6. SURFACE TENSION

HOMEWORK SOLUTIONS

1. Given :

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

$l = 30$ cm $= 30 \times 10^{-2}$ m

To Find :

Surface tension (T) = ?

Formula :

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

Solution :

Length of contact,

$L = 2l$

$\therefore L = 2 \times 30 \times 10^{-2}$

$\therefore L = 0.6$ m

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

$$\therefore T = \frac{1.5 \times 10^{-2}}{0.6}$$

$$\therefore T = \frac{15 \times 10^{-2}}{6}$$

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

2. Given :

$r = 0.75$ cm $= 7.5 \times 10^{-3}$ m

$F = 6.6 \times 10^{-3}$ N

$\theta = 0^{\circ}$

To Find :

Surface tension (T) = ?

Formula :

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

Length of contact,

$L = 2(2\pi r)$

$\therefore L = 4\pi \times 7.5 \times 10^{-3}$

$\therefore L = \pi \times 30.0 \times 10^{-3}$ m

$$\therefore T = \frac{6.6}{\pi \times 30} \times \frac{10^{-3}}{10^{-3}}$$

$$\therefore T = \frac{6.6}{3.142 \times 3 \times 10}$$

$$\therefore T = \frac{2.2}{31.42}$$

$$\therefore T = \frac{22}{314.2}$$

$$\therefore T = \frac{11}{157.1}$$

$\therefore T = Al\,[\log 11 - \log 157.1]$

$$\therefore T = Al \begin{bmatrix} \bar{1}.0414 \\ -\ 2.1962 \end{bmatrix}$$

$\therefore T = Al\,(2.8452)$

$\therefore T = 7.001 \times 10^{-2}$

$\therefore T = 0.07001$ N/m

3. Given :

$l = 10$ cm

$\therefore b = 8$ cm

$t = 0.2$ cm

ST $= 0.070$ N/m

Solution :

Case (I)

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

$L = 2\,[L + B]$

$= 2\,[10 + 8]$

$= 2 \times 18$

$= 36 \times 10^{-2}$ m

$\therefore F = T \times L$

$= 36 \times 10^{-2} \times 0.070$

$= 2.52 \times 10^{-2}$ N

$F = 0.0252$ N

Case (II)

$L = 2\,[L + t]$

$= 2\,[10 + 0.2]$

$= 2 \times 10.2$

$= 20.4 \times 10^{-2}$ m

$\therefore F = T \times L$

$= 0.070 \times 20.4 \times 10^{-2}$

$= 1.43 \times 10^{-2}$

$F = 0.0143\ N$

4. Given :

$l = 10\ cm$

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

$T = 0.074\ N/m$

To Find :

Force (F) = ?

Formula :

$F = T \times L$

Solution :

$L = 2l$

$\therefore L = 2 \times 10 \times 10^{-2}$

$\therefore L = 20 \times 10^{-2}\ m$

$F = T \times L$

$\therefore F = 0.074 \times 20 \times 10^{-2}$

$\therefore F = 148 \times 10^{-4}\ N$

5. Given :

radius (r) = 3 cm

$\therefore r = 3 \times 10^{-2}\ m$

Force (F) = 0.03 N

To Find :

Surface Tension = ?

Formula :

$F = T \times L$

Solution :

$L = 2(2\pi r)$

$\therefore L = 4\pi r$

$F = T \times L$

$\therefore T = \frac{F}{L}$

$\therefore T = \frac{0.03}{4\pi \times 3 \times 10^{-2}}$

$\therefore T = \frac{3 \times 10^{-2}}{4\pi \times 3 \times 10^{-2}}$

$\therefore T = \frac{1}{4\pi}$

$\therefore T = 0.0795\ N/m$

6. Given :

$d = 1.0\ cm$

$\therefore r = 0.5\ cm = 5 \times 10^{-3}\ m$

$T = 0.035\ N/m$

To Find :

$dW = ?$

Formula :

$dW = T \times dA$

Solution :

Mass of 8 droplets = Mass of 1 drop

$\therefore \rho \times V$ (of 8 droplets) = $\rho \times V$ (of 1drop)

