PHYSICS

The following question given below consist of an "Assertion" (A) and "Reason" (R) Type questions. Use the following Key to choose the appropriate answer.

(A) If both (A) and (R) are true, and (R) is the correct explanation of (A).

(B) If both (A) and (R) are true but (R) is not the correct explanation of (A).

(C) If (A) is true but (R) is false.

(D) If (A) is false but (R) is true.

Q.1 **Assertion :** When the surface area of soap-liquid film is increased then surface tension decreases.

Reason : Potential energy of surface molecules increases on increasing surface area. **[D]**

Q. 2 **Assertion :** A capillary tube is dipped in water vertically. It is long enough for the water to rise to the maximum height 'h' in the tube. The length of the immersed portion in water is $\ell(\ell < h)$. The lower end of the tube is closed and the tube is taken out of the water and the lower end is opened again. In opening, the water will not flow out of the tube.

Reason : When the tube is taken out, a meniscus with concavity upward is formed in the lower part of tube and force due to surface tension acts in upward direction which keeps water in tube. **[A]**

Q. 3 **Assertion:** If we break the capillary tube then liquid flow out from capillary due to surface tension force.

Reason : As capillary broken there is no contact between liquid & capillary substance. So it force flat shape.

Sol. **[D]**

A – False

R – True

Q.4 **Assertion :** When the surface area of soap-liquid film is increased then surface tension decreases.

Reason : Potential energy of surface molecules increases on increasing surface area.

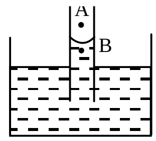
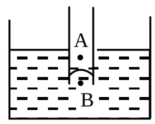
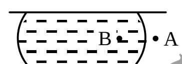
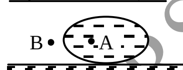
Sol. **[D]**

Surface energy = (surface tension) × (surface area)

Q.5 **Assertion :** Pressure inside water-drop is more than that outside drop.

Reason : Water molecules at the surface layer experience net inward force and hence all the water molecules on surface exert force in just inner layer molecules giving rise to a kind of volumetric compression. **[C]**

Q.1 Capillary rise and shape of droplets on a plate due to surface tension are shown in column II.

Column I	**Column II**
(A) Adhesive forces is greater than cohesive forces	(P) 
(B) Cohesive forces is greater than adhesive forces	(Q) 
(C) Pressure at A > pressure at B	(R) A mercury drop is pressed between two parallel plates of glass 
(D) Pressure at B > Pressure at A	(S) 

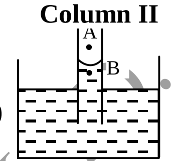
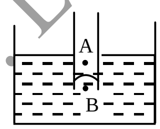
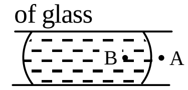
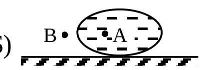
(A) → P ; (B) → Q,R,S ; (C) → P,S ; (D) → Q,R

Q.2 Match the column.

Column-I	**Column-II**
(A) Excess pressure inside a drop	(P) decreases with increase in radius
(B) excess pressure inside a soap bubble	(Q) $\frac{2T}{R}$
(C) Excess pressure inside an air cavity	(R) $\frac{4T}{R}$
(D) Surface tension	(S) decreases with increase in temperature

(A) → P,Q,S (B) → P,Q,S ;(C) → P,R,S; (D) → S

Q.3 Capillary rise and shape of droplets on a plate due to surface tension are shown in column II.

Column I	**Column II**
(A) Adhesive forces is greater than cohesive forces	(P) 
(B) Cohesive forces is greater than adhesive forces	(Q) 
(C) Pressure at A > pressure at B	(R) A mercury drop is pressed between two parallel plates of glass 
(D) Pressure at B > Pressure	(S) 

Sol. **A → P, B → Q, R, S, C → P, S, D → Q, R**

When cohesive forces are greater then adhesive forces shape of meniscus is concave from liquid side and pressure is greater in concave side due to surface tension.

Q.4 Column-I contains different arrangements and column-II contains capillary rise of water in those arrangements. Surface tension of water is S and density is 'ρ'. Match the following -

Column-I	**Column-II**
(A) Silver tube of radius R immersed in water	(P) $\frac{2S}{R\rho g}$
(B) Glass tube of radius R immersed in water	(Q) $\frac{4S}{R\rho g}$

(C) Hollow co-axial cylinder made of glass, having inner and outer radius R and 2R respectively immersed in water — (R) $\frac{3S}{2R\rho g}$

(D) Two parallel glass plate separated by distance 'R' immersed in water — (S) Zero

