SURFACE TENSION

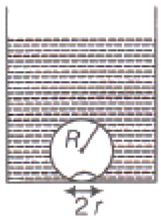
1. A small soap bubble of radius 4cm is trapped inside another bubble of radius 6cm without any contact.Let P_2be the pressure inside the inner bubble and $P_0$the pressure outside the outer bubble. Radius ofanother bubble with pressure difference P2 - P0 between its inside and outside would be : (2018)

(a) 2.4cm
(b) 12cm
(c) 4.8cm
(d) 6cm

2. The following observations were taken for determining surface tension T of water by capillary method. Diameter of capillary, d = 1.25×10^{-2} in rise of water, h= 145×10^{-2}m. Using g = 9.80 m/s^2 and the simplified relation $T=\frac{rhg}{2}\times 10^3 N/m$, the possible error in surface tension is 2 closest to (2017)

(a) 1.5%
(b) 2.4%
(c)10%
(d) 0.15%

3. On heating water, bubble beings formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact 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 bubbles detach is (density of water is ρ) (2014)



(a) $R^2\sqrt{\frac{\rho_w g}{3T}}$
(b) $R^2\sqrt{\frac{\rho_w g}{6T}}$
(c) $R^2\sqrt{\frac{3\rho_w g}{T}}$
(d) None of these

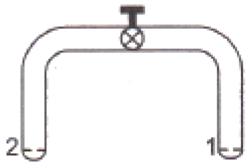
4. Assume that a drop of liquid evaporates by decrease in its surface energy, so that its temperature remains unchanged. What should be the minimum radius of the drop for this to be possible? The surface tension is T, denstiy of liquid is ρ and L is its latent heat of vaporisation (2013)

(a) $\frac{\rho L}{T}$
(b) $\sqrt{\frac{T}{\rho L}}$

(c) $\frac{T}{\rho L}$

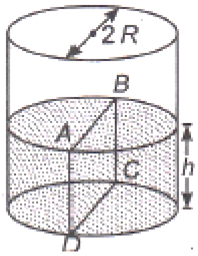
(d) $\frac{2T}{\rho L}$

5. 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 hemispherial soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve. (2008)



(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

6. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water isρ, the surface tension of water is T and the atmospheric pressure is p. Consider a vertical section ABCD of the water column through a diameter of the breaker. The force on water on one side of this section by water on the other side of this section has magnitude (2007)



(a) $|2p_0Rh + \pi R^2 \rho gh - 2RT|$

(b) $|2p_0Rh + R\rho gh^2 - 2RT|$

(c) $|p_0\pi R^2 + R\rho gh^2 - 2RT|$

(d) $|p_0\pi R^2 + R\rho gh^2 + 2RT|$

7. A thin metal disc of radius r float 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) $w - 2\pi rT\cos\theta$

8. A ring is cut from a platinum tube 8.5 cm internal diameter and 8.7 cm external diameter. It is supported horizontally from a pan of a balance so, that it comes in contact with the water is in glass vessel. If an extra 3.47 g-wt is required to pull it away from water, surface tension of water is
(a) 72.07 dyne cm^{-1}
(b) 70.80 dyne cm^{-1}
(c) 65.35 dyne cm^{-1}

(d) 60.00 dyne cm^{-1}

9. What is the pressure inside the drop of mercury of radius 3.00 mm at room temperature? Surface tension of mercury at that temperature (20^0C) is 4.65×10^{-1} N/m. The atmospheric pressure is 101×10^5 Pa. Also give the excess pressure inside the drop.
(a) 1.01×10^5 Pa, 320Pa
(b) 1.01×10^5 Pa, 310Pa
(c) 310 Pa, 1.01×10^5Pa
(d) 320 Pa, 1.01×10^5Pa

10. What is the radius of the biggest aluminium coin of thickness, t and density ρ, which will still be able to float on the water surface of surface tension S?
(a) $\frac{4S}{3\rho gt}$
(b) $\frac{3S}{4\rho gt}$
(c) $\frac{2S}{\rho gt}$
(d) $\frac{S}{\rho gt}$

11. 8000 identical water drops are combined to form a big drop then the ratio to the final surface energy to the initial surface energy, if all the drops together is
(a) 1 : 10
(b) 1 :15
(c) 1 : 20
(d) 1 : 25

