EXERCISE-1

SECTION (A) : SURFACE TENSION, SURFACE ENERGY AND CAPILLARY RISE

A 1. End of glass tube becomes round on heating- Explain why?

A 2. Why hot soup tastes better than cold soup?

A 3. Antiseptics should be of low surface tension. Why?

A 4. A glass capillary tube is dipped vertically in water in a state of weightlessness. How will the rise of water be different to the one observed under normal conditions?

A 5. Can a rough sea be calmed by pouring oil on its surface?

A 6. Why is it difficult to make mercury enter a fine thermometer tube?

A 7. Which is easier to spray into fine drops? Water or mercury. Explain.

A 8. What is the utility of ploughing the fields?

A 9. A new earthen pot keeps water cooler than the older one. Why?

A 10. A thin needle of steel floats on water ; but on dissolving soap in water the needle sinks. Why ?

A 11. A capillary tube is of length 10 cm. It is held vertically with 1 cm length inside water and the rest outside. The water level in the capillary stands at a height of 8 cm. If the capillary is broken at the middle, what would be the position of the water level in it ?

A 12. If the length of a capillary tube is less than that required, will water come out of the capillary? Explain.

A 13. Two tooth picks floating on a water surface are parallel and close to each other. A hot needle is touched between them to the water surface. Explain why they fly apart?

A 14. Water rises in a capillary tube to a height 2.0 cm. In an another capillary whose radius is one-third of it, how much the water will rise ? If the first capillary is inclined at an angle of 60º with the vertical then what will be the position of water in the tube ?

A 15. 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 16. Water rises up in a glass capillary upto a height of 9.0 cm, while mercury falls down by 3.4 cm in the same capillary. Assume angles of contact for water glass and mercury glass 0º and 135º respectively. Determine the ratio of surface tensions of mercury and water (cos 135º = –0.71).

A 17. A square frame of side L is dipped in a liquid soap. When it is taken out of the liquid, a soap film is formed on it. If the surface tension of soap is T, then the force acting on the frame is ______________.

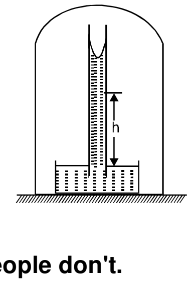
A 18. An impurity which is highly soluble in a liquid______________ the surface tension of the liquid.

A 19. A liquid does not wet the surface of a liquid if the angle of contact is______________.

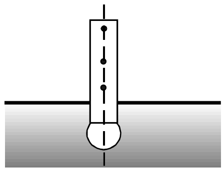
A 20. Water rises to a height of a 5 cm in a glass capillary tube. If the area of cross-section of the tube is reduced to (1/16)th of the former value, the water rises to a height of 40 cm. (State True/False).

A 21. 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 of the column of water left in the capillary ? The thickness of the capillary walls is negligible.

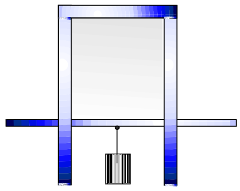
A 22. A capillary tube is lowered into a vessel with a liquid whose vapour pressure may be neglected. The density of the liquid is ρ. The vessel and the tube are in a vacuum under the bell of an air pump (fig.). Find the pressure inside the liquid in the capillary tube at a height h above the level of the liquid in the vessel.



required to form a bubble of air at the end of a capillary immersed in the liquid being investigated (fig.). Calculate the surface tension if the radius of the capillary is r = 1 mm and the difference in the pressures during bubble formation is ΔP = 14 mm of water column. The end of the capillary is near the surface of the liquid.

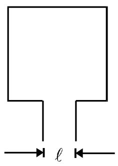


A 24. A rectangular wire frame with one movable side is covered by a soap film (fig.). What force should be applied to the movable side to counterbalance it ? What work will be done if this side of the frame is moved a distance S = 2 cm ? What will be the source of this work when the surface of the film is reduced and into what kind of energy will the work be transformed ? The length of the movable side is ℓ = 6cm. The surface tension of the soap film is α = 40 dyn/cm.

