Type – 02

1. The surface tension of water is 0.072 N/m. Find the vertical force required to detach a floating pin of length 2.5 cm from the surface of water.

Given :-

$T = 0.072\ N/m$

$F = ?$

$l = 2.5\ cm$

$l = 2.5 \times 10^{-2}\ m$

Solution :-

$T = \frac{F}{2l}$

$F = T \times l$

$F = 0.072 \times 2.5 \times 10^{-2} \times 2$

$F = 0.072 \times 5 \times 10^{-2}$

$F = 0.360 \times 10^{-2}$

$F = 3.6 \times 10^{-3}\ N$

$$\begin{array}{r} 0.072 \\ \times \quad 5 \\ \hline 0.360 \end{array}$$

2. A U-Shaped wire is dipped in a soap solution and removed. The thin soap film is formed between the wire and the light slider supports a weight of 1.5×10^{-2} N (which includes the small weight of the slider). The length of the slider is 30cm. What is the surface tension of the film.

Given :-

$T = ?$

$F = 1.5\times10^{-2}$ N

$l = 30$cm

$l = 30\times10^{-2}$ m

Solution :-

$$T = \frac{F}{2l}$$

$$T = \frac{1.5\times10^{-2}}{2\times30\times10^{-2}}$$

$$T = \frac{1.5}{2\times30}$$

$$T = \frac{1.5}{60} = \frac{15}{600} = \frac{1}{40}$$

$$\begin{array}{r} 0.025 \\ 40\,)\,100 \\ -\ 80 \\ \hline 0200 \\ -\ 200 \\ \hline 000 \end{array}$$

$T = 0.025$ N/m

$$\boxed{T = 2.5\times10^{-2}\ \text{N/m}}$$

3. Calculate the force required to take away a flat circular plate of radius 0.01 m from the surface water. The surface tension of water is 0.075 N/m.

Given:-

$r = 0.01\ m$

$T = 0.075\ N/m$

$F = ?$

Solution:-

$T = \frac{F}{l}$

$l = 2\pi r$

$F = T \times l$

$F = T \times 2\pi r$

$F = 0.075 \times 2 \times 3.142 \times 0.01$

$F = 0.150 \times 3.142 \times 1.0 \times 10^{-2}$

$F = 0.150 \times 3.142 \times 10^{-2}$

$F = 4.713 \times 10^{-3}\ N$

Calculations:-

0.150×3.142

0.150
$\times\ 3.142$

$\bar{1}.1761$
$+\ 0.4972$
$\bar{1}.6733$

Antilog →
4713

4969
+ 3
4972

4710
+ 3
4713

4. A beaker of radius 10cm is filled with water. Calculate the force of surface tension on any diametrical line on its surface. Surface tension of water is 0.075 N/m.

Given :-

$l = 10 cm$

$l = 2 \times 10 \times 10^{-2} m$

$F = ?$

$T = 0.075 N/m$

Solution :-

$$T = \frac{F}{l}$$

$F = T \times l$

$F = 0.075 \times 2 \times 10 \times 10^{-2}$

$F = 0.150 \times 10^{-1}$

$F = 1.5 \times 10^{-2} N$

5. A ring of glass is cut from a tube having 7.4cm internal and 7.8cm external diameter. This ring with its lower side horizontal is suspended from one arm of a balance so that the lower edge is just immersed in a vessel of water. It is found that an additional weight of 3.62 g must be placed in the other scale pan to compensate for the pull of surface tension on the ring. Calculate the surface tension of water. ($g = 9.8 m/s^2$)

Given :-

Internal diameter = 7.4 cm (d_i)

$r_i = 3.7 \times 10^{-2}$ m

outer diameter = 7.8 cm (d_o)

$r_o = 3.9 \times 10^{-2}$ m

m = 3.62 g

$m = 3.62 \times 10^{-3}$ kg

T = ? $g = 9.8 m/s^2$

Solution:-

$$T = \frac{F}{l}$$

$$T = \frac{F}{2\pi r}$$

$$T = \frac{F}{2\pi(r_i + r_o)} \qquad [r = r_i + r_o]$$

$$T = \frac{mg}{2\pi(r_i + r_o)} \qquad [F = mg]$$

$$T = \frac{3.62 \times 10^{-3} \times 9.8}{2 \times 3.142 \times (3.7 + 3.9) \times 10^{-2}}$$

$$T = \frac{35.48 \times 10^{-3}}{6.284 \times 7.6 \times 10^{-2}}$$

$$T = \frac{35.48 \times 10^{-3}}{47.76 \times 10^{-2}}$$

$$T = 7.430 \times 10^{-1} \times \frac{10^{-3}}{10^{-2}}$$

$$T = 7.430 \times 10^{-2}\ N/m$$

calculations :-

$$x = \frac{35.48}{47.76}$$

$$x = 35.48 - 47.76$$

$$\begin{array}{r} 1.5500 \\ -\ 1.6790 \\ \hline \bar{1}.8710 \end{array} \rightarrow \log$$

Find Antilog

7430×10^{-1}

6. A horizontal circular loop of a radius 0.02m is lowered into crude oil and a film is formed. The force due to the surface tension of the liquid is 0.0113 N. Calculate the surface tension of the crude oil.(π=3.142)

