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CBCS Sem-6 (Hons) [Physical Chemistry Lab. Study Material]

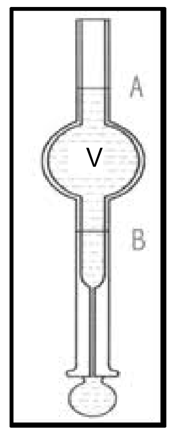
1. Experiment No 1 : Determination of surface tension of a given solution by drop weight method using a stalagmometer.

Theory :

In a liquid, the molecules attract one another. As a result of this intermolecular attraction, a molecule within the bulk of the liquid suffers zero resultant force, whereas, a molecule at the surface suffers a net resultant force of attraction towards the bulk. The surface of a liquid is under a tensile force and behaves like a stretched membrane. This physical property of a liquid at rest is called surface tension.

Surface tension of a liquid thus at a particular temperature is defined as the force acting tangentially across the surface of the liquid and at right angles to any line of unit length on it.

The surface tension may alternatively be defined as the work done in increasing the surface area of the liquid by unity. The unit of surface tension is dyne.cm^{-1} (c.g.s.) or, N.m^{-1} (SI).



Surface tension of a liquid depends upon temperature, it decreases as temperature increases and
vanishes at the critical temperature of the liquid.

The basis of determining surface tension (γ) of a liquid using a stalagmometer is as follows. When a
liquid flows slowly out of the orifice of a capillary tube at the lower end of the stalagmometer, under the action of gravity, the balance of force just at the point of detachment of the spherical drop may be expressed by equation (1) (neglecting the buoyancy effects of surrounding air medium).

$$Ng = 2ny.r.\emptyset \text{ ....(1)}$$

where, m=mass of a drop, g=acceleration due to gravity, r=radius of the capillary, y =surface tension

of the liquid, ∅ = Harkins-Brown correction factor for the instrument. (∅) is a function of (r/V^{3}),where V is volume of a drop.

If a definite volume (V) of two liquids (1 and 2) of density $d_1$and d_2 and surface tension y_1 and y_2 is

passed through a uniform capillary tube (at the bottom of the stalagmometer) produces respectively n_1 and n_2 number of drops, applying the relation (1) one may obtain,

$$\frac{y_1}{y_2} = \frac{(\frac{V}{n_1}) . d_1}{(\frac{V}{n_2}) . d_2}$$

$$\frac{y_1}{y_2} = \frac{n_2}{n_1} . \frac{d_1}{d_2} \text{ ....(2)}$$

If the two liquids have nearly the same drop-size $\frac{\emptyset_1}{\emptyset_2} = 1$.

Thus, by counting the number of drops produced from a fixed volume of two liquids and determining the ratio of their densities one may compare their surface tensions. If the surface tension of one of the liquids, (reference liquid, e.g. water) (y_w) is known, then the surface tension (y_L) of another liquid can be obtained using the relation :

$$\frac{y_L}{y_W} = \frac{n_W}{n_L} \cdot \frac{d_L}{d_W} = \frac{n_W}{n_L} \cdot S_L \text{.........} (3)$$

where, S_L = specific gravity of the liquid.

$$y_L = \frac{n_W}{n_L} \cdot S_L \cdot y_M \text{..........} (4)$$

Thus, by counting the number of drops produced by passing a definite volume of water and the liquid, or, solution and determining its specific gravity, surface tension of the liquid (y_L) can be determined provided (y_{LM}) of water at the same temperature is known.

EFFECT OF ADDITIVES :

(a) NaCl, KCl etc surface tension increase slightly.

(b) HOAc, C_2H_5OH etc surface tension decreases.

PROCEDURE:

1. Determine the specific gravity (S_L) of the solution/liquid by usual procedure (using specific gravity bottle).

2. Rinse the stalagmometer with distilled water thoroughly. Suck in fresh distilled water and adjust the number of drops falling between 10 to 15 per minute. Suck in water again, release and start counting the number of drops as the meniscus touches the upper graduation mark and stop when it touches the lower mark. Repeat the counting and record the average numberof drops (n_w).

3. Repeat the process (2) with the supplied solution/liquid and record the average number of drops (n_L).

4. Calculate the surface tension of the supplied solution using the relation (4).

EXPERIMENTAL DATA:

1. Recording of room temperature.
2. Determination of specific gravity of the unknown liquid:

Wt of empty specific gravity bottle in (g) (W_1)	Wt of specific gravity bottle + water in (g) (W_2)	Wt of specific gravity bottle + supplied liquid in (g) (W_3)	$S_L = \frac{(W_3 - W_1)}{(W_2 - W_1)}$

3. Drop counting for water and supplied solution:

Liquid	No. of drops	Mean no. of drops
Water (n_W)	1.	
	2.	
	3.	
Supplied solution (n_L)	1.	
	2.	
	3.	

4. Calculation :

Surface tension of water at ……..^{o}C = ... dynes/cm

Surface tension of supplied solution $= y_L = \frac{n_W}{n_L} . S_L . y_M$ at ……..^{o}C =........... dynes/cm

Youtube link

https://youtu.be/1ek1RZx9ZHM