Sol. **A→ S　　B→ P　　C→ P　　D→ P**

Contact angle between silver and water = 90°

Capillary rise in glass tube = $\frac{2S}{R\rho g}$

Capillary rise in parallel glass plate

$= \frac{2\,\ell S}{\Delta t\,\ell.\rho g}$　　Δt : separation between plates

$= \frac{2S}{R\rho g}$

Capillary rise in co-axial cylinder

$= \frac{2S}{\rho g(R_2 - R_1)} = \frac{2S}{R\rho g}$

Q.5　COLUMN I　　COLUMN II

(A) Excess pressure inside a drop — (P) $F = 6\pi\eta rv$

(B) Excess pressure inside a soap bubble — (Q) $\frac{V}{t} = \frac{\pi P r^4}{8\eta\ell}$

(C) Stokes' law — (R) $\frac{\rho v D}{\eta}$

(D) Poiseuille's formula — (S) $\frac{2T}{r}$

(E) Reynolds number — (T) $\frac{4T}{r}$

Sol. A → S ; B → T ; C → P ; D → Q ; E → R

PHYSICS

Q.1 n drops of a liquid, each with surface energy E, join to form a single drop–

(A) Some energy will be released in the process

(B) Some energy will be absorbed in the process

(C) The energy released or absorbed will be $E(n - n^{2/3})$

(D) The energy released or absorbed will be $nE[2^{2/3} - 1]$ **[A,C]**

Q.2 When water droplets merge to form a bigger drop–

(A) surface area is decreased

(B) surface energy is decreased

(C) energy is liberated

(D) the temperature of the surrounding air may increase marginally **[A,B,C,D]**

Q.3 Which of the following is incorrect ?

(A) The meniscus between two vertical parallel glass plates dipped in water is cylindricals

(B) A small drop of mercury is spherical but bigger

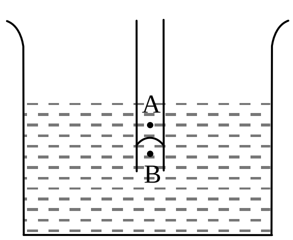
drops are oval in shape

(C) A molecule in the surface of a liquid possesses less potential energy than a molecule in the interior of a liquid

(D) Surface tension is the property of bulk

[C,D]

Q.4 For the capillary rise as shown, A and B are two points just above and just below the meniscus –



(A) Adhesive forces are greater than cohesive forces

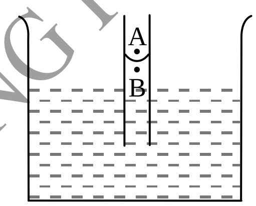
(B) Adhesive forces are less than cohesive forces

(C) Pressure at A is greater than pressure at B

(D) Pressure at A is less than pressure at B

[B,D]

Q.5 For a capillary rise as shown in figure A and B are two points just above and just below the meniscus –



(A) Adhesive forces are greater than cohesive forces

(B) Adhesive forces are less than cohesive forces

(C) Pressure at A is greater than pressure at B

(D) Pressure at A is less than pressure at B

[A,C]

Q.6 A sphere is dropped under gravity through a viscous liquid of viscosity η. If the density of the material of sphere and liquid are ρ and σ respectively with the radius being 'r' then–

(A) initial acceleration is $g\left(\dfrac{\rho-\sigma}{\rho}\right)$

(B) time taken to attain terminal speed $t \propto \sigma^0$

(C) at terminal speed, force on the sphere is zero

(D) at terminal speed, the viscous force is maximum

Sol. **[A, B, C, D]**

Q.7 The properties of a surface are different from those of the bulk liquid because the surface molecules–

(A) are smaller than other molecules

(B) acquire charge due to collision from air molecules

(C) find different type of molecules in their range of influence

(D) feel a net force in one direction

Sol. **[C, D]**

Q.8 The contact angle between a solid and a liquid is a property of–

(A) the material of the solid

(B) the material of the liquid

(C) the shape of the solid

(D) the mass of the solid

Sol. **[A, B]**

Q.9 When a capillary is dipped into a liquid, the liquid neither rises nor falls in the capillary–

(A) the surface tension of the liquid must be zero

(B) the contact angle must be 90º

(C) the surface tension may be zero

(D) the contact angle may be 90º

Sol. **[B, C, D]**

Q.10 A solid sphere moves at a terminal velocity of 20 m/s in air at a place where $g = 9.8\ m/s^2$. The sphere is taken in a gravity free hall having air at the same pressure and pushed down at a speed of 20 m/s -

(A) Its initial acceleration will be $9.8\ m/s^2$ downward

(B) Its initial acceleration will be $9.8\ m/s^2$ upward

(C) The magnitude of acceleration will decrease as the time passes

(D) It will eventually stop

Sol. **[B, C, D]**

Q.11 When an air bubble rises from the bottom of a deep lake to a point just below the water surface, the pressure of air inside the bubble–

