Exercise-1

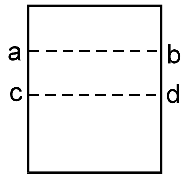
Marked Questions can be used as Revision Questions.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : Surface tension, Surface energy and capillary rise

A-1. A tube of 1 mm bore is dipped into a vessel containing a liquid of density 0.8 g/cm^3, surface tension 30 dyne/cm and angle of contact zero. Calculate the length which the liquid will occupy in the tube when the tube is held (a) vertical (b) inclined to the vertical at an angle of 30º.

A-2. A soap film is stretched over a rectangular vertical wire frame as shown in the figure, what forces hold section abcd in equilibrium ?



A-3. A mercury drop of radius 1.0 cm is sprayed into 10^6 droplets of equal size. Calculate the energy expanded. (Surface tension of mercury = 32×10^{-2} N/m).

A-4. A film of water is formed between two straight parallel wires each 10 cm long and at separation 0.5 cm. Calculate the work required to increase 1 mm distance between wires. Surface tension = 72×10^{-3} N/m.

Section (B) : Excess Pressure in drops and bubble

B-1. A soap bubble has radius R and surface tension S, How much energy is required to double the radius without change of temperature.

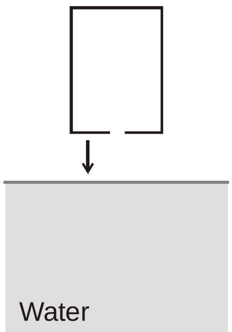
B-2. The work done in blowing a bubble of volume V is W, then what is the work done in blowing a soap bubble of volume 2V ?

B-3. Find the excess pressure inside a drop of mercury of radius 2 mm, a soap bubble of radius 4 mm and an air bubble of radius 4 mm formed inside a tank of water. Surface tension of mercury is 0.465 N/m and soap solution and water are, 0.03 N/m and 0.076 N/m respectively.

B-4_ Two identical soap bubbles each of radius r and of the same surface tension T combine to form a new soap bubble of radius R. The two bubbles contain air at the same temperature. If the atmospheric pressure is p_0 then find the surface tension T of the soap solution in terms of p_0, r and R. Assume process is isothermal.

B-5. A spherical drop of water has 1mm radius. If the surface tension of the water is 50×10^{-3} N/m, then find the difference of pressure between inside and outside the spherical drop is :

B-6. An empty container has a circular hole of radius r at its bottom. The container is pushed into water very slowly as shown. To what depth the lower surface of container (from surface of water) can be pushed into water such that water does not flow into the container ?

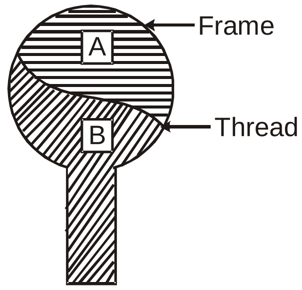


(Surface tension of water = T, density of water = ρ)

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : Surface tension, Surface energy and capillary rise

A-1. A thread is tied slightly loose to a wire frame as shown in the figure. And the frame is dipped into a soap solution and taken out. The frame is completely covered with the film. When the portion A is punctured with a pin, the thread :



(A) becomes convex towards A
(B) becomes concave towards A
(C) remains in the initial position
(D) either (A) or (B) depending on size of A w.r.t. B

A-2. In a surface tension experiment with a capillary tube water rises upto 0.1 m. If the same experiment is repeated in an artificial satellite, which is revolving around the earth ; water will rise in the capillary tube upto a height of :

(A) 0.1 m (B) 0.2 m (C) 0.98 m (D) full length of tube

A-3. A thin metal disc of radius r floats on water surface and bends the surface downwards along the perimeter making an angle θ with vertical edge of the disc. If the disc displaces a weight of water W and surface tension of water is T, then the weight of metal disc is :

(A) $2\pi rT + W$ (B) $2\pi rT\cos\theta - W$ (C) $2\pi rT\cos\theta + W$ (D) $W - 2\pi rT\cos\theta$

A-4. The surface tension of a liquid is 5 Newton per metre. If a film is held on a ring of area 0.02 metres^2, its surface energy is about :