12. A frame made of a metallic wire enclosing a surface area A is covered with a soap film. If the area of the frame of metallic wire is reduced by 50%, the energy of the soap film will be changed by
(a) 100 %
(b) 75 %
(c) 50 %
(d) 25 %

13. A mercury drop of radius 1 cm is broken into 10^6 droplets of equal size.
The work done is ($S = 35 \times 10^{-2}$ Nm^{-1})
(a) 4.35×10^{-2}J
(b) 4.35×10^{-3} J
(c) 4.35×10^{-6} J
(d) 4.35×10^{-8} J

14. Surface tension of a soap solution is able of 2.0 cm diameter will be
(a) $7.6 \times 10^{-6}\pi$J
(b) $15.2 \times 10^{-6}\pi$J
(c) $1.9 \times 10^{-6}\pi$J
(d) $1 \times 10^{-4}\pi$J

15. A drop of water breaks into two droplets of equal size. In this process, which of the following statements is correct?
(a) The sum of the temperatures of the two droplets together is equal to temperature of the original drop
(b) The sum of the masses of the two droplets is equal to mass of drop
(c) The sum of the radii of the two droplets is equal to the radius of the drop
(d) The sum of the surface areas of the two droplets is equal to the surface area of the original drop

16. Work done in splotting a drop of water of 1mm radius no 10^6 droplets is (surface tension of water $72 \times 10^{-3} J / m^2$)
(a)9.8×10^{-5}J
(b)8.95×10^{-5}J
(c) 5.89×10^{-5}J
(d) 5.98×10^{-6}J

17. A drop of liquid of diameter 2 8 mm breaks up into identical drops. The change in energy is nearly IIS = 75 dyne cm^{-1})
(a) zero
(b) 19 erg
(c) 46 erg
(d) 74 erg

18. The surface energy of a liquid drop is u. It is sprayed 1000 equal droplets. Then its surface energy becomes
(a) u
(b) 10 u
(c) 100 u
(d) 1000 u

19. A water film is made between two straight parallel wires of length 10 cm separated by 5 mm from each other. If the distance between the wires is increased by 2 mm. How much work will be done? Surface tension for water is 72 dyne cm^{-1}.
(a) 288 erg
(b) 72 erg
(c) 144 erg
(d) 216 erg

20. What change in surface energy will be noticed when a drop of radius R splits up into 1000 droplets of radius r, surface tension T ?
(a) $4 \pi R^2 T$
(b) $7 \pi R^2 T$
(c)$16 \pi R^2 T$
(d) $36 \pi R^2 T$

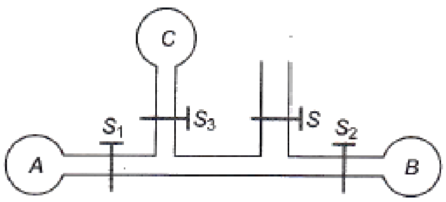
21. Let, W be the work done, when a bubble of volume V is formed from a given solution. How much work is required to be done to form a bubble of volume 2 V ?
(a) W
(b) 2W
(c) $2^{1/3}$ W
(d) $4^{1/3}$ W

22. What is the ratio of surface energy of 1 small drop and 1 large drop if 1000 drops combined to form 1 large drop?
(a) 100 : 1
(b) 1000: 1
(c) 10 : 1
(d) 1 : 100

23. A bigger drop of radius R is converted into n smaller drops of radius r, the required energy is
(a) $(4\pi r^2 n - 4\pi R^2)T$
(b) $\left(\frac{4}{3}\pi r^3 n - \frac{4}{3}\pi R^3\right)T$
(c) $(4\pi R^2 - 4\pi r^2)nT$
(d) $(n4\pi r^2 - 4\pi R^2)T$

24. The angle of contact at the interface of water-glass is 0^0Ethylalcohol-glass is 0^0, Mercury-glass is 140^0 and Methyliodide-glass is 30^0. A glass capillary is put in a trough Containing one of these four liquids. It is observed that the meniscus is convex. The liquid in the trough is
(a) water
(b) ethylalcohol
(c) mercury
(d) methyliodide

25. The 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 volume of A and B increasing
(c) volume of A, B and C will become equal in equilibrium
(d) C and A will both start collapsing with volume of B increasing

26. The amount of work done in blowing a soap bubble such that its diameter increases from d to D is (S = surface tension of solution)
(a) $\pi(D^2 - d^2)S$
(b) $2\pi(D^2 - d^2)S$
(c) $4\pi(D^2 - d^2)S$
(d) $8\pi(D^2 - d^2)S$