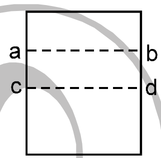


A 25. A capillary of radius r is lowered into a wetting agent with surface tension α and density d. Determine the height h_0 to which the liquid will rise in the capillary. Calculate the work done by surface tension and the potential energy acquired by the liquid in the capillary and compare the two. Explain the difference in the results obtained.

A 26. A light open rigid paper frame as shown in (Fig.) floats on the surface of water. What will happen to the frame if some soap solution is dropped inside it ? What force will acts on the frame and in what direction will it act ?



A 27. A soapy film is stretched over a rectangular vertical wire frame (fig.) What forces hold section abcd in equilibrium ?



A 28. 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.

A 29. 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 hold (a) vertical (b) inclined to the vertical at an angle of 30º.

SECTION (B) : EXCESS PRESSURE IN DROPS AND BUBBLE

B 1. Soap bubble bursts after some time. Explain why?

B 2. It is easier to spray water in which some soap is dissolved. Explain why?

B 3. A large force is needed to normally separate two glass plates having a thin layer of water between them. Why?

B 4. Air is blown into a soap bubble. What will be the effect on the pressure inside a soap bubble?

B 5. Why are the droplets of mercury when brought in contact pull together to form a bigger drop ? Also state with reasons whether the temperature of this bigger drop will be the same, or more, or less than the temperature of the smaller drops.

B 6. A drop of oil placed on the surface of water spreads out, but a drop of water placed on oil contracts to a spherical shape. Explain both the phenomena.

B 7. The excess pressure inside a soap bubble of diameter D and surface tension S is __________.

B 8. A soap bubble has radius R and surface tension S the energy needed to double the radius without change of temperature is _____________.

B 9. Work done in blowing a soap bubble of radius r and surface tension T is _____________.

B 10. The work done in blowing a bubble of volume V is W, then the work done in blowing a soap bubble of volume 2V will be_____________.

B 11. If T is the surface tension of soap solution, the amount of work done in blowing a soap bubble from diameter D to a diameter 2D is $8\pi D^2T$. (State true/false)

B 12. Pressure inside the two soap bubbles are 1.01 and 1.02 atmospheres. Ratio between their volume is 2 : 1. (State true/false)

B 13. A cylinder with a movable piston contains air under a pressure p_1 and a soap bubble of radius r. The surface tension is σ, and the temperature T is maintained constant. Determine the pressure p_2 to which the air should be compressed by slowly pulling the piston into the cylinder for the soap bubble to reduce its size by half.

B 14. Assuming the surface tension of rain water to be 72 dyne/cm, find the difference of pressure inside and outside a rain drop of diameter 0.02 cm. What would this pressure difference amount to, if the drop were to be decreased by evaporation to a diameter of 0.0002 cm?

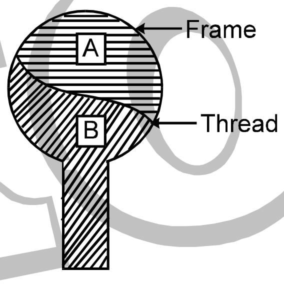
EXERCISE-2

SECTION (A) : SURFACE TENSION, SURFACE ENERGY AND CAPILLARY RISE

A 1. 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

A 2. A liquid will not wet the surface of a solid if the angle of contact is :
(A) 0^0 (B) 45^0 (C) 60^0 (D) $> 90^0$

A 3. 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 4. The force required to drag a circular flat plate of radius 5 cm on the surface of water is (ST of water is 75 dyne/cm).
(A) 30 dyne (B) 60 dyne (C) 750 dyne (D) 750π dyne

A 5. A liquid rises in a capillary tube when the angle of contact is :
(A) an acute one (B) an obtuse one (C) $\pi/2$ radian (D) π radian

A 6. 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 7. Neglecting gravity, the potential energy of a molecule of liquid on the surface of liquid when compared with PE of a molecule inside liquid is :
(A) greater (B) less (C) equal
(D) depending on the liquid sometimes more, sometimes less