$\therefore 8 \times \frac{4\pi}{3} R^3 = \frac{4}{3} \pi r^3$ ....(R → radius of 1 droplet , r → radius of whole drop)

$\therefore R^3 = \frac{r^3}{8}$

$\therefore R^3 = \frac{(5 \times 10^{-3})^3}{(2)^3}$

$\therefore R = \frac{5 \times 10^{-3}}{2}$

$\therefore R = 2.5 \times 10^{-3}\ m$

dA = Area of droplets - Area of drop

$\therefore dA = (8 \times 4\pi R^2) - (4\pi r^2)$

$\therefore dA = [32\pi (2.5 \times 10^{-3})^2] - [4\pi (5 \times 10^{-3})^2]$

$\therefore dA = 4\pi [(8 \times 6.25 \times 10^{-6}) - (25 \times 10^{-6})]$

$\therefore dA = 4\pi \times 10^{-6} [50 - 25]$

$\therefore dA = 4\pi \times 25 \times 10^{-6}$

$\therefore dA = \pi \times 10^2 \times 10^{-6}\ m^2$

$\therefore dA = \pi \times 10^{-4}\ m^2$

$dW = T \times dA$

$\therefore dW = 0.035 \times 3.142 \times 10^{-4}$

$\therefore dW = 35 \times 3.142 \times 10^{-7}$

$\therefore dW = 109.97 \times 10^{-7}$

$\therefore dW = 1.0997 \times 10^{-5}\ J$

$\therefore dW = 1.1 \times 10^{-5}\ J$

7. Given :

r_1 = 0 cm

r_2 = 5 cm = 5×10^{-2} m

T = 3×10^{-2} N/m

To Find :

dW = ?

Formula :

dW = T x dA

Solution :

$dA = 2(4\pi r_2^2) - 2(4\pi r_1^2)$

$\therefore dA = 8\pi (r_2^2 - r_1^2)$

$\therefore dA = 8\pi [(25 \times 10^{-4}) - 0]$

$\therefore dA = 200 \times 3.142 \times 10^{-4}$

$\therefore dA = 2 \times 314.2 \times 10^{-4}$

$\therefore dA = 628.4 \times 10^{-4}\ m^2$

$dW = T \times dA$

$\therefore dW = 3 \times 10^{-2} \times 628.4 \times 10^{-4}$

$\therefore dW = 1885.2 \times 10^{-2} \times 10^{-4}$

$\therefore dW = 18.852 \times 10^{-4}$

$\therefore dW = 1.8852 \times 10^{-3}$ J

8. Given :

r_1 = 1 cm = 1×10^{-2} m

r_2 = 2 cm = 2×10^{-2} m

T = 30 dyne/cm

$\therefore$ T = 30×10^{-3} N/m

To Find :

dW = ?

Formula :

dW = T x dA

Solution :

$dA = 2(4\pi r_2^2) - 2(4\pi r_1^2)$

$\therefore dA = 8\pi (r_2^2 - r_1^2)$

$\therefore dA = 8 \times 3.142 \times [(2 \times 10^{-2})^2 - (1 \times 10^{-2})^2]$

$\therefore dA = 8 \times 3.142 \times 10^{-4} \times [2^2 - 1^2]$

$\therefore dA = 24 \times 3.142 \times 10^{-4}\ m^2$

$dW = T \times dA$

$\therefore dW = 30 \times 10^{-3} \times 24 \times 3.142 \times 10^{-4}$

$\therefore dW = 3 \times 10^{-6} \times 75.408$

$\therefore dW = 226.224 \times 10^{-6}$

$\therefore dW = 2.26224 \times 10^{-4}$ J

9. Given :

r = 1 mm = 1×10^{-3} m

No. of droplets = 10^6

T = 72 dyne / cm = 72×10^{-3} N/m

To Find :

dW = ?