(A) 5×10^{-2} J (B) 2.5×10^{-2} J (C) 2×10^{-1} J (D) 3×10^{-1} J

A-5. The radii of the two columns is U-tube are r_1 and r_2. When a liquid of density ρ (angle of contact is 0°) is filled in it, the level difference of liquid in two arms is h. The surface tension of liquid is: (g = acceleration due to gravity) :

(A) $\frac{\rho g h r_1 r_2}{2(r_2 - r_1)}$ (B) $\frac{\rho g h (r_2 - r_1)}{2 r_1 r_2}$ (C) $\frac{2(r_2 - r_1)}{\rho g h r_1 r_2}$ (D) $\frac{\rho g h}{2(r_2 - r_1)}$

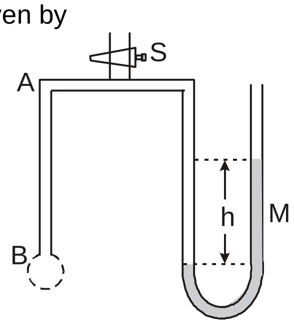
A-6. Water rises in a capillary tube to a height h. it will rise to a height more than h

(A) on the surface of sun (B) in a lift moving down with an acceleration
(C) at the poles (D) in a lift moving up with an acceleration.

A-7. Insects are able to run on the surface of water because :

(A) insects have less weight
(B) insects swim on water
(C) of the Archimede's upthrust
(D) surface tension makes the surface behave as elastic membrane.

A-8. A tube of fine bore AB is connected to a manometer M as shown. The stop cock S controls the flow of air. AB is dipped into a liquid whose surface tension is σ. On opening the stop cock for a while, a bubble is formed at B and the manometer level is recorded, showing a difference h in the levels in the two arms. if ρ be the density of manometer liquid and r the radius of curvature of the bubble, then the surface tension σ of the liquid is given by



(A) ρhrg (B) $2\rho hgr$ (C) $4\rho hrg$ (D) $\frac{rh\rho g}{4}$

A-9. Two parallel glass plates are dipped partly in the liquid of density 'd' keeping them vertical. If the distance between the plates is 'x', Surface tension for liquid is T & angle of contact is θ then rise of liquid between the plates due to capillary will be :

(A) $\frac{T\cos\theta}{xd}$ (B) $\frac{2T\cos\theta}{xdg}$ (C) $\frac{2T}{xdg\cos\theta}$ (D) $\frac{T\cos\theta}{xdg}$

Section (B) : Excess Pressure in drops and bubble

B-1. When charge is given to a soap bubble, it shows :

(A) a decrease in size (B) no change in size (C) an increase in size

(D) sometimes an increase and sometimes a decreases in size

B-2. A water drop is divided into 8 equal droplets. The pressure difference between the inner and outer side of the big drop will be :

(A) same as for smaller droplet (B) 1/2 of that for smaller droplet

(C) 1/4 of that for smaller droplet (D) twice that for smaller droplet

B-3. An air bubble of radius r in water is at a depth h below the water surface at some instant. If P is atmospheric pressure, d and T are density and surface tension of water respectively, the pressure inside the bubble will be :

(A) $P + h\,dg - \frac{4T}{r}$ (B) $P + h\,dg + \frac{2T}{r}$ (C) $P + h\,dg - \frac{2T}{r}$ (D) $P + h\,dg + \frac{4T}{r}$

B-4. The work done to get n smaller equal size spherical drops from a bigger size spherical drop of water is proportional to :

(A) $\left(\frac{1}{n^{2/3}}\right) - 1$ (B) $\left(\frac{1}{n^{1/3}}\right) - 1$ (C) $n^{1/3} - 1$ (D) $n^{4/3} - 1$

B-5. Two unequal soap bubbles are formed one on each side of a tube closed in the middle by a tap. What happens when the tap is opened to put the two bubbles in communication ?