(A) is greater than the pressure outside it

(B) is less than the pressure outside it

(C) increases as the bubble moves up

(D) decreases as the bubble moves up

Sol. **[A, D]**

Q.12 n drops of a liquid, each with surface energy E, join to form a single drop–

(A) Some energy will be released in the process

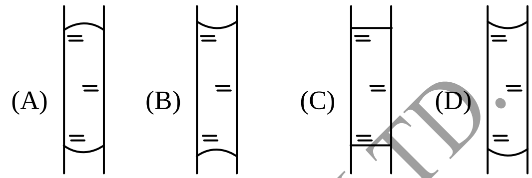
(B) Some energy will be absorbed in the process

(C) The energy released or absorbed will be $E(n - n^{2/3})$

(D) The energy released or absorbed will be $nE[2^{2/3} - 1]$

Sol. **[A, C]**

Q.13 A vertical glass capillary tube, open at both ends, contains some water. Which of the following shapes may be taken by the water in the tube ?



Sol. **[D]**

Q.14 When water droplets merge to form a bigger drop–

(A) surface area is decreased

(B) surface energy is decreased

(C) energy is liberated

(D) the temperature of the surrounding air may increase marginally

Sol. **[A, B, C, D]**

Q.15 Which of the following is correct ?

(A) The meniscus between two vertical parallel glass plates dipped in water is cylindrical

(B) A small drop of mercury is spherical but bigger drops are oval in shape

(C) A molecule in the surface of a liquid possesses less potential energy than a molecule in the interior of a liquid

(D) Only (B) and (C)

Sol. **[A, B]**

Q.16 Which of the following statements is correct ?

(A) If angle of contact is obtuse, the liquid rises in capillary

(B) If angle of contact is acute, then liquid wets solid

(C) If angle of contact is obtuse, the shape of liquid meniscus is convex upwards

(D) Surface tension of liquids, decreases with rise in temperature

Sol.[B,C,D] Informative

PHYSICS

Q.1 A liquid flows out drop by drop from a vessel through a vertical tube with an internal diameter of 2 mm, then the total number of drops that flows out during 10 grams of the liquid flow out: [Assume that the diameter of the neck of a drop at the moment it breaks away is equal to the internal diameter of tube and surface tension is 0.02 N/m] **[0780]**

Sol. If m is mass of single drop then as it drops

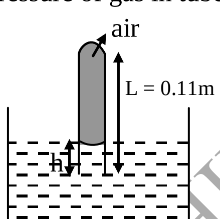
$mg = 2\pi rT$

If number of drops in M = 10 grams is N then,

$$N = \frac{M}{m} = \frac{Mg}{mg} = \frac{Mg}{2\pi rT} \approx 779.86 \approx 780$$

Q.2 A glass capillary sealed at the upper end is of length 0.11 m and internal diameter 2×10^{-5} m. This tube is immersed vertically into a liquid of surface tension 5.06×10^{-2} N/m. When the length $x \times 10^{-2}$ m of the tube is immersed in liquid then the liquid level inside and outside the capillary tube becomes the same, then the value of x is : (Assume atmospheric pressure is $1.01 \times 10^5 \frac{N}{m^2}$) **[0001]**

Sol. If final pressure of gas in tube is P_2 then



$$P_2 - \frac{2T}{r} = P_0$$

(as levels inside and outside are same)

i.e. $P_2 = P_0 + \frac{2T}{r}$

but as temperature remains constant

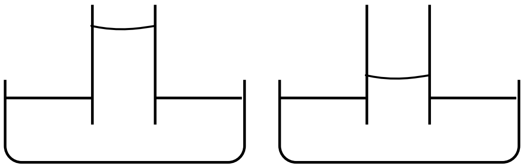
$\therefore \quad P_1V_1 = P_2V_2$

$$P_0AL = \left(P_0 + \frac{2T}{r}\right)A(L - h)$$

On solving, h = 0.01 m

PHYSICS

Q.1 Which water is having detergent dissolved in it



P Q

(A) P (B) Q

(C) both (D) data insufficient

[B]

Sol. detergent decreases the surface tension so level of water rise will be lesser.