27. If pressure at half the depth of a lake is equal to $\frac{2}{3}$ pressure at the bottom of the lake then what is the depth of the lake?
(a) 10 m
(b) 20 m
(c) 60 m

(d) 30 m

28. In a test experiment on a model aeroplane in a wind tunnel, the flow speeds on the upper and lower surfaces of the wing are 70 m/s and 63 m/s respectively. What is the lift on the wing, if its area is 2.5 m^2? Take the density of air to be 1.3 kg/m^3.
(a) 5.1×10^2 N
(b) 6.1×10^2 N
(c)1.6×10^3N
(d)1.5×10^3 N

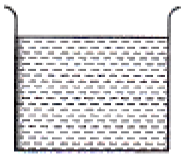
29. With the increase in temperature, the angle of contact
(a) decreases
(b) increases
(c) remains constant
(d) sometimes increases and sometimes decreases

30. Water rises to a height of 10 cm in a capillary tube and mercury falls to a depth of 3.42 cm in the same capillary tube. If the density of mercury and water are 135^0 and 0^0 respectively, the ratio of surface tension of water and mercury is
(a) 1 : 0.15
(b) 1 : 3
(c) 1 :6.5
(d)1.5 : 1

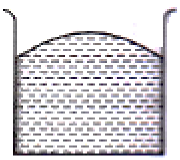
31. Water rises to a height of 16.3 cm in a capillary of height 18 cm above the water level. If the tube is cut at a height of 12 cm in the capillary tube,
(a) water will come as a fountain from the capillary tube
(b) water will stay at a height of 12 cm in the capillary tube
(c) the height of water in the capillary tube will be 10.3 cm
(d) water height flow down the sides of the capillary tube

32. 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

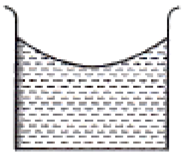
33. If a liquid is placed in a vertical cylindrical vessel and the vessel is rotated about its axis, the liquid will take the shape of figure.
(a)



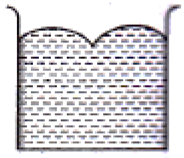
(b)



(c)



(d)

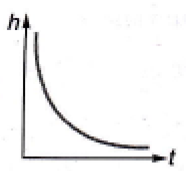


34. By inserting a capillary tube upto a depth l in the water rises to a height h. If the lower end of the capillary tube is closed inside water and the capillary is taken out and closed end opened, to what height the water will remain in the tube, when l >h
(a) zero
(b) l + h
(c) 2 h
(d) h

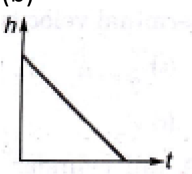
35. Two capillary tubes of radii 0.2 cm and 0.4 cm are dipped in the same liquid. The ratio of heights through which liquid will rise in the tubes is
(a)1 : 2
(b) 2 :1
(c) 1 : 4
(d) 4 : 1

36. The rate of flow of liquid through a capillary tube of radius r is V, when the pressure difference across the two ends of the capillary is p. If pressure is increased by 3 p and radius is reduced to r/2, then the rate of flow becomes
(a) V/9
(b) 3V/8
(c) V/4
(d) V/3

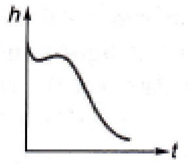
37. Water in a vessel of uniform cross-section escapes through a narrow tube at the base of the vessel. Which graph given below represents the variation of the height h of the liquid with time t?
(a)

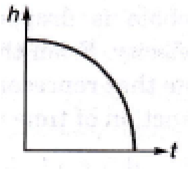


(b)



(c)



(d)


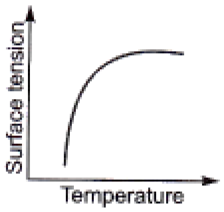
38. When a pinch of salt or any other salt which is soluble in water is added to water, its surface
(a) Increases
(b) decreases
(c) may Increase or decrease depending upon salt
(d) None of the above

39. At which of the following temperatures, the values of surface tension of water is minimum?
(a) 4^0C
(b) 25^0 C
(c) 50^0 C
(d) 75^0 C