(A) No air passes in any direction as the pressures are the same on two sides of the tap

(B) Larger bubble shrinks and smaller bubble increases in size till they become equal in size

(C) Smaller bubble gradually collapses and the bigger one increases in size

(D) None of the above

B-6. A soap bubble in vacuum has a radius of 3 cm and another soap bubble in vacuum has a radius of 4 cm. If the two bubbles coalesce under isothermal conditions then the radius of the new bubble is :

(A) 2.3 cm (B) 4.5 cm (C) 5 cm (D) 7 cm

B-7. A cylinder with a movable piston contains air under a pressure p_1 and a soap bubble of radius 'r'. The pressure p_2 to which the air should be compressed by slowly pushing the piston into the cylinder for the soap bubble to reduce its size by half will be : (The surface tension is σ, and the temperature T is maintained constant)

(A) $\left[8p_1 + \frac{24\sigma}{r}\right]$ (B) $\left[4p_1 + \frac{24\sigma}{r}\right]$ (C) $\left[2p_1 + \frac{24\sigma}{r}\right]$ (D) $\left[2p_1 + \frac{12\sigma}{r}\right]$

B-8. A vessel whose bottom has round holes with a diameter of d = 0.1 mm is filled with water. The maximum height of the water level h at which the water does not flow out, will be : (The water does not wet the bottom of the vessel). [S.T of water = 70 dyn/cm]

(A) h = 24.0 cm (B) h = 25.0 cm (C) h = 26.0 cm (D) h = 28.0 cm

PART - III : MATCH THE COLUMN

1.

Column - I	Column - II
(A) Spliting of brigger drop into small drops	(P) Temperature changes
(B) Formation of bigger drop from small drops.	(Q) Temprerature remain constant
(C) Spraying of liquid	(R) Surface energy changes
(D) Spliting of bigger soap bubble into small soap bubble of same thickness	(S) Surface energy remain unchange

Exercise-2

Marked Questions can be used as Revision Questions.

PART - I : ONLY ONE OPTION CORRECT TYPE

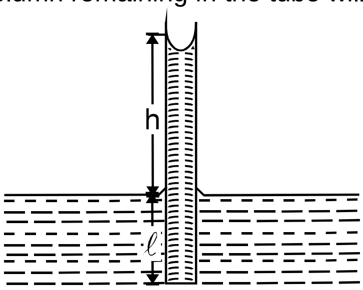
1. There is a horizontal film of soap solution. On it a thread is placed in the form of a loop. The film is punctured inside the loop and the thread becomes a circular loop of radius R. If the surface tension of the soap solution be T, then the tension in the thread will be :

(A) $\pi R^2/T$ (B) $\pi R^2 T$ (C) $2\pi RT$ (D) $2RT$

2. A capillary tube of radius R is immersed in water and water rises in it to a height H. Mass of water in capillary tube is M. If the radius of the tube is doubled, mass of water that will rise in capillary tube will be

(A) 2M (B) M (C) $\frac{M}{2}$ (D) 4M

3. Water rises to a height h in a capillary tube lowered vertically into water to a depth □ as shown in the figure. The lower end of the tube is now closed, the tube is then taken out of the water and opened again. The length of the water column remaining in the tube will be :



(A) 2h if□□ > h and □ + h if □ < h (B) h if □ > h and □ + h if □ < h
(C) 4h if □ > h and □ – h if □ < h (D) h/2 if □ > h and □ + h if □ < h

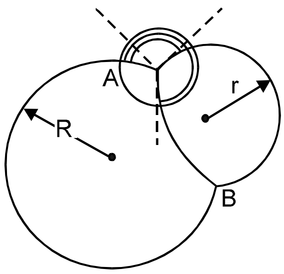
4. A soap bubble of radius r_1 is placed on another soap bubble of radius $r_2 (r_1 < r_2)$. The radius R of the soapy film separating the two bubbles is :

(A) $r_1 + r_2$ (B) $\sqrt{r_1^2 + r_2^2}$ (C) $(r_1^3 + r_2^3)$ (D) $\frac{r_2 r_1}{r_2 - r_1}$

5. The high domes of ancient buildings have structural value (besides beauty). It arises from pressure difference on the two faces due to curvature (as in soap bubbles). There is a dome of radius 5 m and uniform (but small) thickness. The 'surface tension' of its masonary structure is about 500 N/m. Treated as hemispherical, the maximum load the dome can support is nearest to

(A) 1500 kg wt. (B) 3000 kg wt. (C) 6000 kg wt. (D) 12000 kg wt.