A 8. The lower end of a capillary tube touches a liquid whose angle of contact is 90^0,the liquid
(A) rises into the tube (B) falls in the tube
(C) may rise or fall inside (D) neither rises nor falls inside the tube

A 9. There is a horizontal film of soap solution. On it a thread is placed in the form of a loop. The film is pierced inside the loop and the thread becomes a circular loop of radius R. If the surface tension of the loop 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

A 10. A thin metal disc of radius r floats on water surface and bends the surface down words 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 11. A 10 cm long wire is placed horizontally on the surface of water and is gently pulled up with a force of 2×10^{-2} N to keep the wire in equilibrium. The surface tension, in Nm^{-1}, of water is
(A) 0.1 (B) 0.2 (C) 0.001 (D) 0.002

A 12. 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 13. In a vessel equal masses of alcohol (sp. gravity 0.8) and water are mixed together. A capillary tube of radius 1 mm is dipped vertically in it. If the mixture rises to a height 5 cm in the capillary tube, the surface tension of the mixture is :
(A) 217.9 dyne/cm (B) 234.18 dyne/cm (C) 107.9 dyne/cm (D) 10.79 dyne/cm

A 14. A glass capillary tube of inner diameter 0.28 mm is lowered vertically into water in a vessel. The pressure to be applied on the water in the capillary tube so that water level in the tube is same as that in the vessel in N/m^2 is (surface tension of water = 0.07 N/m and atmospheric pressure = 10^5 N/m^2) :
(A) 10^3 (B) 99×10^3 (C) 100×10^3 (D) 101×10^3

A 15. The work done in increasing the size of a rectangular soap film with dimensions 8 cm × 3.75 cm to 10cm × 6 cm is 2×10^{-4} J. The surface tension of the film in N/m is :
(A) 1.65×10^{-2} (B) 3.3×10^{-2} (C) 6.6×10^{-2} (D) 8.25×10^{-2}

A 16. A capillary tube is filled with liquid up to a height of 50 cm. The reading when the capillary tube is tilted to an angle of 45^0 is :
(A) 50 cm (B) $50\sqrt{2}$ (C) zero (D) none of these

A 17. When a cylindrical tube is dipped vertically into a liquid, the angle of contact is 140^0. When the tube is dipped with an inclination of 40^0, then the angle of contact is :
(A) 100^0 (B) 140^0 (C) 180^0 (D) 60^0

A 18. 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 0^0) 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) $\frac{\rho g h(r_2 - r_1)}{2r_1 r_2}$ (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 19. The property of surface tension is to :
(A) increase the volume (B) decrease the volume
(C) increase the surface area (D) decrease the surface area

A 20. Radius of a capillary is 2×10^{-3} m. A liquid of weight 6.28×10^{-4} N may remain in the tube if surface tension of the liquid will be :
(A) 5×10^{-3} N/m (B) 5×10^{-2} N/m (C) 5 N/m (D) 50 N/m

A 21. A thin metal ring of internal radius 8 cm and external radius 9 cm is supported horizontally from the pan of a balance so that it comes in contact with water in a glass vessel. It is found that an extra weight of 7.48 g is required to pull the ring out of water. The surface tension of water is
(A) 80×10^{-3} N/m (B) 75×10^{-3} N/m (C) 65×10^{-3} N/m (D) 70×10^{-3} N/m

A 22. A capillary tube of radius R is immeresed 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

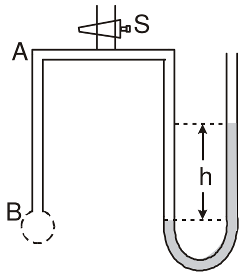
A 23. Water rises in a capillary tube to a height h. it will rise to a height more than h
(A) on the surface of sun (B) in a lift moving down with an acceleration
(C) at the poles (D) in a lift moving up with an acceleration.