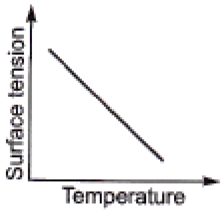
40. Two spherical soap bubbles of radii a and b in vacuum coalesce under isothermal conditions. The resulting bubble has a radius given by
(a) $\frac{(a+b)}{2}$
(b) $\frac{ab}{a+b}$
(c) $\sqrt{a^2+b^2}$
(d) $a+b$

41. When two soap bubbles of radius r_1 and r_2 ($r_2 > r_1$) coalesce, the radius of curvature of common surface is
(a) $(r_2 - r_1)$
(b) $(r_2 + r_1)$
(c) $\frac{r_2 - r_1}{r_1 r_2}$
(d) $\frac{r_2 r_1}{r_2 - r_1}$

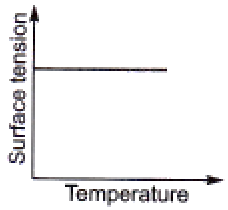
42. Which graph represent the variation of surface tension with temperature over small temperature ranges for water?
(a)



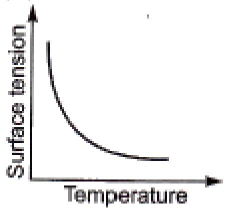
(b)



(c)



(d)



43. A capillary tube of radius R and length L is connected m series with another tube of radius R/2 and length L/4. If the pressure difference across the two tubes taken together is p, then the ratio of pressure difference across the first tube to that across the second tube is
(a)1 : 4
(b) 1 :1
(c) 4 :1
(d) 2 : 1

44. The relative velocity of two parallel layers of water is 8 cms^{-1}. If the perpendicular distance between the layers is 0.1 cm, then velocity gradient will be
(a) 40 s^{-1}
(b) 50 s^{-1}
(c) 60 s^{-1}
(d) 80 s^{-1}

45. Two water pipes P and Q having diameter 2×10^{-2} m and 4×10^{-2} m respectively are joined in series with the main supply line of water. The velocity of water flowing in pipe P is
(a) 4 times that of Q
(b) 2 times that of Q
(c) 1/2 times that of Q
(d) 1/4 times that of Q

ANSWER KEYS

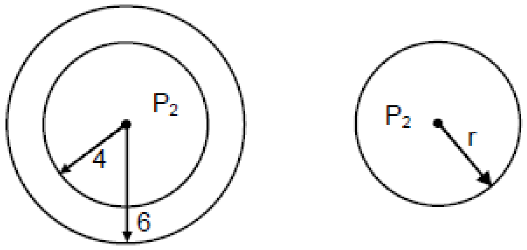
1.(a) 2. (a) 3. (a) 4. (d) 5. (b) 6. (b) 7. (c) 8. (a) 9. (b) 10. (c) 11. (c) 12. (c) 13. (a) 14. (b) 15. (b) 16. (b) 17. (d) 18. (b) 19. (a) 20. (d) 21. (d) 22. (d) 23. (d) 24. (c) 25. (b) 26. (b) 27. (b) 28. (d) 29. (a) 30. (c) 31. (b) 32. (b) 33. (c) 34.(c) 35. (b) 36. (c) 37. (a) 38. (a) 39. (d) 40. (c) 41. (d) 42. (b) 43. (a) 44. (d) 45. (a)

SOLUTIONS

1. (a)

$P_2 = P_0 + \frac{4T}{6} + \frac{4T}{4}$ $\quad$ $P_2 = P_0 + \frac{4T}{r}$

$\Rightarrow \quad \frac{1}{r} = \frac{1}{6} + \frac{1}{4}$ $\quad \Rightarrow \quad r = 2.4\text{cm}$



2. (a)

By ascent formula, we have surface tension,

$$T = \frac{rhg}{2} \times 10^3 \frac{\text{N}}{\text{m}}$$

$$= \frac{dhg}{4} \times 10^3 \frac{\text{N}}{\text{m}}$$

$$\Rightarrow \quad \frac{\Delta T}{T} = \frac{\Delta d}{d} + \frac{\Delta h}{h} \qquad \text{[given, } g \text{ is constant]}$$

$$\text{So, percentage} = \frac{\Delta T}{T} \times 100 = \left(\frac{\Delta d}{d} + \frac{\Delta h}{h}\right) \times 100$$

