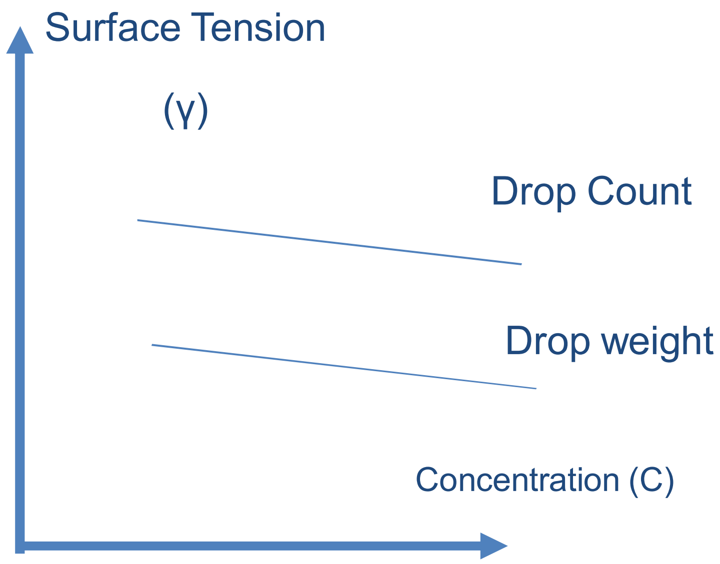
For Drop-weight method



For Butyl Alcohol



For Isobutyl Alcohol



For Ethanol

✓ Should include in your report