A 24. A small hollow rectangular vessel having a small circular hole in its base of radius R mm immersed in a tank of water. Water will start coming into the vessel when it is immersed to a depth of (T is surface tension of water)

(A) $\frac{T}{49R}$ (B) $\frac{T}{980R}$ (C) $\frac{T}{245R}$ (D) $\frac{T}{1960R}$

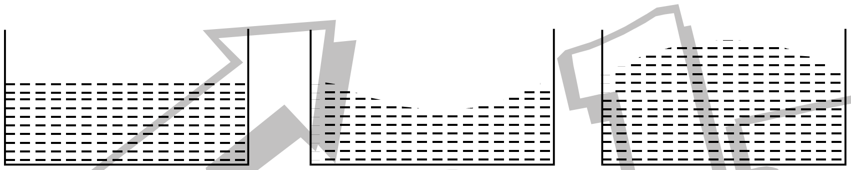
A 25. Insects are able to run on the surface of water because :
(A) insects have less weight
(B) insects swim on water
(C) of the Archimede's upthrust
(D) surface tension makes the surface behave as elastic membrane.

A 26. 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 differene 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) rhrg (B) 2rhgr
(C) 4rhrg (D) $\frac{rh\rho g}{4}$

A 27. Three surfaces of liquids are shown here. Find the correct statements :



[A] [B] [C]

(A) the surface tension of liquid A is infinite and such a surface is not possible practically.
(B) in case of liquid B, the resultant force on a molecule on the surface would be downward, and the surface is concave.
(C) in case of liquid C, the resultant force due to surface tension is directed downwards
(D) the surfaces of all three liquids A, B and C are in equilibrium and so the net force due to surface tension in the same

A 28. A capillary of radius r is lowered into a wetting agent with surface tension α and density d.
(i) The height h_0 to which the liquid will rise in the capillary is –

(A) $\left[\frac{2\alpha}{dgr}\right]$ (B) $\left[\frac{4\alpha}{dgr}\right]$ (C) $\left[\frac{8\alpha}{dgr}\right]$ (D) $\left[\frac{\alpha}{8dgr}\right]$

(ii) The work done by surface tension is –

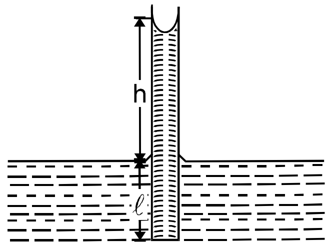
(A) $\left[\frac{2\pi\alpha^2}{dg}\right]$ (B) $\left[\frac{4\pi\alpha^2}{dg}\right]$ (C) $\left[\frac{8\pi\alpha^2}{dg}\right]$ (D) $\left[\frac{12\pi\alpha^2}{dg}\right]$

(iii) The potential energy acquired by the liquid in the capillary is equal to –

(A) $\left[\frac{4\pi\alpha^2}{dg}\right]$ (B) $\left[\frac{6\pi\alpha^2}{dg}\right]$ (C) $\left[\frac{2\pi\alpha^2}{dg}\right]$ (D) $\left[\frac{7\pi\alpha^2}{dg}\right]$

A 29. A long capillary tube of radius r = 1 mm open at both ends is filled with water and placed vertically. The height of the column of water left in the capillary (The thickness of the capillary walls is negligible) is –
(A) 2.5 cm (B) 2.8 cm (C) 2.0 cm (D) 3.5 cm

A 30. Water rises to a height h in a capillary tube lowered vertically into water to a depth ℓ (fig.). The lower end of the tube is 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 $l \geq h$ and $l + h$ if $l \leq h$ (B) h if $l \geq h$ and $l + h$ if $l \leq h$
(C) 4h if $l \geq h$ and $l - h$ if $l \leq h$ (D) h/2 if $l \geq h$ and $l + h$ if $l \leq h$

A 31. A thin wire is bent in the form of a ring of diameter 3.0 cm. The ring is placed horizontally on the surface of soap solution and then raised up slowly. Upward force necessary to break the vertical film formed between the ring and the solution is –
(A) 5.652×10^{-3} N. (B) 4.652×10^{-3} N. (C) 6.652×10^{-3} N. (D) 9.652×10^{-3} N.