6. A soap - bubble with a radius 'r' is placed on another bubble with a radius R (figure). Angles between the films at the points of contact will be –



(A) 120° (B) 30° (C) 45° (D) 90°

7. A large number of liquid drops each of radius 'a' coalesce to form a single spherical drop of radius 'b'. The energy released in the process is converted into kinetic energy of the big drop formed. The speed of big drop will be :

(A) $\sqrt{\frac{6T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (B) $\sqrt{\frac{4T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (C) $\sqrt{\frac{8T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$ (D) $\sqrt{\frac{5T}{\rho}\left[\frac{1}{a}-\frac{1}{b}\right]}$

8. At critical temperature, the surface tension of a liquid :

(A) is zero (B) is infinity

(C) is same as that at any other temperature (D) cannot be determined

9._ The excess pressure inside a soap bubble is equal to 2 mm of kerosene (density 0.8 g cm^{-3}). If the diameter of the bubble is 3.0 cm, the surface tension of soap solution is **[Olympiad (Stage-1) 2017]**

(A) 39.2 dyne cm^{-1} (B) 45.0 dyne cm^{-1} (C) 51.1 dyne cm^{-1} (D) 58.8 dyne cm^{-1}

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. There is a soap bubble of radius 2.4×10^{-4} m in air cylinder which is originally at the pressure 10^5 N/m^2. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure (in atm) of air in the cylinder. The surface tension of the soap solution is 0.08 N/m

2. A long capillary tube of radius r = 1 mm open at both ends is filled with water and placed vertically. What will be the height (in cm) of the column of water left in the capillary in nearest integer ? The thickness of the capillary walls is negligible. (Surface tension of water is 72 dyne/cm and g = 1000 cm/sec^2)

3. Two spherical soap bubbles collapses. If V is the consequent change in volume of the contained air and S is the change in the total surface area and T is the surface tension of the soap solution, then if relation between P_0, V, S and T are $\lambda P_0 V + 4ST = 0$, then find λ ? (if P_0 is atmospheric pressure) : Assume temperature of the air remain same in all the bubbles

4. A capillary of 1mm diameter, is dipped vertically in a pot of water. If gauge pressure of the water in the tube 5.0 cm below the surface is 2λ N/m^2 then find λ. Surface tension of water = 0.075 N/m. (take g = 9.8 m/s^2 and ρ_w = 1000 kg/m^3)

5. A capillary tube with very thin walls is attached to the beam of a balance which is then equalized. The lower end of the capillary is brought in contact with the surface of water after which an additional load of P = 0.135 gm force is needed to regain equilibrium. If the radius of the capillary is $\frac{\lambda}{10}$ mm then find λ. The surface tension of water is 70 dyn/cm. (g = 9.8 m/s^2)

6. A capillary tube sealed at the top has an internal radius of r = 0.05 cm. The tube is placed vertically in water, with its open end dipped in water. Find greatest integer corresponding to the length (in meter) of such a tube be for the water in it to rise in these conditions to a height h = 1 cm ? The pressure of the air is P_0 = 1 atm. = 76 cm of Hg, density of Hg = 13.6 g/cm^3, g = 9.8 m/sec^2. The surface tension of water is σ = 70 dyn/cm. (Assume temperature of air in the tube is constant)

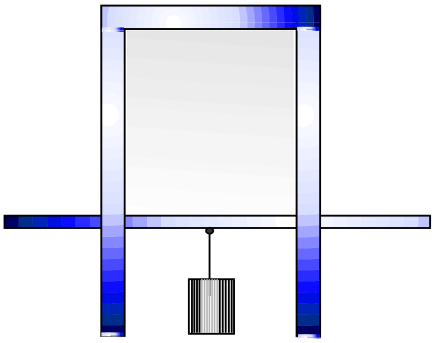
7. A cube with mass m = 20 g wettable by water floats on the surface of water. Each face of the cube is 3 cm long. If the distance (cm) between the lower face of the cube and the surface of the water in contact with the cube is 4.6/ λ cm, then find λ ? [S.T of water α = 70 dyn/cm, assume contact angle to be $\theta = 0^o$]

8. The end of a capillary tube with a radius r is immersed into water. What amount of heat will be evolved when the water rises in the tube ? If surface tension of water 'T' density of water = ρ. Given $\frac{T^2}{\rho g} = \frac{2}{\pi}$

9. A soap bubble of radius 'r' and surface tension 'T' is given a potential of 'V' volt. If the new radius 'R' of the bubble is related to its initial radius by equation, $P_0 [R^3 - r^3] + \lambda T [R^2 - r^2] - \varepsilon_0 V^2 R/2 = 0$, where P_0 is the atmospheric pressure. Then find λ

10. A glass rod of diameter d_1 = 1.5 mm is inserted symmetrically into a glass capillary with inside diameter d_2 = 2.0 mm. Then the whole arrangement is vertically oriented and brought in contact with the surface water To what height (cm) will the liquid rise in the capillary. Surface tension of water = 73×10^{-3} N/m, Angle of contact = 0^o. (Use g = 9.8 m/s^2)

11. A rectangular wire frame with one movable side is covered by a soap film (fig.). What work (erg) will be done if this side of the frame is moved a distance S = 2 mm ? The length of the movable side is ℓ = 6cm. The surface tension of the soap film is α = 40 dyn/cm.



PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. When a capillary tube is dipped in a liquid, the liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical in shape. The tube is now pushed down so that the height of the tube outside the liquid is less than h :
(A) the liquid will ooze out of the tube slowly
(B) the liquid will come out of the tube like in a small fountain
(C) the free liquid surface inside the tube will not be hemispherical
(D) the liquid will fill the tube but not come out of its upper end

2. When a capillary tube is immersed into a liquid, the liquid neither rises nor falls in the capillary ?
(A) The angle of contact must be 90°
(B) The angle of contact may be 90°
(C) The surface tension of liquid must be zero
(D) The surface tension of liquid may be zero

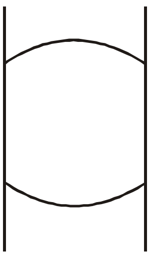
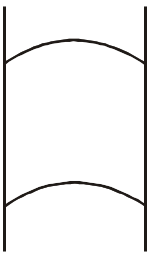
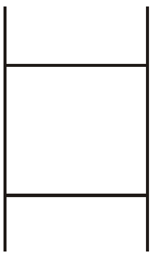
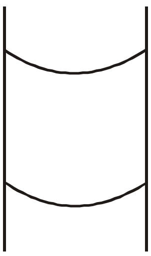
3. Angle of contact between a liquid and a solid is a property of :
(A) the material of liquid
(B) the material of solid
(C) the mass of the solid
(D) the shape of the solid

4. When a drop splits up into number of drops:
(A) total surface area increases
(B) volume increases
(C) energy is absorbed
(D) energy is liberated

5. If a liquid rises to same height in two capillaries of same material at same tempreture then.
(A) Weight of liquid in both capillaries will be equal
(B) Radius of miniscus will be equal
(C) For this capillaries must be curve and vertical.
(D) Hydrostatic pressure at the bare of capillaries must be same.

6. When a glass capillary tube is dipped in a liquid, then liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical. The tube is now pushed down so that the height of the tube outside the liquid is less than h. Then
(A) The liquid will come out of the tube
(B) The liquid will fill the tube but not come out of its upper end
(C) The free liquid surface inside tube may be concave
(D) The free liquid surface inside tube may be convex.

7. A vertical glass capillary tube, open at both ends, contains some water. Which of following shapes may not be possible ?

(A)  (B)  (C)  (D) 

8. The rise of liquid in a capillary tube depends on.

(A) The material (B) The length (C) Outer radius (D) Inner radius

9. Suppose outside pressure is P_0 and surface tension of soapwater solution is T and we are blowing a soap bubble of radius R. Then

(A) Pressure inside soap babble of radius R will be $P_0 + \frac{4T}{R}$.

(B) Pressure inside soap bubble of radius R will be $P_0 + \frac{2T}{R}$

(C) work done by external agent to blow soap bubble is equal to summation of work done against increase pressure from P_0 to ($P_0 + \frac{4T}{R}$) and work done against increase in surface energy.

(D) None of these

10.✍ If for a liquid in a vessel, force of a cohesion is twice of adhesion:
(A) the meniscus will be convex upwards (B) the angle of contact will be obtuse
(C) the liquid will descend in the capillary tube (D) the liquid will wet the solid

PART - IV : COMPREHENSION

Comprehension - 1

The internal radius of one limb of a capillary U-tube is r_1 = 1 mm and the internal radius of the second limb is r_2 = 2 mm. The tube is filled with some mercury, and one of the limbs is connected to a vacuum pump. The surface tension & density of mercury are 480 dyn/cm & 13.6 gm/cm^3 respectively. (Assume contact angle to be θ = 180º) (g = 9.8 m/s^2)

