SURFACE TENSION

K.L Kapoor page (127-128)

(2.6)

The surface tension of water at 20°C is $72.75 \times 10^{-3}\ N m^{-1}$. How high will a column of water rise in a capillary tube with radius of 0.005 cm?

⇒ The given data,

Surface tension of water (γ) $= 72.75 \times 10^{-3}\ N m^{-1}$

$= 72.75 \times 10^{-3} \times 10^{3}$ dyne cm^{-1} [$\because 1 N m^{-1} = 10^{3}$ dyne cm^{-1}]

$= 72.75$ dyne cm^{-1}

and, the radius of capillary tube (r) $= 0.005$ cm

Now, $\gamma = \frac{1}{2} r h \rho g$. [where, h is the height of water column rise in a capillary. ρ is the density of water and g is the accelaration due to gravity.]

or, $h = \frac{2\gamma}{r \rho g}$

or, $h = \frac{2 \times 72.75 \text{ dyne } cm^{-1}}{0.005\ cm \times 1\ gm\, cm^{-3} \times 981\ cm s^{-2}}$ [$\because gm\, cm s^{-2} = dyne$]

$\Rightarrow \frac{2 \times 72.75}{0.005 \times 1 \times 981} \frac{\text{dyne } cm^{-1}}{\text{dyne } cm^{-2}}$

$= 29.66$ cm

2.7

In the determination of the surface tension of a liquid by the drop number method, equal volumes of A and water gave 60 and 20 drops respectively. Calculate the surface tension of A if $\rho(A) = 0.896\ g cm^{-3}$ and ρ(water) $= 0.964\ g cm^{-3}$. Given: $\gamma(H_2O) = 72.75 \times 10^{-3}\ N m^{-1}$

$\Rightarrow \frac{\gamma_A}{\gamma_{water}} = \frac{n_{water} \times \rho_A}{n_A \times \rho_{water}}$

$= \frac{20 \times 0.896\ g cm^{-3}}{60 \times 0.964\ g cm^{-3}}$

$= 0.3098$

$\therefore \gamma_A = 0.3098 \times \gamma_{water}$

$= 0.3098 \times 72.75 \times 10^{-3}\ N m^{-1}$

$= 22.54 \times 10^{-3}\ N m^{-1}$

(b) In the liquid phase, CCl_4 and water form two distinct layers but in the vapour phase they get completely mixed up — Explain. (2)

3(a) Find the change in surface energy when two identical mercury droplets of of diameter 1.5 mm merge isothermally to form one drop

$\gamma_{mercury} = 490$ dyne cm^{-1}

⇒ Let 'R' is the ~~drop~~ radius of the big drop

$$\frac{4}{3}\pi R^3 = 2 \times \frac{4}{3}\pi\left(\frac{1.5}{2}\right)^3$$

$$\text{or, } R^3 = \frac{(1.5)^3}{4} = 0.844 \text{ mm}$$

$$\text{or, } R = 0.945 \text{ mm}$$

$$\text{or, } R = 0.0945 \text{ cm.}$$

So, the surface energy change.

$= 2\times\{4\pi\times(0.075)^2\}\times \gamma_{mercury} - 4\times\pi\times(0.945)^2\times \gamma_{mercury}$

$= \{8\pi\times(2\times0.075)^2 - 4\pi\times(0.945)^2\} \gamma_{mercury}$

$= 0.0292\times 490$ dyne cm/cm²

$= 14.28$ erg

(b) How does surface tension vary with temperature? Comment on the temperature co-efficient in the case of associated liquids.

⇒ The force of attraction between the molecules of a liquid decreases with increase in temperature it follows, therefore, that the surface will decrease when the temperature is increased. The following relation relates between surface tension and temperature.

$\gamma(M_V)^{2/3} = K(t_c - t - 6)$

where, γ is the surface tension of the liquid.

M_V is the molar volume of the liquid.

t_c is the critical temperature of the liquid.

So, at $t = (t_c - 6)$, the surface tension of the liquid is zero i.e vanished the surface tension of the liquid.

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1998

3.(c) A spherical drop of a liquid weighting 0.04 gm is dispersed into 1500 microglobules of radius 0.02 cm each by a suitable exprimental device. Find the resultant increase in surface energy ($\rho_L = 0.8$ gm/cc) : $\gamma = 27$ dyne cm^{-1}

$\Rightarrow$ volume of 0.04 gm of liquid $= \frac{0.04}{0.8}$ cc
$= \frac{1}{20}$ cc.

Let, radius of this spherical drop $= R$

or, $\frac{4}{3}\pi R^3 = \frac{1}{20}$

or, $R^3 = \frac{3}{80\pi}$ cm.

$R = (\;)^{1/3}$

or, $R = 0.2285$ cm.