A 32. Water rises up in a glass capillary upto a height of 9.0 cm, while mercury falls down by 3.1 cm in the same capillary. Assume angles of contact for water glass and mercury glass 0º and 135º respectively. The ratio of surface tensions of mercury and water (cos 135º = – 0.71) will be :
(A) 1.2 : 1 (B) 7.2 : 1 (C) 6.2 : 1 (D) 4.2 : 1

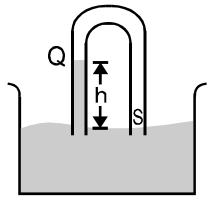
A 33. The internal radius of one limb of a capillary U-tube is r_1 = 1 mm and the internal radius of the second limb is r_2 = 2 mm. The tube is filled with some mercury, and one of the limbs is connected to a vacuum pump. The difference in air pressure when the mercury levels in both limbs at the same height are – (The surface tension & density of mercury are 480 dyn/cm & 13.6 gm/cm respectively)
(A) 3.53 mm of Hg (B) 2.53 mm of Hg (C) 4.53 mm of Hg (D) 5.53 mm of Hg

A 34. A capillary tube sealed at the top has an internal radius of r = 0.05 cm. the tube is placed vertically in water, open end first.
The length of such a tube be for the water in it to rise in these conditions to a height h = 1 cm is – (The pressure of the air is P_0 = 1 atm. The surface tension of water is = 70 dyn/cm):
(A) 540 cm (B) 440 cm (C) 556 cm (D) 560 cm

A 35. A glass plate of length 0.1 m, breadth 15×10^{-3} m and thickness 2×10^{-3} m weighs 8×10^{-3} kg in air. it is held vertically with its longer side horizontal and its lower half immersed in water. If the surface tension of water is 72×10^{-3} N/m, the apparent weight of the plate will be
(A) 97.4×10^{-3} N (B) 36.1×10^{-3} N (C) 72.2×10^{-3} N (D) 79.4×10^{-3} N

A 36. When two glass plates are placed one over the other, there is no difficulty in separating them but if a drop of liquid, say water, is placed between them and squeezed into a thin layer, it requires a considerable force to pull them apart. The reason for this is that
(A) the pressure inside the film is less than the outside atmospheric pressure
(B) the thin layer of water produces a large resistive force on account of viscocity
(C) there is internal frinction between the microlayers of the film
(D) electrostatic charges of opposite nature are produced between the plates.

A 37. A glass U-tube is inverted with open ends of the straight limbs, of diamters 0.5 mm and 1.0 mm below the surface of water in a beaker. The air pressure in the upper part is increased until the meniscus in one limb is level with the water outside. The height of water in the other limb will be : (Density of water is 10^3 kg/m^3 and surface tension of water is 7.5×10^{-2} N/m. Take contact angle θ = 0º)



(A) 6.1×10^{-2} m (B) 3.1×10^{-2} m
(C) 4.1×10^{-2} m (D) 8.1×10^{-2} m

A 38. Two parallel glass plates are dipped partly in the liquid of density 'd'. keeping therm 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) $\frac{T\cos\theta}{xdg}$

A 39*. 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 heimspherical
(D) the liquid will fill the tube but not come out of its upper end

A 40*. 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

A 41*. 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 90^0 (B) The angle of contact may be 90^0
(C) The surface tension of liquid must be zero (D) The surface tension of liquid may be zero

A 42*. 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

A 43*. The rise of liquid in a capillary tube depends on :
(A) the material of tube and nature of liquid (B) the length of tube
(C) the outer radius (D) the inner radius of the tube

SECTION (B) : EXCESS PRESSURE IN DROPS AND BUBBLE

B 1. A soap bubble of diameter 8 mm is formed in air. The surface tension of liquid is 30 dyne/cm. The excess pressure inside the soap bubble is :
(A) 150 dyne/cm^2 (B) 300 dyne/cm^2 (C) 3×10^{-3} dyne/cm^2 (D) 12 dyne/cm^2

B 2. Two spherical soap bubbles coalesce. 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 P_0 is atmospheric pressure) :
(A) $3P_0V + 4ST = 0$ (B) $4P_0V + 3ST = 0$ (C) $P_0V + 4TS = 0$ (D) $4P_0V + ST = 0$