Given:-

$r = 0.02m$

$l = 2\pi r \times 2$

$l = 2 \times 3.142 \times 0.02 \times 2$

$l = 4 \times 3.142 \times 0.02$

$l = 4 \times 3.142 \times 2 \times 10^{-2} m$

$F = 0.0113 N \quad T = ?$

Solution:-

$$T = \frac{F}{l}$$

Calculations:-

4×3.142
$= 12.568$

12.568
$\times \; 2$
25.136

$$T = \frac{0.0113}{4 \times 3.142 \times 2 \times 10^{-2}}$$

$$T = \frac{0.0113}{12.568 \times 2 \times 10^{-2}}$$

$$T = \frac{0.0113}{25.136 \times 10^{-2}} = \frac{0.011}{25.14 \times 10^{-2}}$$

$$T = \frac{0.011}{25.14 \times 10^{-2}}$$

$$\boxed{T = 4.375 \times 10^{-2}\ N/m}$$

Calculations :-

$$x = \frac{0.011}{25.14}$$

$$\begin{array}{r} 0.011 \\ -\ 25.14 \\ \hline \\ \hline \end{array}$$

$$\begin{array}{r} \bar{2}.0414 \\ -\ 1.4004 \\ \hline \bar{4}.6410 \\ \hline \end{array}$$

Taking Antilog

$$\begin{array}{r} 3997 \\ +\ \ \ 7 \\ \hline 4004 \\ \hline \end{array}$$

4375×10^{-4}

7. A drop of water of radius 6 mm breaks into number of droplets, each of radius 1mm. How many droplets will be formed?

Given :-

Radius of big drop,

$R = 6\,mm$

Radius of smaller drop,

$r = 1\,mm$

Number of droplets = ?

Solutions :-

$$\text{Number of droplets} = \frac{\text{Volm of big drop}}{\text{Volm of smaller drop}}$$

$$n = \frac{V_1}{V_2}$$

$$n = \frac{\frac{4}{3}\pi R^3}{\frac{4}{3}\pi r^3}$$

$$n = \frac{R^3}{r^3}$$

$$n = \frac{(6)^3}{(1)^3}$$

$$\boxed{n = 216}$$

8. A drop of mercury of radius 0.2cm is broken into 8 droplets of the same size. Find the work done if the surface tension of mercury is 435.5 dyne/cm.

Given :-

$R = 0.2 cm$

$R = 0.2 \times 10^{-2} m$

$n = 8$

Work done = ?

$T = 435.5 dyne/cm$

$T = \frac{435.5 \times 10^{-5}}{10^{-2}}$ 10^{-3}

$T = 435.5 \times 10^{-3} N/m$

Volume of single drop $= \frac{4}{3}\pi R^3$

Volume of single droplets $= \frac{4}{3}\pi r^3$

Now,

$$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$$

$$R^3 = nr^3$$

$$r = \frac{R}{\sqrt[3]{n}}$$

$$r = \frac{R}{\sqrt[3]{8}} = \frac{0.2 \times 10^{-2}}{2}$$

$$r = \frac{2\times10^{-3}}{2}$$

$$\boxed{r = 10^{-3}\,m}$$

$$\text{work done} = T \times dA$$

$$W.D. = T\times(n\times4\pi r^2 - 4\pi R^2)$$

$$= T\times4\pi\,(nr^2 - R^2)$$

$$W.D. = T\times4\pi\left(8\times(10^{-3})^2 - (2\times10^{-3})^2\right)$$

$$W.D. = 435.5\times10^{-3}\times4\times\pi\,(8\times10^{-6} - 4\times10^{-6})$$

$$W.D. = 435.5\times10^{-3}\times4\times3.142\times10^{-6}\times4$$

$$W.D. = 1742\times12.568\times10^{-3}\times10^{-6}$$

$$W.D. = 1742\times12.57\times10^{-9}$$

$$W.D. = 2.190\times10^{4}\times10^{-9}$$

$$\boxed{W.D. = 2.190\times10^{-5}\,J}$$

Calculations

1742×12.57

$$\begin{array}{r} 1742 \\ \times\ 12.57 \\ \hline 2.190\times10^{4} \\ \hline \end{array}$$

$$\begin{array}{r} 3.2410 \\ +\ 1.0993 \\ \hline 4.3403 \end{array}$$

Taking Antilog

2.190×10^{4}

9. Calculate the work done in blowing a soap bubble to a radius of 1 cm. The surface tension of soap solution is 2.5×10^{-2} N/m.

Given :-

W.D. = ?

R = 1 cm

$R = 1 \times 10^{-2}$ m

r = 0 $T = 2.5 \times 10^{-2}$ N/m

Solution :-

Work done $= T \times dA$

Final surface area of soap bubble,

$A = 2 \times 4\pi R^2$

$A = 8\pi R^2$

Change in area $= A - 0$

$= 8\pi R^2$

$W.D. = T \times dA$

$W.D. = 2.5 \times 10^{-2} \times 8\pi R^2$

$W.D. = 2.5 \times 10^{-2} \times 8 \times 3.142 \times (1 \times 10^{-2})^2$

$W.D. = 2.5 \times 10^{-2} \times 8 \times 3.142 \times 10^{-4}$

$W.D. = 20.0 \times 10^{-2} \times 3.142 \times 10^{-4}$

$W.D. = 62.840 \times 10^{-6}$

$W.D. = 62.85 \times 10^{-6}$ J