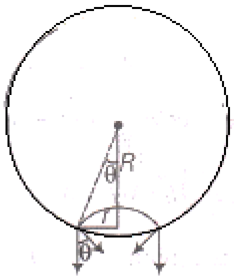
$$= \left(\frac{0.01 \times 10^{-2}}{1.25 \times 10^{-2}} + \frac{0.01 \times 10^{-2}}{1.45 \times 10^{-2}}\right) \times 100$$

$$= 1.5\%$$

$$\therefore \quad \frac{\Delta T}{T} \times 100 = 1.5\%$$

3. (d)

The bubble will detach if,



$$\int \sin\theta T \times dl = T(2\pi r)\sin\theta$$

Buoyant force ≥ Surface tension force

$$\frac{4}{3}\pi R^3 \rho_w g \geq \int T \times dl \sin\theta$$

$$(\rho_w)\left(\frac{4}{3}\pi R^3\right)g \geq (T)(2\pi r)\sin\theta$$

⇒ $$\sin\theta = \frac{r}{R}$$

Solving, $$r = \sqrt{\frac{2\rho_w R^4 g}{3T}}$$

$$= R^2\sqrt{\frac{2\rho_w g}{3T}}$$

No option matches with the correct answer.

4. (d)

Decrease in surface energy = heat required in vaporisation.

∴ $$T(dS) = L(dm)$$

∴ $$T(2)(4\pi r)dr = L(4\pi r^2 dr)\rho$$

∴ $$r = \frac{2T}{\rho L}$$

5. (b)

$$\Delta p_1 = \frac{4T}{r_1} \text{ and } \Delta p_2 = \frac{4T}{r_2}$$

$$r_1 < r_2$$

∴ $$\Delta p_1 > \Delta p_2$$

∴ Air will flow from 1 to 2 and volume of bubble at end 1 will decrease.

Therefore, correct option is (b).

6. (b)

Force from right hand side liquid on left hand side liquid.

(i) Due to surface tension force $= 2RT$ (towards right)

(ii) Due to liquid pressure force

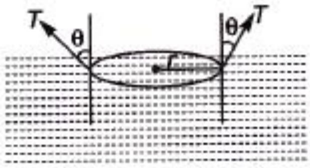
$$= \int_{x=0}^{x=h} (p_0 + \rho gh)(2R \cdot x)\, dx$$

$$= (2p_0Rh + R\rho gh^2)\text{ (towards left)}$$

$\therefore$ Net force is $|2p_0Rh + R\rho gh^2 - 2RT|$

7. (c)

As, weight of metal disc = total upward force



= upthrust force + force due of surface tension

= weight of displaced water $+ T\cos\theta\,(2\pi r)$

$= w + 2\pi rT\cos\theta$

8. (a)

Force on the ring due to surface tension of water

$$= (\pi D_1 + \pi D_2)\,S = mg$$

So, $$S = \frac{mg}{\pi(D_1 + D_2)} = \frac{3.47 \times 980}{(22/7) \times (8.5 + 8.7)}$$

$$= 72.07 \text{ dyne cm}^{-1}$$

9. (b)

Given, radius of drop $(R) = 3.00$ mm

$$= 3 \times 10^{-3} \text{ m}$$

Surface tension of mercury $(S) = 4.65 \times 10^{-1}$ N/m

Atmospheric pressure $(p_0) = 1.01 \times 10^5$ Pa

Pressure inside the drop

= Atmospheric pressure + Excess inside the liquid drop

$$= p_0 + \frac{2S}{R}$$

$$= 1.01 \times 10^5 + \frac{2 \times 4.65 \times 10^{-1}}{3 \times 10^{-3}}$$

$$= 1.01 \times 10^5 + 3.10 \times 10^2$$

$$= 1.01 \times 10^5 + 0.00310 \times 10^5$$

$$= 1.01310 \times 10^5 \text{ Pa}$$

Excess pressure inside the drop $(\Delta p) = \dfrac{2S}{R} = \dfrac{2 \times 4.65 \times 10^{-1}}{3 \times 10^{-3}}$

$$= 3.10 \times 10^2$$

$$= 310 \text{ Pa}$$

10. (c)

Let R be the radius of the biggest aluminium coin which will be supported on the surface of water due to surface tension.