B 3. 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 4. Two water droplets combine to form a large drop. In this process energy is :
(A) liberated (B) absorbed
(C) neither liberated nor absorbed (D) sometimes liberated and sometimes absorbed

B 5. 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) $\frac{r_2 r_1}{r_2 - r_1}$

B 6. A spherical liquid drop of radius R is divided into 8 equal droplets. If the surface tension is T, then work done in the process will be :
(A) $2\pi R^2T$ (B) $3\pi R^2T$ (C) $4\pi R^2T$ (D) $2\pi RT^2$

B 7. 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 8. 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 9. 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 10. 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 pressure 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 11. 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 12. The shape of a liquid drop becomes spherical due to its :
(A) surface tension (B) density (C) viscosity (D) temperature

B 13. The energy required to blow a bubble of radius 4 cm and 3 cm in the same liquid is in the ratio of:
(A) 4 : 3 (B) 3 : 4 (C) 16 : 9 (D) 64 : 27

B 14. A number of small drops of mercury adiabatically coalesce to form a single drop. The temperature of the drop will
(A) increase (B) remain same (C) decrease (D) depend on size.

B 15. 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.

B 16. A spherical soap bubble of radius 1.0 cm is formed inside another of radius 2 cm. If a single soap bubble is formed which maintains the same pressure difference as inside the smaller and outside the larger bubble, the radius of this bubble is
(A) 0.005 m (B) 0.05 m (C) 0.0067 m (D) 0.067 m

B 17. An oil bath (density of oil = 0.85×10^3 kg/m^3) has a spherical cavity of diameter 26×10^{-6} m at a depth of 0.2 m. If the surface tension of oil is 26×10^{-3} N/m and the pressure of air over the surface of oil is 76 cm of mercury, the pressure inside the cavity will be
(A) 1.03×105 N/m^2 (B) 1.07×10^5 N/m^2 (C) 1.17×10^5 N/m^2 (D) 3.07×10^5 N/m^2

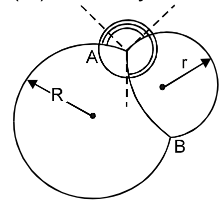
B 18. A drop of water is placed between two parallel glass plates which are then pressed together until the water film is 0.01 cm thick. If the area in contact with either plate is 10 sq. cm, the force due to surface tension drawing the plates together is ($\sigma = 70 \times 10^{-3}$ N/m)
(A) 1.4 N (B) 0.7 N (C) 2.8 N (D) 1.05 N

B 19. 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 20. 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

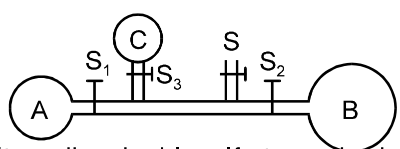
B 21. One end of a glass capillary tube with a radius r = 0.05 cm is immersed into water to a depth of h = 2 cm. Pressure required to blow an air bubble out of the lower end of the tube will be :
[S.T. of water = 70 dyn/cm]
(A) 2840 dyn/cm^2 (B) 5840 dyn/cm^2 (C) 7840 dyn/cm^2 (D) 4840 dyn/cm^2

B 22. 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) 120^0 (B) 30^0
(C) 45^0 (D) 90^0



B 23. 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) $\sqrt{\frac{5T}{\rho}\left[\frac{1}{a} - \frac{1}{b}\right]}$

B 24. The adjoining diagram shows three soap bubbles A, B and C prepared by blowing the capillary tube fitted with stop cocks S, S_1, S_2 and S_3. With stop cock S closed and stop cocks S_1, S_2 and S_3 opened:
(A) B will start collapsing with volumes of A and C increasing
(B) C will start collapsing with volumes of A and B increasing
(C) C and A will both start collapsing with the volume of B increasing
(D) Volumes of A, B and C will become equal at equilibrium



B 25. When a large bubble rises from the bottom of a lake to the surface. Its radius doubles. If atmospheric pressure is equal to that of column of water height H, then the depth of lake is :