Formula :

dW = T x dA

Solution :

Mass of droplets = Mass of drop

$\therefore$ ρ x V (of droplets) = ρ x V (of drop)

$\therefore 10^6 \times \frac{4}{3}\pi R^3 = \frac{4}{3}\pi r^3$

$\therefore R^3 = \frac{r^3}{10^6}$

$\therefore R^3 = \frac{(1 \times 10^{-3})^3}{(10^2)^3}$

$\therefore R = \frac{1 \times 10^{-3}}{10^2}$

$\therefore R = 1 \times 10^{-5}$

dA = Area of droplets - Area of drop

$\therefore dA = 10^6 (4\pi R^2) - (4\pi r^2)$

$\therefore dA = 4\pi [(10^6 \times (1 \times 10^{-5})^2 - (1 \times 10^{-3})^2]$

$\therefore dA = 4\pi [(10^6 \times 10^{-10}) - (10^{-6})]$

$\therefore dA = 4\pi [10^{-4} - 10^{-6}]$

$\therefore dA = 4\pi \times 10^{-4} [1 - 10^{-2}]$

$\therefore dA = 4\pi \times 10^{-4} [1 - 0.01]$

$\therefore dA = 4\pi \times 10^{-4} \times 0.99$

$dW = T \times dA$

$\therefore dW = 72 \times 10^{-3} \times 4 \times 3.142 \times 10^{-4} \times 0.99$

$\therefore$ dW = $288 \times 3.142 \times 0.99 \times 10^{-7}$

$\therefore$ dW = $28.8 \times 3.142 \times 9.9 \times 10^{-7}$

$\therefore$ dW = Al [log 28.8 + log 3.142 + log 9.9] $\times 10^{-7}$

$$\therefore dW = Al \left[\begin{array}{r} 1.4594 \\ +\ 0.4972 \\ +\ 0.9956 \\ \hline 2.9522 \end{array} \right] \times 10^{-7}$$

$\therefore$ dW = $Al\ (2.9522) \times 10^{-7}$

$\therefore$ dW = 8.958×10^{-5} J

$\therefore$ dW = $8.958 \times 10^{-5} \times 10^{7}$ ergs

$\therefore$ dW = 8.958×10^{2} ergs

$\therefore$ dW = 895.8 ergs

10. Given :

r = Radius of small drop

R = Radius of big drop

8 = No. of drops

To Find : Change in Surface Energy

Solution :

Vol. of 8 droplets = Vol. of original drop

$$8 \times \frac{4}{3} \pi r^3 = \frac{4}{3} \pi R^3$$

R = 2×4

R = 2×0.001

R = 0.002 m

Suface energy of original drop = $4\pi R^2 T$

$= 4 \times 3.142 \times (0.002)^2 \times 0.465$

$= 2.34 \times 10^{-5}$ J

Suface energy of 'n' droplets = $n4\pi r^2 T$

$= 8 \times 4 \times 3.142 \times 0.001 \times 0.46$

$= 4.67 \times 10^{-5}$ J

Change in surface energy

$= 4.67 \times 10^{-5} - 2.34 \times 10^{-5}$

$= 2.34 \times 10^{-5}$ J

11. Given :

Surface energy = 2π (Surface Tension)

= $2\pi T$ ($\because$ S.T. = T)

To Find :

diameter (D) = ?

Formula :

Surface Energy = $4\pi R^2 T$

Solution :

$\therefore$ Surface Energy = $4\pi R^2 T$

$2\pi T = 4\pi R^2 T$

$R^2 = \frac{2\pi T}{4\pi T}$

$R^2 = \frac{1}{2}$

$\therefore$ Diameter = 2.R

$D = 2 \times \frac{1}{\sqrt{2}}$

$= \sqrt{2}$

D = 1.414 m

12. Given :

d_1 = 30 cm

d_2 = 3 cm

T = 0.045 N/m

To Find : Work done

Formula :

dW = T x dA

Solution :

d_1 = 30 cm

$\therefore$ r_1 = 15 cm

$\therefore$ r_1 = 15×10^{-2} m

d_2 = 3 cm

$\therefore$ r_2 = 1.5 cm

$\therefore$ r_2 = 1.5×10^{-2} m

dA = $2\ [4\pi r_1^2 - 4\pi r_2^2]$

$\therefore$ dA = $8\pi\ (r_1^2 - r_2^2)$

$\therefore$ dA = $8\pi\ [(15 \times 10^{-2})^2 - (1.5 \times 10^{-2})^2]$

$\therefore$ dA = $8\pi\ (225 - 2.25) \times 10^{-4}$

$\therefore$ dA = $8\pi\ (222.75) \times 10^{-4}$

dW = T x dA

$\therefore$ dW = $0.045 \times 8 \times 3.142 \times 222.75 \times 10^{-4}$

$\therefore$ dW = Al [log45 + log8 + log3.142 + log222.75] $\times 10^{-7}$

$$\therefore dW = Al\begin{bmatrix} 1.6532 \\ 0.9031 \\ +\ 0.4972 \\ \underline{2.3478} \\ 5.4013 \end{bmatrix} \times 10^{-7}$$

