High Level Problems (HLP)

SUBJECTIVE QUESTIONS

1. A capillary of radius r is lowered into a wetting agent with surface tension α and density d. Determine the height h_0 to which the liquid will rise in the capillary. Calculate the work done by surface tension and the potential energy acquired by the liquid in the capillary and compare the two. Explain the difference in the results obtained.

2. A U-tube is made up of capillaries of bores 1 mm and 2 mm respectively. The tube is held vertically and partially filled with a liquid of surface tension 49 dyne/cm and zero contact angle. Calculate the density of the liquid if the difference in the levels of the meniscus is 1.25 cm.

3. A film of soap solution is formed on a loop frame loop of 6.28 cm long thread is gently put on the film and the film is broken with a needle inside the loop. The thread loop takes the shape of a circle. Find the tension in the thread. Surface tension of soap solution = 0.030 N/m.

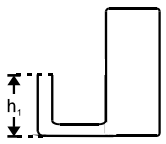
4. What is the excess pressure inside a bubble of soap solution of radius 5.0 mm, given that the surface tension of soap solution is 2.5×10^{-2} N/m. If an air bubble of the same dimension were formed at a depth of 40.0 cm inside a container containing the soap solution (of relative density 1.2) what would be pressure inside the bubble. [1 atm = 1.01×10^5 N/m^2]

5. A mercury drop shaped as round tablet of radius 'R' and thickness 'h' is located between two horizontal glass-plates. Assuming h << R, find the expression in weight which has placed on the upper plate to diminish the distance between the plates 'n' times. The angle of contact = θ. Calculate the weight if R = 2.0 cm, h = 0.38 mm, n = 2 and θ = 135º. Surface tension of Hg = 0.49 N/m.

6. The lower end of a capillary of radius r = 0.2 mm and length ℓ = 8 cm is immersed in water whose temperature is constant and equal to T_{low} = 0ºC. The temperature of the upper end of the capillary is T_{up} = 100ºC. Determine the height h to which the water in the capillary rises, assuming that the thermal conductivity of the capillary is much higher than the thermal conductivity of water in it. The heat exchange with the ambient should be neglected.
Use the following temperature dependence of the surface tension of water :

T, ºC	0	20	50	90
σ, mN/m	76	73	67	60

7. A capillary tube of radius r and height h_1 is connected to a broad tube as shown in fig. The broad tube is gradually filled with drops of water falling at equal intervals. Plot the changes in the levels of the water in both tubes with time and changes in the difference between these levels. Calculate the maximum water level in the broad-tube and maximum difference in levels. The surface tension of water is α.



8. If the radius and surface tension of a spherical soap bubble be 'R' & 'T' respectively, show that the charge required to double its radius would be, $8\pi R\,[\varepsilon_0 R[7\,PR + 12\,T]]^{1/2}$. (Where P is the atmospheric pressure and process isothermal)

9. A conical glass capillary tube A of length 0.1 m has diameters 10^{-3} m and 5×10^{-4} m at the ends. When it is just immersed in a liquid at 0ºC with larger diameter in contact with it, the liquid rises to 8×10^{-2} m in the tube. In another cylindrical glass capillary tube B, when immersed in the same liquid at 0ºC, the liquid rises to 6×10^{-2} m height. The rise of liquid in the tube B is only 5.5×10^{-2} m when the liquid is at 50ºC. Find the rate at which the surface tension changes with temperature, considering the change to be linear. The density of liquids is $(1/14) \times 10^4$ kg/m^3 and the angle of contact is zero. (Effect of temperature on the density of liquid and glass is negligible). (g = 9.8 N/kg.) **[REE - 1994]**

10. The limbs of a manometer consists of uniform capillary tubes of radii 1.44×10^{-3} m and 7.2×10^{-4} m. Find out the correct pressure difference if the level of the liquid in the narrower tube stands 0.2 m above that in the broader tube. (density = 10^3 kg/m^3, surface tension = 72×10^{-3} N/m). (take g = 9.8 m/s^2) **[REE - 1985]**

11. A glass capillary sealed at the upper end is of length 0.11 m and internal diameter 2×10^{-5} m. Tube is immersed vertically into a liquid of surface tension 5.06×10^{-2} N/m. To what length has the capillary to be immersed so that the liquid level inside and outside the capillary becomes the same. What will happen to the water level inside the capillary if the seal is now broken. Assume isothermal condition in the tube. (Use g = 10 m/s^2) **[REE - 1993]**

12. Find the attraction force between two parallel glass plates separated by a distance h = 0.10 mm, after a water drop of mass m = 70 mg was introduced between them. The wetting is assumed to be complete.

13. Two vertical plates submerged, partially in a wetting liquid form a wedge with a very small angle $\delta\varphi$. The edge of this wedge is vertical. The density of the liquid is ρ, its surface tension is α, the contact angle is θ. Find the height h, to which the liquid rises, as a function of the distance x from the edge.

14. A water drop falls in air with a uniform velocity. Find the difference between the curvature radii of the drops surface at the upper and lower points of the drop separated by the distance h = 2.3 mm.

15. Bubbles are made by dipping a circular ring of radius b in a soap solution and then blowing air on the film formed on the ring. Assume that the blown air is in the form of a cylinder of radius b. It has speed v and stops after striking the surface of the bubble being formed. The bubble grows spherically. Let the radius R of the bubble (>> b), so that the air strikes the bubble surface perpendicularly. The surface tension of the solution is T and air density is ρ. Obtain the radius of the bubble when it separates from the ring in terms of the given parameters (neglect the mass of the bubble). **[JEE 2003, 4/60]**

HLP Answers

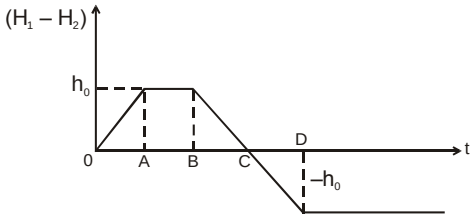
1. $\left[\frac{2\alpha}{dgr}, \frac{4\pi\alpha^2}{dg}, \frac{2\pi\alpha^2}{dg}\right]$ **2.** 0.7991 g/cm^3

3. 6×10^{-4} N

4. 20 N/m^2, 1.05714×10^5 N/m^2

5. 0.7 kg **6.** 6.4 cm

7.



Maximum height = $h_1 + h_0$

Maximum difference in level = h_0 where $h_0 = \frac{2\alpha}{dgr}$.

9. -1.4×10^{-4} N/(m – ºC)

10. 1860 N/m^2

11. $\approx$ 0.01 m, liquid will rise to top and radius of meniscus will be 1.012×10^{-4} m

12. $F \approx 2\alpha m/\rho h^2 = 1.0$ N

13. $h = 2a\cos\theta / \rho g x \delta\varphi$

14. $R_2 - R_1 \approx 1/8\rho g h^3/\alpha = 0.20$ mm

15. $\frac{4T}{\rho v^2}$