(A) H (B) 2H (C) 7H (D) 8 H

B 26*. Which of the following statements are true in case when two water drops coalesce and make a bigger drop:
(A) Energy is released
(B) Energy is absorbed
(C) The surface area of the bigger drop is greater than the sum of the surface areas of both the drops
(D) The surface area of the bigger drop is smaller than the sum of the surface areas of both the drops

B 27*. When a drop splits up into number of drops :
(A) area increases
(B) volume increases
(C) energy is absorbed
(D) energy is liberated

EXERCISE-3

1. 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 (density 10^3 kg/m^3, surface tension 72×10^{-3} N/m) in the narrower tube stands 0.2 m above that in the broader tube. **[REE - 85]**

2. A water film is made between two straight parallel wires of length 10 cm each, and at a distance of 0.5 cm from each other. If the distance between the wires is increased by 1 mm, how much work will be done ? (Surface tension of water = 7.2×10^{-2} N/m). **[REE - 86]**

3. A soap bubble of radius a has been formed at normal temperature and pressure under isothermal conditions. Compute the work one. The surface tension of soap solution is T. **[REE - 87]**

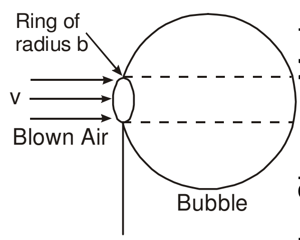
4. Two separate air bubbles (radii 0.002 m and 0.004 m) formed of the same liquid (surface tension 0.07 N/m) come together to form a double bubble. Find the radius and the sense of curvature of two internal film surface common to both the bubbles. **[REE - 89]**

5. A glass capillary sealed at the upper end is of length 0.11 m and internal diameter 2×10^{-5} m. The tube is immersed vertically into a liquid of surface tension 5.06×10^{-2} N/m. To what length the capillary has to be immersed so that the liquid level inside and outside the capillary becomes the same. What will happen to liquid level inside the capillary if the seal is now broken ? Atmospheric pressure is 1.012×10^5 N/m^2. **[REE - 93]**

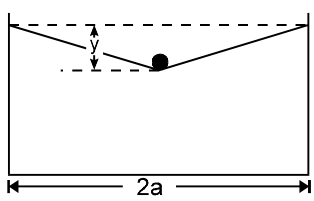
6. A conical glass capillary tube A of length 0.1 m has diameters 10^{-3} m and 5×10^{-4} m at the ends. When it is just immersed in a liquid at 0ºC with larger diameter in contact with it, the liquid rises to 8×10^{-2} m in the tube. In another cylindrical glass capillary tube B, when immersed in the same liquid at 0ºC, the liquid rises to 6×10^{-2} m height. The rise of liquid is 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 - 94]**

7. There is a soap bubble of radius 2.4×10^{-4} m in an air cylinder which is originally at the pressure of 10^5 Nm^{-2}. The air in the cylinder is now compressed isothermally until the radius of the bubble is halved. Calculate now the pressure of air in the cylinder. The surface tension of the soap film is 0.08N m^{-1}. **[REE - 96]**

8. 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]**



9. A long thin straight uniform wire of negligible radius is supported on the surface of a liquid. The width of the container is 2α and the wire is kept at its centre, parallel to its length (as shown i n figure). The surface of the liquid is depressed by a vertical distance $y(y << \alpha)$ at the centre as shown in figure. If the wire has mass λ per unit length, what is the surface tension of the liquid? Ignore end effects. **[JEE 2004, 2/60]**



ANSWER

EXERCISE - 1

SECTION (A) :

A 1. Due to lesser surface area.

A 2. At high temp. surface tension gets reduced and it spreads over larger area of tongue.

A 3. To spread over larger area.

A 4. It will rise to total length of tube.

A 5. Yes, pouring of oil reduced surface tension of water. Wind carries the surface film of oil in the forward direction and leaves behind a cleaner water of higher surface tension. Greater backward pull is exerted by clener water.

A 6. Because of large force of cohension.

A 7. Water, due to lesser surface tension.

A 8. To preserve the moisture in soil, capillaries must be broken.