Then, $mg = S \times 2\pi R$

or $\pi R^2 t \rho g = S \times 2\pi R$

or $R = 2S/\rho g t$

11. (c)

As volume remains constant *i. e.*, $R^3 = 8000\, r^3$ or $R = 20\, r$

Now, $\dfrac{\text{Surface energy of one big drop}}{\text{Surface energy of 8000 small drops}}$

$$= \frac{4\pi R^2 T}{8000 \times 4\pi r^2 T} = \frac{R^2}{8000\, r^2} = \frac{(20\, r)^2}{8000\, r^2} = \frac{1}{20}$$

12. (c)

As, surface energy = surface tension × surface area

i.e., $E = S \times 2A$

New surface energy, $E_1 = S \times 2(A/2) = S \times A$

% decrease in surface energy $= \dfrac{E - E_1}{E} \times 100$

$$= \frac{2SA - SA}{2SA} \times 100 = 50\%$$

13. (a)

$W = T\,\Delta A = T.[4\pi r^2 n - 4\pi R^2]$

but, 10^6 × volume of one small drop

= volume of one big drop

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

or $\quad R = 10^2 r,\ r = \dfrac{R}{10^2}$

$$\therefore \quad W = T\left[4\pi\left(\frac{R}{10^2}\right)^2 .n - 4\pi R^2\right]$$

$$W = 35 \times 10^{-2} \times 4 \times \frac{22}{7}\left[\frac{(10^{-2})^2}{10^4} \times 10^6 - (10^{-2})^2\right]$$

$$= 440 \times 10^{-2} \times 10^{-4} \times 99 = 4.35 \times 10^{-2} \text{ Joule}$$

14. (b)

As, work done = surface tension × surface area

$= 1.9 \times 10^{-2} \times (4\pi R^2) \times 2$

$= 1.9 \times 10^{-2} \times 4 \times \pi (1 \times 10^{-2})^2 \times 2$

$= 15.2 \times 10^{-6}\ \pi \text{J}$

15. (b)

When two drops are split, the law of conservation of mass is obeyed.

16. (b)

Work done in splotting a water drop of radius R into n drops of equal size $= 4\pi R^2 T\,(n^{1/3} - 1)$

$$= 4\pi \times (10^{-3})^2 \times 72 \times 10^{-3} \times 10^{6/3} - 1$$
$$= 4\pi \times 10^{-6} \times 72 \times 10^{-3} \times 99 = 8.95 \times 10^{-5}\ \text{J}$$

17. (d)

Here, $R = 2.8/2 = 1.4\ \text{mm} = 0.14\ \text{cm}$

Now, $\frac{4}{3}\pi R^3 = 125 \times \frac{4}{3}\pi r^3$ (equality of volume)

or $r = \frac{R}{5} = \frac{0.14}{5} = 0.028\ \text{cm}$

$\therefore$ Change in energy = surface tension $\times$ increase in area

$$= 75 \times (125 \times 4 \times 4\pi r^2 - 4\pi R^2) = 74\ \text{erg}$$

18. (b)

Given ; $u = S \times 4\pi R^2$; when droplet is splitted into 1000 droplets each of radius r, then

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3 \text{ or } r = R/10$$

$\therefore$ Surface energy of all droplets

$$= S \times 1000 \times 4\pi r^2 = S \times 1000 \times 4\pi (R/10)^2$$
$$= 10\,(S\,4\pi R^2) = 10\,u$$

19. (a)

As, work done = surface tension $\times$ increase in area

$$= 72 \times [10 \times 0.7 - 10 \times 0.5] \times 2 = 288\ \text{erg}$$

20. (d)

Increase in surface energy = surface tension $\times$ increase in surface area

$$= T(1000 \times 4\pi r^2 - 4\pi R^2)\ \left(100 \times \frac{4}{3}\pi r^3 = \frac{4}{3}R^2 \text{ or } r = \frac{R}{10}\right)$$
$$= T \times 4\pi\left(1000 \times \frac{R^2}{100} - R^2\right) = 36\,\pi R^2\,T$$

21. (d)

Let R and R' be the radius of bubble of volume V and $2V$ respectively. Then

$$\frac{4}{3}\pi R^3 = V \text{ and } \frac{4}{3}\pi R'^3 = 2V$$

So, $$\frac{R'^3}{R^3} = 2 \quad \text{or} \quad R' = (2)^{1/3} R$$

As $$W = S \times (4\pi R^2)^2$$

and $$W' = S \times (4\pi R'^2)^2$$

$$\frac{W'}{W} = \frac{R'^2}{R^2} = 2^{2/3} = (4)^{1/3}$$

or $$W' = (4)^{1/3} W$$

22. (d)