1.✍ What will be the difference in air pressure when the mercury levels in both limbs are at the same height ?
(A) 3.53 mm of Hg (B) 1.51 mm of Hg (C) 0.51 mm of Hg (D) 5.52 mm of Hg

2.✍ Which limb of the tube should be connected to the pump ?
(A) Limb having radius 2 mm (B) Limb having radius 1mm
(C) Any of the limb (D) None of these

Comprehension - 2

An open capillary tube contains a drop of water. The internal diameter of the capillary tube is 1mm. Determine the radii of curvature of the upper and lower meniscuses in each case. Consider the wetting to be complete. Surface tension of water = 0.073 N/m. (g = 9.8 m/s^2)

3. When the tube is in its vertical position, the drop forms a column with a length of 2 cm.
(A) 0.5 mm, 1.52 mm (B) 0.5 mm, 1.46 mm
(C) 0.5 mm, lower surface will be flat (D) 0.4 mm, 1.46 mm

4. When the tube is in its vertical position, the drop forms a column with a length of 4 cm.
(A) 0.5 mm, 1.52 mm (B) 0.5 mm, 1.46 mm
(C) 0.5 mm, lower surface will be flat (D) 0.4 mm, 1.46 mm

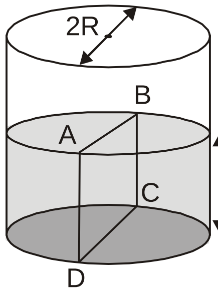
5. When the tube is in its vertical position, the drop forms a column with a length of 2.98 cm.
(A) 0.5 mm, 1.52 mm (B) 0.5 mm, 1.46 mm
(C) 0.5 mm, lower surface will be flat (D) 0.4 mm, 1.46 mm

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

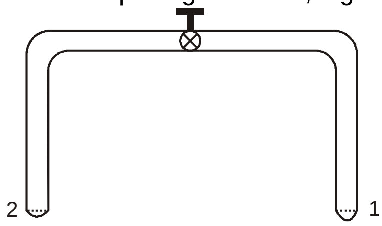
1.✍ Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude **[JEE 2007, 3/184]**



(A) $\left|2P_0Rh + \pi R^2\rho gh - 2RT\right|$ (B) $\left|2P_0Rh + R\rho gh^2 - 2RT\right|$

(C) $\left|P_0\pi R^2 + R\rho gh^2 - 2RT\right|$ (D) $\left|P_0\pi R^2 + R\rho gh^2 + 2RT\right|$

2. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve, Figure : **[JEE -2008 3/163, –1]**



(A) air from end 1 flows towards end 2. No change in the volume of the soap bubbles
(B) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases
(C) no change occurs
(D) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases.

3. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m^2. The radii of bubbles A and B are 2cm and 4cm, respectively. Surface tension of the soap-water used to make bubbles is 0.04 N/m. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity.] **[IIT 2009_4/160, –1]**

Paragraph for questions 4 to 6

When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper.

4. If the radius of the opening of the dropper is r; the vertical force due to the surface tension on the drop of radius R (assuming r << R) is : **[IIT 2010; 3/163, –1]**

(A) $2\pi rT$ (B) $2\pi RT$ (C) $\frac{2\pi r^2T}{R}$ (D) $\frac{2\pi R^2T}{r}$

5. If r = 5 $\times 10^{-4}$ m, $\rho = 10^3$ kgm^{-3}, g = 10 ms^{-2}, T = 0.11 Nm^{-1}, the radius of the drop when it detaches from the dropper is approximately : **[IIT 2010; 3/163, –1]**

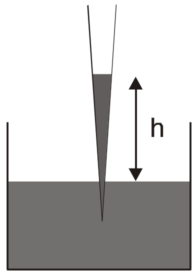
(A) 1.4×10^{-3} m (B) 3.3×10^{-3} m (C) 2.0×10^{-3} m (D) 4.1×10^{-3} m

6. After the drop detaches, its surface energy is : **[IIT 2010; 3/163, –1]**

(A) 1.4×10^{-6} J (B) 2.7×10^{-6} J (C) 5.4×10^{-6} J (D) 8.1×10^{-6} J

7. Four point charges, each of +q, are rigidly fixed at the four corners of a square planar soap film of side 'a'.The surface tension of the soap film is γ. The system of charges and planar film are in equilibrium, and a = k, $\left[\frac{q^2}{\gamma}\right]^{1/N}$ where 'k' is a constant. Then N is **[JEE-2011, 4/160]**

8. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross section is b. If the surface tension of water is S, its density is ρ, and its contact angle with glass is θ, the value of h will be (g is the acceleration due to gravity)
[JEE (Advanced)-2014, 3/60, –1]



(A) $\frac{2S}{b\rho g}\cos(\theta-\alpha)$ (B) $\frac{2S}{b\rho g}\cos(\theta+\alpha)$ (C) $\frac{2S}{b\rho g}\cos(\theta-\alpha/2)$ (D) $\frac{2S}{b\rho g}\cos(\theta+\alpha/2)$

9. A drop of liquid of radius R = 10^{-2} m having surface tension $S = \frac{0.1}{4\pi} Nm^{-1}$ divides itself into K identical drops. In this process the total change in the surface energy $\Delta U = 10^{-3}$ J. If $K = 10^{\alpha}$ then the value of α is : **[JEE (Advanced) 2017, 3/61]**

10*. A uniform capillary tube of inner radius r is dipped vertically into a beaker filled with water. The water rises to a height h in the capillary tube above the water surface in the beaker. The surface tension of water is σ. The angle of contact between water and the wall of the capillary tube is θ. Ignore the mass of water in the meniscus. Which of the following statements is (are) true? **[JEE (Advanced) 2018, P-1, 4/60, –2]**

(A) For a given material of the capillary tube, h decreases with increase in r

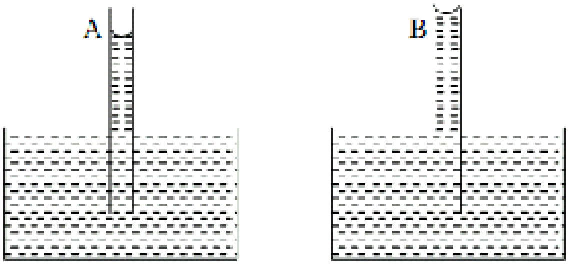
(B) For a given material of the capillary tube, h is independent of σ

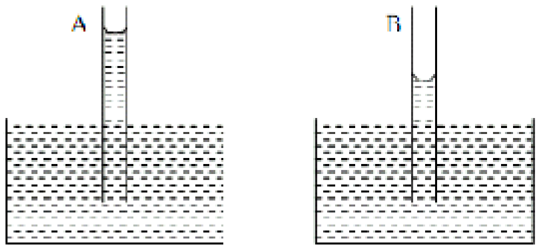
(C) If this experiment is performed in a lift going up with a constant acceleration, then h decreases

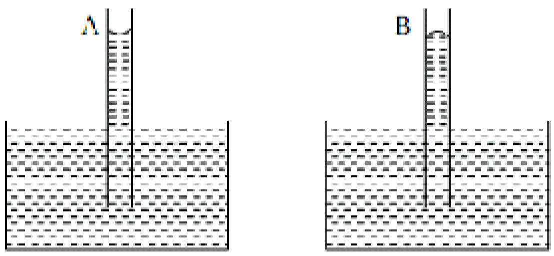
(D) h is proportional to contact angle θ

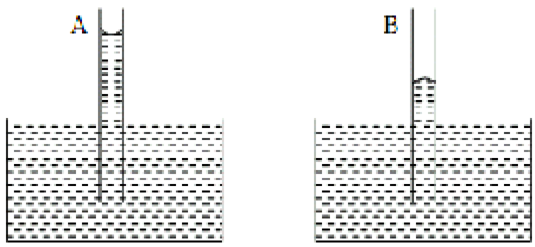
PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A capillary tube (1) is dipped in water. Another identical tube (2) is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes ? **[AIEEE 2008, 4/120, –1]**

(1) 

(2) 

(3) 

(4) 

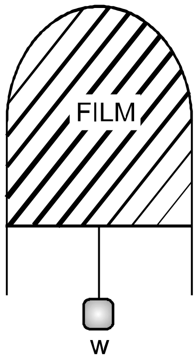
2. Work done in increasing the size of a soap bubble from a radius of 3 cm to 5 cm is nearly. (Surface tension of soap solution = 0.03 Nm^{-1}) **[AIEEE - 2011, 4/120, –1]**