$\therefore$ dW = 2.519×10^{-2} J

13. Given :

r = 0

R = 5 cm

R = 5×10^{-2} m

S.T. = 0.035 N/m

To Find :

dW = ?

Formula :

dW = T x dA

Solution :

dA = $2(4\pi R^2) - 2(4\pi r^2)$

$\therefore$ dA = $[8\pi(5)^2 - 8\pi(0)^2] \times 10^{-4}$ m

$\therefore$ dA = $200\pi \times 10^{-4}$

dW = T x dA

$\therefore$ dW = $0.035 \times 200\pi \times 10^{-4}$

$\therefore$ dW = $7 \times 3.142 \times 10^{-4}$

$\therefore$ dW = 2.1994×10^{-3} J

14. Given :

Length of slider (l) = 4cm

Increased breadth = 2 cm

T = 0.025 N

To Find : Work done (dW)

Force (F)

Formula :

dW = T x dA

F = T x L

Solution :

dW = T x dA

$\therefore$ dW = $0.025 \times [(4 \times 2) \times 2] \times 10^{-4}$

$\therefore$ dW = 0.4×10^{-4}

$\therefore$ dW = 4×10^{-5} J

F = T x L

$\therefore$ F = $0.025 \times 8 \times 10^{-2}$

$\therefore$ F = 0.2×10^{-2}

$\therefore$ F = 2×10^{-3} N

15. Given :

Length of wire (L) = 10 cm

Breadth of wire (B) = 0.1 cm

Tension (T) = 0.072 N/m

To Find : Work done (dW)

Formula :

dW = T x dA

Solution :

dA = 2 (10 x 0.1)

$\therefore$ = $2\ cm^2$

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

dW = T x dA

$\therefore$ dW = $0.072 \times 2 \times 10^{-4}$

$\therefore$ dW = 144×10^{-7} J

16. Given :

r = 10^{-3}

No. of droplets = 125

S.T. = 0.55 N/m

To Find :

Change in energy i.e work done

Formula :

dW = T x dA

Solution :

Mass of droplets = Mass of drop

$\therefore$ ρ x Vol. of droplet = ρ x Vol. of drop

$\therefore \quad 125 \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\therefore \quad R^3 = \frac{r^3}{125}$

$\therefore \quad R^3 = \frac{(10^{-3})^3}{(5)^3}$

$\therefore \quad R = \frac{10^{-3}}{5}$

$\therefore \quad R = 0.2 \times 10^{-3}$

dA = Area of droplets - Area of drop

$\therefore \quad dA = 125(4\pi R^2) - 4\pi r^2$

$\therefore \quad dA = 4\pi\,(125R^2 - r^2)$

$\therefore \quad dA = 4\pi\,(125 \times (0.2 \times 10^{-3})^2 - (10^{-3})^2\,]$

$\therefore \quad dA = 4\pi\,[\,(125 \times 0.04 \times 10^{-6}) - 10^{-6}]$

$\therefore \quad dA = 4\pi \times 10^{-6}\,[\,5 - 1\,]$

$\therefore \quad dA = 4\pi \times 4 \times 10^{-6}$

$dW = T \times dA$

$\therefore \quad dW = 0.55 \times 4\pi \times 4 \times 10^{-6}$

$\therefore \quad dW = 2.20 \times 4 \times 3.142 \times 10^{-6}$

$\therefore \quad dW = 8.8 \times 3.142 \times 10^{-6}$

$\therefore \quad dW = 27.6496 \times 10^{-6}$ J

17. Given :

d = 0.4 mm

r = 0.2 mm $= 2 \times 10^{-4}$ m

ρ = 850 kg/m³

T = 0.026 N/m

θ = 30°

g = 9.8 m/s²

To Find :

rise (h) = ?

