Test Paper 5

1. Oil is sprinkled on sea waves to calm them. Why?

Ans. Since the surface tension of sea-water without oil is greater than the oily water, therefore the water without oil pulls the oily water against the direction of breeze, and sea waves calm down.

2. A drop of oil placed on the surface of water spreads out, but a drop of water placed on oil contracts. Why?

Ans. Since the cohesive forces between the oil molecules are less than the adhesive force between the oil molecules and the drop of oil spreads out and reverse holds for drop of water.

3. Water rises in a capillary tube but mercury falls in the same tube. Why?

Ans. $$h = \frac{2S\cos\theta}{r\rho g}$$

For mercury – glass surface, θ is obtuse hence cos θ is negative, hence h is negative hence mercury will depress below the level of surrounding liquid.

4. What should be the pressure inside a small air bubble of 0.1mm radius situated just below the water surface? Surface tension of water = 7.2×10^{-2} N/m and atmospheric pressure = 1.013×10^{5} N/m^2?

Ans. *Given*: $S = 7.2 \times 10^{-2}\, Nm^{-1}$

$R = 0.1mm = 0.1 \times 10^{-3}\, m$

$P_1 = 1.013 \times 10^{5}\, Nm^{-2}$

To find: $P_2 = ?$

Sol^n: *Excess pressure inside drop is*

$$P_2 - P_1 = \frac{2S}{R}$$

$$P_2 - 1.013 \times 10^5 = \frac{2 \times 7.2 \times 10^{-2}}{0.1 \times 10^{-3}}$$

$$P_2 = 1.44 \times 10^3 + 1.013 \times 10^5$$

$$= 1.027 \times 10^5\, Pa$$

5. Why is a soap solution a better cleansing agent than ordinary water?

Ans. Since a cloth has narrow spaces in the form of fine capillaries, capillary rise is $h = \dfrac{2S\cos\theta}{r\rho g}$

Now, addition of soap to water reduces the angle of contact θ, this will increase cosθ and hence the value of h. that is, the soap water will rise more in narrow spaces in the cloth and clean fabrics better than water alone.

6. The antiseptics used for cuts and wounds in human flesh have low surface tension. Why?

Ans. Since the surface tension of antiseptics is less, they spread more on cuts and wounds and as a result, cut or wound is healed quickly.

7. If the radius of a soap bubble is r and surface tension of the soap solution is T. Keeping the temperature constant, what is the extra energy needed to double the radius of soap bubble?

Ans. $Case\,1: r_1 = r, S = S$

$$A_1 = 4\pi r^2$$

$$Energy\ required\ to\ blow\ soap\ bubble, E_1 = 2SA_1 = 8\pi r^2 S$$

$Case\,2: r_2 = 2r, S = S$

$$A_2 = 4\pi(2r)^2 = 16\pi r^2$$

$$Energy\ required\ to\ blow\ soap\ bubble, E_2 = 2SA_2 = 32\pi r^2 S$$

$$Extra\ energy\ required = E_2 - E_1$$

$$= 32\pi r^2 S - 8\pi r^2 S$$

$$= 24\pi r^2 S$$

8. Find the work done in breaking a water drop of radius 1 mm into 1000 drops. Given the surface tension of water is 72×10^{-3} N/m?

Ans. $Given: \quad S = 72\times10^{-3}\,Nm^{-1}$

$$R = 10^{-3}\,m$$

$To\ find: W = ?$

$Sol^n: \quad Let\ \ r - radius\ of\ small\ drop$

$$R - radius\ of\ big\ drop$$

$$Now,\ \frac{4}{3}\pi R^3 = 1000\times\frac{4}{3}\pi r^3$$

$$R = 10r$$

$$r = 10^{-4}\,m$$

$$Surface\ area\ of\ big\ drop = 4\pi R^2 = 4\times3.14\times\left(10^{-3}\right)^2 = 12.56\times10^{-6}\,m^2$$

$$Surface\ area\ of\ 1000\ small\ drops = 10004\pi r^2 = 4000\times3.14\times\left(10^{-4}\right)^2 = 12.56\times10^{-5}\,m^2$$

$$Increase\ in\ surface\ area, \Delta A = 12.56\times10^{-5} - 12.56\times10^{-6} = 113.04\times10^{-6}\,m^2$$

$$W = S\times\Delta A = 72\times10^{-3}\times113.04\times10^{-6} = 8138\times10^{-8}\,J$$