A 9. Due to more capillaries.

A 10. Surface tension gets reduced.

A 11. Water level will be at top of the broken tube.

A 12. No, miniscus gets adjusted.

A 13. Surface tension of water surface in between tooth picks gets reduced due to hot needle, resulting net force outward on toothpick by outer layer.

A 14. 6.0 cm, 4.0 cm **A 15.** 3.98×10^{-2} J

A 16. 7.2 : 1 **A 17.** 8 TL

A 18. increases **A 19.** Obtuse

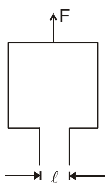
A 20. False **A 21.** 2.8cm

A 22. – r g h **A 23.** 70 dyn/cm

A 24. F = 480 dyn, w = 960 erg

A 25. $\left[\dfrac{2\alpha}{dgr}, \dfrac{4\pi\alpha^2}{dg}, \dfrac{2\pi\alpha^2}{dg}\right]$

A 26. The frame will be acted upon by a force $F = (\alpha_1 - \alpha_2)\ell$ and it will more in the direction of force. α_1 and α_2 are surface tensions of water and soap solution.



A 27. 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 28. 0.7991 g/cm^3 **A 29.** (a) 1.51 cm, (b) 1.75 cm

SECTION (B) :

B 1. When pressure inside becomes larger.

B 2. Dissolving soap reducing surface tension and less work is required.

B 3. Due to decrease in pressure on the inner-side of liquid film.

B 4. Due to air brown, size i.e. radius of bubble increases, pressure decreases.

B 5. Due to surface tension, liquids tends to have smallest surface area. Temperature of big drip will be more based on energy consevation.

B 6. Due to surface tension of oil is less than the surface tension of water.

B 7. 8S/D **B 8.** $24\pi R^2 S$

B 9. $8\pi r^2 T$ **B 10.** $2^{2/3}$ W

B 11. False **B 12.** False

B 13. $\left[p_2 = 8p_1 + \dfrac{24\sigma}{r}\right]$

B 14. 1.44×10^4 dyn/cm^2 and 1.44×10^7 dyn/cm^2

EXERCISE - 2

SECTION (A) :

A 1. A	**A 2.** D	**A 3.** B	**A 4.** D
A 5. A	**A 6.** D	**A 7.** A	**A 8.** D
A 9. D	**A 10.** C	**A 11.** A	**A 12.** C
A 13. C	**A 14.** D	**A 15.** B	**A 16.** B
A 17. B	**A 18.** A	**A 19.** D	**A 20.** B
A 21. D	**A 22.** A	**A 23.** B	**A 24.** A
A 25. D	**A 26.** D	**A 27.** C	
A 28. (i) S	(ii) B	(iii) C	
A 29. B	**A 30.** A	**A 31.** A	**A 32.** B
A 33. A	**A 34.** C	**A 35.** D	**A 36.** A
A 37. B	**A 38.** B	**A 39*.** CD	**A 40*.** ABC
A 41*. BD	**A 42*.** AB	**A 43*.** ABD	

SECTION (B) :

B 1. B	**B 2.** A	**B 3.** C	**B 4.** A
B 5. D	**B 6.** C	**B 7.** B	**B 8.** B
B 9. C	**B 10.** C	**B 11.** C	**B 12.** A
B 13. C	**B 14.** A	**B 15.** B	**B 16.** C
B 17. B	**B 18.** A	**B 19.** A	**B 20.** D
B 21. D	**B 22.** A	**B 23.** A	**B 24.** C
B 25. C	**B 26*.** AD	**B 27*.** AC	

EXERCISE - 3

1. 1860 N/m^2 **2.** 1.44×10^{-5} J.

3. $8\pi a^2 T$ **4.** 0.004 meter.

5. 1 cm. **6.** -1.4×10^{-4} N/(m – ºC)

7. 8.08×10^5 Nm

8. $\dfrac{4T}{\rho v^2}$ **9.** $\dfrac{\lambda g\sqrt{a^2+y^2}}{2y} \approx \dfrac{\lambda g a}{2y}$.