Formula :

$$h = \frac{2T\cos\theta}{r\rho g}$$

Solution :

$$h = \frac{2T\cos\theta}{r\rho g}$$

$\therefore \quad h = \frac{2 \times 0.026 \times \cos 30}{2 \times 10^{-4} \times 850 \times 9.8}$

$\therefore \quad h = \frac{0.026 \times \sqrt{3}}{85 \times 98 \times 10^{-4} \times 2}$

$\left(\because \cos 30^\circ = \frac{\sqrt{3}}{2}\right)$

$\therefore \quad h = \frac{13 \times 10^{-3} \times 1.732}{85 \times 98 \times 10^{-4}}$

$\therefore \quad h = \frac{13 \times 17.32 \times 10^{-4}}{85 \times 98 \times 10^{-4}}$

$= Al\left[\begin{pmatrix} 1.1139 \\ 1.2385 \\ \hline 2.3524 \end{pmatrix} - \begin{pmatrix} 1.9294 \\ 1.9912 \\ \hline 3.9206 \end{pmatrix}\right]$

$= Al\begin{pmatrix} 2.3524 \\ -\,3.9206 \\ \hline \bar{2}.4318 \end{pmatrix}$

$= 2.70 \times 10^{-2}$ m

$\therefore h = 0.027$ m

18. Given :

r = 1 mm = 1×10^{-3} m

T = 0.55 N/m

θ = 140°

ρ = 13600 kg/m³

g = 9.8 m/s²

To Find :

error (h) = ?

Formula :

$$h = \frac{2T\cos\theta}{r\rho g}$$

Solution :

$$h = \frac{2T\cos\theta}{r\rho g}$$

$\therefore \quad h = \frac{2 \times 0.55 \times \cos 140^\circ}{1 \times 10^{-3} \times 13600 \times 9.8}$

$\therefore \quad h = \frac{1.10 \times (\sin 50)}{9.8 \times 1.36 \times 10}$

$(\because \cos\theta = \sin(90-\theta)$ and $\sin(-\theta) = -\sin\theta)$

$\therefore\ h = -\left[\frac{110 \times 0.7660}{98 \times 136}\right]$

$\therefore\ h = -\left[\frac{84.26}{98 \times 136}\right]$

$h = -Al\ [\log 84.26 - (\log 98 + \log 136)]$

$h = -Al\ [1.9256 - (1.9912 + 2.1335)]$

$h = -Al\ [1.9256 - (4.1247)]$

$h = -Al\ [\bar{3}.8009]$

$h = -6.322 \times 10^{-3} m$

$= -0.63221 \times 10^{-2} m$

19. Given :

$h_1 = 4.5\ cm = 4.5 \times 10^{-2}\ m$

$d_1 = 2\ mm$

$\therefore\ r_1 = 1\ mm = 1 \times 10^{-3}\ m$

$d_2 = 0.075\ cm$

$\therefore\ r_2 = (0.075/2) cm$

$\therefore\ r_2 = \frac{7.5}{2} \times 10^{-4}\ m$

To Find :

$h_2 = ?$

Formula :

$$h = \frac{2T \cos \theta}{r \rho g}$$

Solution :

$$h_1 = \frac{2T \cos \theta}{r_1 \rho g}$$

$$h_2 = \frac{2T \cos \theta}{r_2 \rho g}$$

$$\therefore\ \frac{h_1}{h_2} = \frac{r_2}{r_1}$$

$$\therefore\ \frac{4.5 \times 10^{-2}}{h_2} = \frac{7.5 \times 10^{-4}}{1 \times 10^{-3} \times 2}$$

$$\therefore\ h_2 = \frac{4.5 \times 10^{-5} \times 2}{7.5 \times 10^{-4}}$$

$$\therefore\ h_2 = \frac{3}{5} \times 10^{-1} \times 2$$

$\therefore\ h_2 = 0.6 \times 10^{-1} \times 2$

$\therefore\ h_2 = 1.2 \times 10^{-1}\ m$

$\therefore\ h_2 = 12\ cm$

20. Given :

$\rho = 900\ kg/m^2$

$h = 7\ mm = 7 \times 10^{-3}\ m$

$d = 2\ mm$

$r = 1\ mm = 1 \times 10^{-3}\ m$

$\theta = 25^o$

$g = 9.8\ m/s^2$

To Find :