9. What is the energy stored in a soap babble of diameter 4 cm, given the surface tension = 0.07 N/m?

Ans. $Diameter\ of\ soap\ bubble = 4cm = 4\times10^{-2}\,m$

$$Radius\ of\ soap\ bubble, r = 2\times10^{-2}\,m$$

$$Increase\ in\ surface\ area, A = 2\times4\pi r^2 = 2\times4\times3.14\times\left(2\times10^{-2}\right)^2 = 100.48\times10^{-4}\,m^2$$

$$Energy\ stored = SA = 0.07\times100.48\times10^{-4} = 7\times10^{-4}\,J$$

10. What is the work done in splitting a drop of water of 1 mm radius into 64 droplets? Given the surface tension of water is 72×10^{-3} N/m^2?

Ans. $Given: \ S = 72\times10^{-3} Nm^{-1}$

$R = 10^{-3} m$

$To\ find: \ W = ?$

$Sol^n: \ Let\ r - radius\ of\ small\ drop$

$R - radius\ of\ big\ drop$

$Now, \ \frac{4}{3}\pi R^3 = 64\times\frac{4}{3}\pi r^3$

$R = 4r$

$r = 0.25\times10^{-3} m$

$Surface\ area\ of\ big\ drop = 4\pi R^2 = 4\times3.14\times\left(10^{-3}\right)^2 = 12.56\times10^{-6} m^2$

$Surface\ area\ of\ 64\ small\ drops = 64\times4\pi r^2 = 256\times3.14\times\left(0.25\times10^{-3}\right)^2 = 50.24\times10^{-6} m^2$

$Increase\ in\ surface\ area, \Delta A = 50.24\times10^{-6} - 12.56\times10^{-6} = 37.68\times10^{-6} m^2$

$W = S\times\Delta A = 72\times10^{-3}\times37.68\times10^{-6} = 2712\times10^{-9} J$

11. Why should detergents have small angles of contact?

Ans. $h = \frac{2S\cos\theta}{r\rho g}$

Now If θ→ Small then Cos θ is large and if detergents should have smaller angle of contact then detergent will pentrate more in the cloth and clean better.

12. Show that if two soap bubbles of radii a and b coalesce to from a single bubble of radius c. If the external pressure is P, show that the surface tension T of soap solution is $T = \frac{P\left(c^3 - a^3 - b^3\right)}{4\left(a^2 + b^2 - c^2\right)}$

Ans. Pressure inside the bubble of radius a, $P_1 = P + \frac{4T}{a}$

Volume of bubble of radius a, $V_1 = \frac{4}{3}\pi a^3$

Pressure inside the bubble of radius b, $P_2 = P + \frac{4T}{b}$

Volume of bubble of radius b, $V_2 = \frac{4}{3}\pi b^3$

Pressure inside the bubble of radius c, $P_3 = P + \frac{4T}{c}$

Volume of bubble of radius c, $V_3 = \frac{4}{3}\pi c^3$

Since, temperature remains the same during the change, from Boyle's Law

$$P_1V_1 + P_2V_2 = P_3V_3$$

$$\left(P + \frac{4T}{a}\right)\frac{4}{3}\pi a^3 + \left(P + \frac{4T}{b}\right)\frac{4}{3}\pi b^3 = \left(P + \frac{4T}{c}\right)\frac{4}{3}\pi c^3$$

$$\left(P + \frac{4T}{a}\right)a^3 + \left(P + \frac{4T}{b}\right)b^3 = \left(P + \frac{4T}{c}\right)c^3$$

$$Pa^3 + 4Ta^2 + Pb^3 + 4Tb^2 = Pc^3 + 4Tc^2$$

$$4T(a^2 + b^2 - c^2) = P(c^3 - a^3 - b^3)$$

$$T = \frac{P(c^3 - a^3 - b^3)}{4(a^2 + b^2 - c^2)}$$