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

$\Rightarrow$ $$R = 10\,r$$

Surface energy of small drop $E_1 = S \times 4\pi r^2$

Surface energy of large drop $E_2 = S \times 4\pi (10\,r)^2$

$\therefore$ $$E_1/E_2 = 1/100$$

23. (d)

As, work done = surface tension $\times$ increase in surface area

$$= T(n\,4\pi r^2 - 4\pi R^2)$$

24. (c)

The meniscus of liquid in a capillary tube will be convex upwards if angle of contact is obtuse. It is so when one end of glass capillary tube is immersed in a trough of mercury.

25. (b)

As excess pressure, $p \propto 1/r$, therefore, pressure inside C is highest and pressure inside B is lowest. The pressure inside A is in between. Therefore, C starts collapsing with volume of A and B increasing.

26. (b)

Change in surface area $= 2 \times 4\pi\,[(D/2)^2 - (d/2)^2]$

$$= 2\pi (D^2 - d^2)$$

$\therefore$ Work done = surface tension $\times$ change in area

$$= 2\pi S (D^2 - d^2)$$

27. (b)

Pressure at half the depth $= p_0 + \frac{h}{2}dg$

Pressure at the bottom $= p_0 + hdg$

According to given condition,

$$p_0 + \frac{h}{2}dg = \frac{2}{3}(p_0 + hdg)$$

$$\Rightarrow \quad 3p_0 + \frac{3h}{2}dg = 2p_0 + 2hdg$$

$$\Rightarrow \quad h = \frac{2p_0}{dg} = \frac{2\times 10^5}{10^3 \times 10} = 20 \text{ m}$$

28. (d)

Let the lower and upper surface of the wings of the aeroplane be at the same height h and speeds of air on the upper and lower surfaces of the wings be v_1 and v_2.

Speed of air on the upper surface of the wing $v_1 = 70$ m/s

Speed of air on the lower surface of the wings $v_2 = 63$ m/s

Density of the air $\rho = 1.3$ kg/m^3

Area $A = 2.5$ m^2

According to Bernoulli's theorem,

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho gh = p_2 + \frac{1}{2}\rho v^2 + \rho gh$$

or

$$p_2 - P_1 = \frac{1}{2}\rho(v_1^2 - v_2^2)$$

$\therefore$ Lifting force acting on the wings,

$$F = (p_2 - p_1) \times A = \frac{1}{2}\rho(v_1^2 - v_2^2) \times A$$

$$\left[\because \text{Pressure} = \frac{\text{Force}}{\text{Area}}\right]$$

$$= \frac{1}{2} \times 1.3 \times [(70)^2 - (63)^2] \times 2.5$$

$$= \frac{1}{2} \times 1.3\,[4900 - 3969] \times 2.5$$

$$= \frac{1}{2} \times 1.3 \times 931 \times 2.5 = 1.51 \times 10^3 \text{ N}$$

29. (a)

With the increase in temperature, the surface tension of liquid decreases and angle of contact also decreases.

30. (c)

As, $$h = \frac{2S\cos\theta}{r\rho g}$$ (height raised = h)

or $$S = \frac{hr\rho g}{2\cos\theta} \quad \text{or} \quad S \propto \frac{h\rho}{\cos\theta}$$

$\therefore$ $$\frac{S_w}{S_{Hg}} = \frac{h_1}{h_2} \times \frac{\cos\theta_2}{\cos\theta_1} \times \frac{\rho_1}{\rho_2}$$

$$= \frac{10}{(-3.42)} \times \frac{\cos 135^\circ}{\cos 0^\circ} \times \frac{1}{13.6}$$

$$= \frac{10}{3.42} \times \frac{0.707}{13.6} = \frac{1}{6.5}$$

31. (b)

There will be no over flowing of liquid in a tube of insufficient height but there will be adjustment of the radius of curvature of meniscus so that hR = a finite constant.

32. (b)

When lift is accelerated downwards, the observed weight of body in a lift decreases. Hence, to counter balance the upward pull due to surface tension on the liquid meniscus, the height through which the liquid rises must increase.

33. (c)

For the given angular velocity of rotation, the centrifugal force $F \propto r$; Therefore, more liquid will be accumulated near the wall of tube and the liquid meniscus will become concave upwards.