$T = ?$

Formula :

$$h = \frac{2T \cos \theta}{r \rho g}$$

Solution :

$$h = \frac{2T \cos \theta}{r \rho g}$$

$$\therefore\ T = \frac{hr\rho g}{2 \cos \theta}$$

$$\therefore\ T = \frac{7 \times 10^{-3} \times 1 \times 10^{-3} \times 900 \times 9.8}{2 \times \cos 25}$$

$$\therefore\ T = \frac{7 \times 98 \times 90 \times 10^{-6}}{2 \times 0.9063}$$

$$\therefore\ T = \frac{343 \times 90}{9.063} \times 10^{-5}$$

$= Al\ [(\log 343 + \log 90) - \log 9.063)] \times 10^{-5}$

$$= Al\left[\begin{pmatrix} 2.5353 \\ +\ 1.9542 \\ \hline 4.4895 \end{pmatrix} - (0.9573)\right] \times 10^{-5}$$

$$\therefore\ T = Al\begin{pmatrix} 4.4895 \\ -0.9573 \\ \hline 3.5322 \end{pmatrix} \times 10^{-5}$$

$\therefore\ T = Al\ (3.5322) \times 10^{-5}$

$\therefore\ T = 3.406 \times 10^{-2}\ N/m$

$\therefore\ T = 0.034\ N/m$

21. Given :

$h = 4.5\ cm = 4.5 \times 10^{-2}\ m$

$T = 72\ dynes/cm = 72 \times 10^{-3}\ N/m$

$\theta = 15^o$

$\rho = 1000\ kg/m^2$

$g = 9.8\ m/s^2$

To Find :

$r = ?$

Formula :

$$h = \frac{2T\cos\theta}{r\rho g}$$

Solution :

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\therefore\ r = \frac{2T\cos\theta}{h\rho g}$$

$$\therefore\ r = \frac{2 \times 72 \times 10^{-3} \times \cos 15}{4.5 \times 10^{-2} \times 10^{3} \times 9.8}$$

$$\therefore\ r = \frac{144 \times 0.9659 \times 10^{-3}}{4.5 \times 9.8 \times 10}$$

$$\therefore\ r = \frac{144 \times 96.59}{45 \times 98} \times 10^{-4}$$

$= Al\,[(\log 144 + \log 96.59) - (\log 45 + \log 98)] \times 10^{-4}$

$$= Al\left[\begin{pmatrix} 2.1584 \\ \underline{1.9849} \\ 4.1433 \end{pmatrix} - \begin{pmatrix} 1.6532 \\ \underline{1.9912} \\ 3.6444 \end{pmatrix}\right] \times 10^{-4}$$

$$= Al\begin{pmatrix} 4.1433 \\ -3.6444 \end{pmatrix} \times 10^{-4}$$

$= Al\ (0.4989)$

$= 3.154 \times 10^{-4}$ m

$\therefore\ r = 0.315$ mm

22. Given :

d = 3 mm

$r = \frac{d}{2} = 1.5 \times 10^{-3}$ m

T = 0.48 N/m

$\theta = 140^0$

$\rho = 13600$ kg/m^3

g = 9.8 m/s^2

$R_1 = 76.56$ cm

To Find :

$R_1 + h = ?$

Formula :

$$h = \frac{2T\cos\theta}{\rho g r}$$

Solution :

$$\therefore\ h = \frac{2 \times 0.48 \times \cos 140}{13600 \times 9.8 \times 1.5 \times 10^{-3}}$$

$$\therefore\ h = \frac{2 \times 0.48 \times \cos(90 + 50)}{13.6 \times 9.8 \times 1.5}$$

$$\therefore\ h = \frac{2 \times 0.48 \times (-\sin 50)}{13.6 \times 9.8 \times 1.5}$$

$$\therefore\ h = \frac{-0.96 \times 0.766}{13.6 \times 9.8 \times 1.5}$$

$\therefore\ h = -Al\,[\bar{1}.9823 + \bar{1}.8842 - 1.1335 - 0.9912 - 0.1761]$

$\therefore\ h = -Al\,[\bar{1}.8665 - 2.3008]$

$\therefore\ h = -Al\,[\bar{3}.5657]$

$\therefore\ h = -3.679 \times 10^{-3}$ m

$\therefore\ h = -0.3679$ cm

The mercury level drops down.