$\therefore$ Increase of surface energy

$= \left\{1500\left(4\pi \times 0.02^2\right) - 4\pi \times 0.2285^2\right\} \gamma$

$= 6.884 \times 27$ dyne cm^{-1}. cm^2

$= 185.86$ erg.

1999

3. (a) What do you mean by surface tension of a liquid? 2+1

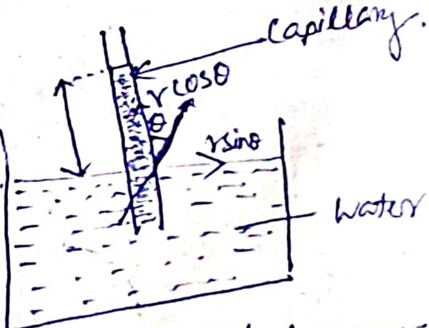
What is its S.I unit?

⇒ Surface tension :- Surface tension is a force acting tangentially to the surface and perpendicular to a line of unit length down on a surface.

S.I unit of surface tension :- Nm^{-1}

3(b) Describe the capillary rise method of determination of surface tension of a liquid?

⇒ capillary rise method :-



Let θ is the contact angle of water and glass. The upword force of surface tension ($\gamma\cos\theta$) act all around the capillary tube and rises the liquid in the tube untill the weight of the rising liquid becomes equal to this lifting force.

Thus, Lifting force = $(\gamma\cos\theta)2\pi\gamma$

weight of the liquid in the capillary tube

$$= \{(\pi r^2)h\}\rho g + (\pi r^3 - \frac{1}{2}\frac{4}{3}\pi r^3)\rho g$$

Where γ is the surface tension of the liquid.

r the radius of the capillary.

h = height of the rising liquid column in the capillary

ρ is the density of the liquid.

and g is acceleration of gravity.

At equillibrium

$$(\gamma\cos\theta)\,2\pi r = \pi r^2 h \rho g$$

$$\text{or, } \gamma = \frac{r h \rho g}{2\cos\theta}$$

Being θ is very small value $\cos\theta \to 1$

$$\therefore \gamma = \frac{1}{2} r h \rho g$$

3. (c) When a glass capilary tube is dipped into liquid mercury. there is a depression of mercury level inside the tube - Explain ?

(d) Surface tension of liquid varishes at its critical temperature - Explain.

2000

9 (g) A spherical soap-bubble of volume $\pi/6$ cm3 stands suspended in air. What is the excess pressure inside the bubble? [Give the interfacial tension for the soap soln - air interface is 27 dyne cm^{-1}]

Let, radius of the soap bubble $= r$

$\therefore \frac{4}{3}\pi r^3 = \pi/6 \ cm^3$

or. $r^3 = \frac{1}{8} \ cm^3$

or $r^3 = \left(\frac{1}{2}\right)^3 cm^3$

or, $r = \frac{1}{2} \ cm$

$\therefore$ Total surface area $= 2 \times 4\pi \left(\frac{1}{2}\right)^2 cm^2$

$= 2\pi \ cm^2$

$\therefore$ Total surface energy = surfac area x surface tension of soap soln.

$= 2\pi \ cm^2 \times 27 \ dyne \ cm^{-1}$

$= 54\pi \ dyne \ cm$

Let 'P' is the excess pressure,

$\pi \left(\frac{1}{2}\right)^2 P = 54\pi$

or, $P = 54 \times 4 \ dyne \ cm^{-1}$

$= 216 \ dyne \ cm^{-1}$

2002.

11.(J) An excess pressure of 364 Pa is required to produce a newies spherical bubble at the end of the capillary tube of 0.3 mm diameter immersed in accetone. calculate γ.

Excess pressure $p = 364\ Pa = 364\ dyne\ cm^{-2}$

Diameter of capillary $= 0.3\ mm$

Radius of " $= \frac{0.3}{2}\ mm$

$= 0.15\ mm$

$= 0.015\ cm.$

$\therefore$ Disruptive force $= \pi \times (0.015)^2 \times 364\ dyne\ cm$

Binding force $= (2\pi r^2 + \pi r^2)\gamma$

$= 3\pi r^2 \gamma$

$= 3 \times \pi \times (0.015)^2 \gamma$

At equillibrium.

$3\pi \times (0.015)^2 \gamma = \pi \times (0.015)^2 \times 364.$

$\gamma = \frac{364}{3}\ dyne\ cm^{-2}$

$= 121.3\ dyne\ cm^{-2}.$

2004

11 (d) Calculate the work done is blowing a soap bubble in air of radius 10 cm. γ for soap soln = 30 dyne cm^{-1}.

$\Rightarrow$ Total area of the soap bubble $= 2 \times 4 \times \pi \times 10^2\ cm^2$.

$\therefore$ total workdone to blow this bubble

$= 800\pi \times 30$ dyne cm

$= 75.398 \times 10^3$ erg

$= 0.754$ joul.