(1) 4π mJ (2) 0.2π mJ (3) 2π mJ (4) 0.4π mJ

3. Two mercury drops (each of radius 'r') merge to from bigger drop. The surface energy of the bigger drop, if T is the surface tension, is : **[AIEEE 2011, 4/120, –1]**

(1) $4\pi r^2$ T (2) $2\pi r^2 T$ (3) $2^{8/3}\pi r^2 T$ (4) $2^{5/3}\pi r^2 T$

4. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is : **[AIEEE 2012, 4/120, –1]**

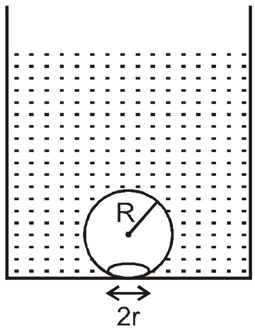


(1) 0.0125 Nm^{-1} (2) 0.1 Nm^{-1} (3) 0.05 Nm^{-1} (4) 0.025 Nm^{-1}

5. Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible ? The surface tension is T, density of liquid is ρ and L is its latent heat of vaporization. **[JEE (Main) 2013, 4/120,–1]**

(1) $\rho L/T$ (2) $\sqrt{T/\rho L}$ (3) $T/\rho L$ (4) $2T/\rho L$

6. On heating water, bubbles beings formed at the bottom of the vessel detatch and rise. Take the bubles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If r << R, and the surface tension of water is T, value of r just before bubles detatch is : (density of water is ρ_w) **[JEE (Main) 2014,4/120,–1]**



(1) $R^2\sqrt{\frac{\rho_w g}{3T}}$ (2) $R^2\sqrt{\frac{\rho_w g}{6T}}$ (3) $R^2\sqrt{\frac{\rho_w g}{T}}$ (4) $R^2\sqrt{\frac{3\rho_w g}{T}}$

Answers

EXERCISE-1

PART - I

Section (A) :

A-1. (a) 1.53 cm, (b) 1.77 cm

A-2. Surface tension forces F_{ab}, F_{cd} and weight. Equilibrium only when $F_{ab} > F_{cd}$ and this is due to difference in concentration of soap solution in film.

A-3. 3.98×10^{-2} J **A-4.** 1.44×10^{-5} J

Section (B) :

B-1. $24\pi R^2S$ **B-2.** $2^{2/3}$ W

B-3. (a) 465 N/m^2 (b) 30 N/m^2 (c) 38 N/m^2

B-4 $T = \dfrac{p_0(2r^3 - R^3)}{4(R^2 - 2r^2)}$ **B-5.** 100N/m^2

B-6. $\dfrac{2T}{\rho gr}$

PART - II

Section (A) :

A-1.	(B)	**A-2.**	(D)	**A-3.**	(C)
A-4.	(C)	**A-5.**	(A)	**A-6.**	(B)
A-7.	(D)	**A-8.**	(D)	**A-9.**	(B)

Section (B) :

B-1.	(C)	**B-2.**	(B)	**B-3.**	(B)
B-4.	(C)	**B-5.**	(C)	**B-6.**	(C)
B-7.	(A)	**B-8.**	(D)		

PART - III

1. (A) – P,R ; (B) – P,R ; (C) – P,R ;(D) –Q,S

EXERCISE-2

PART - I

1.	(D)	**2.**	(A)	**3.**	(A)
4.	(D)	**5.**	(B)	**6.**	(A)
7.	(A)	**8.**	(A)	**9.**	(D)

PART - II

1.	8	**2.**	3	**3.**	3
4.	98	**5.**	15	**6.**	5
7.	2	**8.**	4	**9.**	4
10.	6	**11.**	96		

PART - III

1.	(CD)	**2.**	(BD)	**3.**	(AB)
4.	(AC)	**5.**	(AB)	**6.**	(BCD)
7.	(ABC)	**8.**	(ABD)	**9.**	(AC)
10.	(ABC)				

PART - IV

1.	(A)	**2.**	(B)	**3.**	(A)
4.	(B)	**5.**	(C)		

EXERCISE-3

PART - I

1.	(B)	**2.**	(B)	**3.**	6
4.	(C)	**5.**	(A)	**6.**	(B)
7.	**3**	**8.**	(D)	**9.**	6
10.	(AC)				

PART - II

1.	(2)	**2.**	(4)	**3.**	(3)
4.	(4)	**5.**	(4)	**6.**	(Bonus)