Hence, the actual barometric reading is to be added to the observed barometric reading.

$\therefore\ R_1 + h = 76.56 + 0.3679 = 76.93$ m.

23. Given :

d = 0.25 mm

R = 0.125×10^{-3} m

T = 0.024 N/m

h = 4 cm = 0.04 m

$\theta = 20^0$

g = 9.8 m/s^2

To Find :

e = ?

Formula :

$$h = \frac{2T\cos\theta}{\rho g r}$$

Solution :

$$\therefore\ e = \frac{2T\cos\theta}{hgr}$$

$$\therefore\ = \frac{2 \times 0.0245 \times \cos 20}{0.04 \times 9.8 \times 0.125 \times 10^{-3}}$$

$$= \frac{0.0245 \times 0.9397 \times 10^{3}}{0.02 \times 9.8 \times 0.125}$$

$$= \frac{245 \times 9397 \times 10^{-4} \times 10^{-4} \times 10^{3}}{2 \times 98 \times 125 \times 10^{-2} \times 10^{-1} \times 10^{-3}}$$

$$= \frac{245 \times 9397 \times 10^{-5} \times 10^{6}}{196 \times 125}$$

$$= \frac{245 \times 9397 \times 10}{196 \times 125}$$

= A*l* [log 245 + log 9397 + log 10 – (log 196 + log 125)]

$$= Al\left[\begin{pmatrix} 2.3892 \\ +\ 3.9730 \\ +\ 1.0000 \\ \hline 7.3622 \end{pmatrix} - \begin{pmatrix} 2.2923 \\ +\ 2.0969 \\ \hline 4.3892 \end{pmatrix}\right]$$

= A*l* (7.3622 – 4.3892)

= A*l* (2.9730)

$\therefore \rho$ = 939.7 kg/m^3

24. Given :

d = 3 mm

R = 1.5 mm

= 1.5×10^{-3} m

θ = 135^0

ST = 0.460 N/m

ρ = 13.6 g/cc

= 13.6×10^3 kg/m^3

g = 9.8 m/s^2

To Find :

error in reading = ?

Solution :

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

$$\therefore e = \frac{2T\cos\theta}{h\rho g}$$

$$\therefore = \frac{2 \times 0.460 \times \cos(90 + 45)}{1.5 \times 10^{-3} \times 13.6 \times 10^{3} \times 9.8}$$

$$= \frac{2 \times 0.460 \times \cos(-\sin 45)}{1.5 \times 10^{-3} \times 13.6 \times 10^{3} \times 9.8}$$

$$= \frac{0.920 \times (-0.707)}{199.92}$$

$$= \frac{-0.650}{199.92}$$

= –0.00325 m

= – 3.25 mm

Negative sign indicates that mercury level will be lowerd by 3.25 mm.

25. Given :

h_1 = 9 cm = 9×10^{-2} m

r_1 = 0.02 cm = 2×10^{-4} m

r_2 = 0.03 cm = 3×10^{-4} m

To Find : h_2

Formula : $h = \dfrac{2T\cos\theta}{r\rho g}$

Solution :

$$h_1 = \frac{2T\cos 0}{r_1\rho g}$$

$$\therefore h_2 = \frac{2T\cos\theta}{r_2\rho g}$$

$\therefore h_1r_1 = h_2r_2$

$\therefore 9 \times 0.02 = h_2 \times 0.03$

$$\therefore h_2 = \frac{9 \times 0.02}{0.03}$$

$$\therefore h_2 = \frac{9 \times 2}{3}$$

$\therefore h_2$ = 6 cm

26. Given :

h = 7 cm = 7×10^{-2} m

S.T. = 70 dynes/cm

$\therefore$ S.T. = 70×10^{-3} N/m

g = 9.8 m/s^2

ρ = 10^3 kg/m^3

θ = 0^o

To Find : radius (r)