34.(c)

Due to surface tension, water rises in the capillary tube upto a height h with concave meniscus on both the sides. Therefore, the total height of water column in the capillary tube $= h + h = 2h$.

35. (b)

Height, $h \propto 1/R$

So, $$h_1/h_2 = R_2/R_1 = 0.4/0.2 = 2$$

36. (c)

As, $V = \frac{\pi p r^4}{8\eta l}$ and $V' = \frac{\pi(3p+p)(r/2)^4}{8\eta l}$

$\therefore$ $$\frac{V'}{V} = 4 \times (1/2)^4 = \frac{1}{4}$$

or $$V' = \frac{V}{4}$$

37. (a)

Let at a time t dV be the decrease in volume of water in vessel in time dt. Therefore rate of decrease of water in vessel = rate of water flowing out of narrow tube

So, $$\frac{dV}{dt} = \frac{\pi(p_1 - p_2)r^4}{8\eta l}$$

But, $$p_1 = p_2 = h\rho g$$

$\therefore$ $$-\frac{dV}{dt} = \frac{\pi(h\rho g)r^4}{8\eta l} = \frac{(\pi\rho g r^4)}{8\eta l \times A} \times (h \times A)$$

where $h \times A$ = volume of water in vessel at a time $t = V$

$\therefore$ $$dV = -\left(\frac{\pi\rho g r^4}{8\eta l A}\right) \times V\,dt = -\lambda V\,dt$$

or $$\frac{dV}{V} = -\lambda\,dt$$

where, $$\frac{\pi\rho g r^4}{8\eta l A} = \lambda = \text{constant}$$

Integrating it within the limits as time changes 0 to t, volume changes from V_0 to V.

or $$\log_e \frac{V}{V_0} = -\lambda t$$

or $$V = V_0 e^{-\lambda t}$$

where, V_0 = initial volume of water in vessel = Ah_0

Therefore, $$h \times A = h_0 A e^{-\lambda t}$$

or $$h = h_0 e^{-\lambda t}$$

Thus, the variation of h and t will be represented by exponential curve as given by (a).

38. (a)

When highly soluble salt (like sodium chloride) is dissolved in water, the surface tension of water increases.

39. (d)

Surface tension of water decreases with rise in temperature.

40. (c)

Since, the bubbles coalesce in vacuum and there is no change in temperature, hence its surface energy does not change. This means that the surface area remains unchanged. Hence,

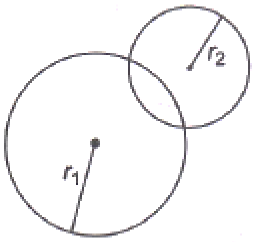
$$4\pi a^2 + 4\pi b^2 = 4\pi R^2$$

or $$R = \sqrt{a^2 + b^2}$$

41. (d)

The excess of pressure inside the first bubble of radius r_1 is $p_1 = 4S/r_1$; and in the second bubble of radius r_2 is, $p_2 = 4S/r_2$.

$\therefore$ Excess pressure $p = \frac{4S}{r} = \frac{4S}{r_1} - \frac{4S}{r_2}$



$\Rightarrow$ $$\frac{1}{r} = \frac{r_2 - r_1}{r_1 r_2}$$

$\Rightarrow$ $$r = \frac{r_1 r_2}{r_2 - r_1}$$

$= T_0(1 - \alpha t)$, *i.e.*, surface tension decreases with increase

42. (b)

As, $T_c = T_0(1 - \alpha t)$, *i.e.*, surface tension decreases with increase in temperature.

43. (a)

Volume of liquid flowing per second through each of the two tubes in series will be the same. So,

$$V = \frac{\pi r_1 R^4}{8\eta L} = \frac{\pi p_2 (R/2)^4}{8\eta\ (L/2)} \text{ or } \frac{p_1}{p_2} = \frac{1}{4}$$

44. (d)

The velocity gradient, $\frac{\Delta V}{\Delta r} = \frac{8}{0.1} = 80\ s^{-1}$

45. (a)

Using theorem of continuity, we have

$$\pi D_p^2 v_p = \pi D_Q^2 v_Q$$

$$v_p = \left(\frac{D_Q}{D_p}\right)^2 v_Q = \left(\frac{4\times10^{-2}}{2\times10^{-2}}\right) \times v_Q = 4v_Q$$