Formula :

$$h = \frac{2T\cos\theta}{r\rho g}$$

Solution :

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\therefore r = \frac{2T\cos\theta}{h\rho g}$$

$\therefore \quad r = \dfrac{2 \times 70 \times 10^{-3} \times \cos 0}{7 \times 10^{-2} \times 9.8 \times 10^{3}}$

$\therefore \quad r = \dfrac{2 \times 10^{-2}}{10^{-2} \times 9.8} \times 10^{-3}$

$\therefore \quad r = \dfrac{2}{9.8} \times 10^{-3}$

$\therefore \quad r = \dfrac{1}{4.9} \times 10^{-3}$

$\therefore \quad r = 0.2041 \times 10^{-3}$ m

$\therefore \quad r = 0.2041$ mm

27. Given :

$(P_i - P_o) = 1.02$

$(P_i - P_o) = 1.03$

To Find :

$\dfrac{V_1}{V_2} = ?$

Formula :

$(P_i - P_o) \propto \dfrac{1}{r}$

Solution :

Assume,

$P_o = 1$ atm

$(P_i - P_o) = 1.02$ atm

$(P_i)_1 = (1.02 - 1)$

$(P_i)_1 = 0.02$ atm ...(i)

Similarly,

$(P_i - P_o)_2 = 1.03$ atm

$(P_i)_2 = (1.03 - 1)$

$(P_i)_2 = 0.03$ atm ...(ii)

Since,

$P_i \propto \dfrac{1}{r}$

$\therefore \quad \dfrac{(P_i)_1}{(P_i)_2} = \dfrac{r_2}{r_1} = \dfrac{0.02}{0.03} = \dfrac{2}{3}$

$\therefore \quad \dfrac{r_1}{r_2} = \dfrac{3}{2}$

Since,

Volume $\propto r^3$

$\therefore \quad \dfrac{V_1}{V_2} = \left(\dfrac{r_1}{r_2}\right)^3 = \left(\dfrac{3}{2}\right)^3$

$\therefore \quad \dfrac{V_1}{V_2} = \dfrac{27}{8}$

28. Given :

$r_1 = 2$ mm

$r_2 = 4$ mm

$\Delta P_1 = (P_i - P_o)_1$

$= 70$ N/m^2

To Find :

$\Delta P_2 = (P_i - P_o)_2 = ?$

Formula :

$\Delta P \propto \dfrac{1}{r}$

Solution :

Assume,

$\Delta P = (P_i - P_o) = \dfrac{4T}{r}$

...(Excess presuure inside drop)

$\therefore \quad \Delta P \propto \dfrac{1}{r}$

$\therefore \quad \dfrac{\Delta P_1}{\Delta P_2} = \dfrac{r_2}{r_1}$

$\therefore \quad \dfrac{70}{\Delta P_2} = \dfrac{4}{2}$

$\therefore \quad \Delta P_2 = 35$ N/m^2

29. Given :

$r = 0.1$ mm

$= 10^{-4}$ m

$h = 10$ m

$P_o = 10^5$ N/m^2

$g = 10$ m/s^2

To Find :

$P_i = ?$

Formula :

$(P_i - P_o) = h\rho g$

Solution :

$P_i - P_o = h\rho g$

$P_i - 10^5 = 10 \times 10^3 \times 10$

...($\rho_w = 1000$ kg/m^3)

$P_i = 10^5 + 10^5$

$P_i = 2 \times 10^5$ N/m^2

30. Given :

r = 0.1 mm

= 10^{-4} m

T = 0.07 N/m

To Find :

P_i = ?

Formula :

$$(P_i - P_o) = \frac{2T}{r}$$

Solution :

Excess pressure inside bubble is given by,

$$(P_i - P_o) = \frac{2T}{r}$$

$$(P_i - P_o) = \frac{2 \times 0.07}{10^{-4}}$$

$P_i = 2 \times 7 \times 10^2 + P_o$

$= 0.014 \times 10^5 + 10^5$

$= (0.014 + 1) \times 10^5$

$P_i = 1.0014 \times 10^5$ N/m^2