Q.2 In a capillary tube, water rises to a height of 4 cm. If the cross-sectional area of the tube were one-fourth, water would have risen to a height of -

(A) 2 cm (B) 4 cm

(C) 8 cm (D) 16 cm **[C]**

Sol. $h = \dfrac{2T\cos\theta}{rdg} \Rightarrow r_1 h_1 = r_2 h_2$

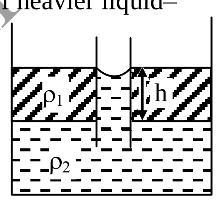
and $A = 2\pi r^2 \Rightarrow r \,\alpha \sqrt{A}$

$\therefore \sqrt{A_1}\; h_1 = \sqrt{A_2}\; h_2$

$\Rightarrow \sqrt{A} \times 4 = \sqrt{\dfrac{A}{4}} \times h_2$

$\Rightarrow h_2 = 8$ cm

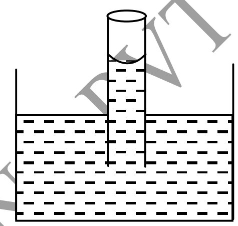
Q.3 A container contains two immiscible liquids of density ρ_1 and ρ_2 ($\rho_2 > \rho_1$). A capillary of radius r is inserted in the liquid so that its bottom reaches upto denser liquid. Denser liquid rises in capillary and attain height equal to h which is also equal to column length of lighter liquid. Assuming zero contact angle find surface tension of heavier liquid–



(A) $\dfrac{r\rho_2 gh}{2}$ (B) $2\pi r\rho_2 gh$

(C) $\dfrac{r}{2}(\rho_2 - \rho_1)gh$ (D) $2\pi r(\rho_2 - \rho_1)gh$ **[C]**

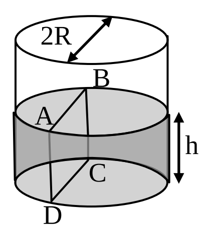
Q.4 A long capillary tube of mass π gram radius 2mm, and negligible thickness is partially immersed in a liquid of surface tension 0.1 N/m. Take contact angle to be zero and neglect buoyant force. The force required to hold the tube vertically will be. ($g = 10$ m/s^2)



(A) 10.4 π mN (B) 10.8 π mN

(C) 0.8 π mN (D) 4.8 π mN **[A]**

Q.5 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 -



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

(B) $|2P_0Rh + R^2\rho gh - 2RT|$

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

(D) $|P_0\pi R^2 + R\rho gh^2 + 2RT|$ **[B]**

Q.6 The drops of a liquid of density ρ are swimming half immersed inside a liquid of density σ. If the surface tension of the liquid is T, then the radius R of the drop is-

(A) $R = \sqrt{\dfrac{3T}{g(2\rho - \sigma)}}$ (B) $R = \sqrt{\dfrac{3T}{2g(2\rho - \sigma)}}$

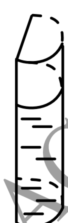
(C) $R = \sqrt{\dfrac{3T}{2g\rho}}$ (D) $R = \sqrt{\dfrac{2T}{3g\rho}}$ **[A]**

Q.7 A thin metal ring of radius r floats on water surface and bends the surface downwards along the perimeter making an angle θ with vertical edge of the ring. If the ring displaces a weight of water W and surface tension of water is T, then the weight of metal ring is–

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

(C) $4\pi rT\cos\theta + 2W$ (D) $4\pi rT\cos\theta + W$ **[D]**

Q.8 A liquid is contained in a vertical tube of semicircular cross-section (shown in figure). The contact angle is zero. The force of surface tension on the flat part and on the curved part are in ratio-



(A) 1 : 1 (B) 1 : 2

(C) π : 2 (D) 2 : π **[D]**

Q.9 Energy liberated in combining n equal drops (surface tension = T) of radius r to form a big drop of radius R is

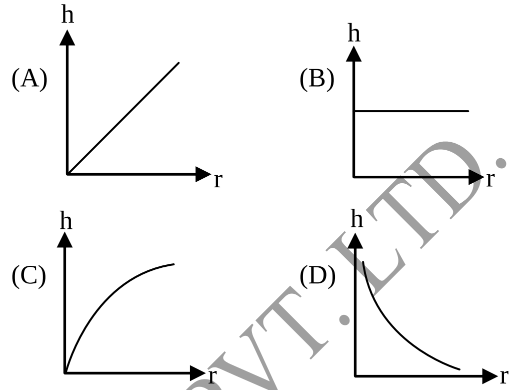
(A) $E = 4\pi r^2 T(n^{1/3} - 1)$

(B) $E = 4\pi R^2 T(n^{1/3} - 1)$

(C) $E = \pi r^2 T(n^{1/3} - 1)$

(D) $E = \pi R^2 T(n^{1/3} - 1)$ **[B]**

Q.10 If in a liquid, different capillaries (radius = r) are dipped, then the graph between liquid rise (h) and r is



[D]

Q.11 The amount of work done in increasing size of a soap film from 10cm × 6cm to 10cm × 10 cm is (surface tension = 30×10^{-3} N/m)

(A) 2.4×10^{-2} J (B) 2.4×10^{-4} J

(C) 1.2×10^{-2} J (D) 1.2×10^{-4} J

[B]

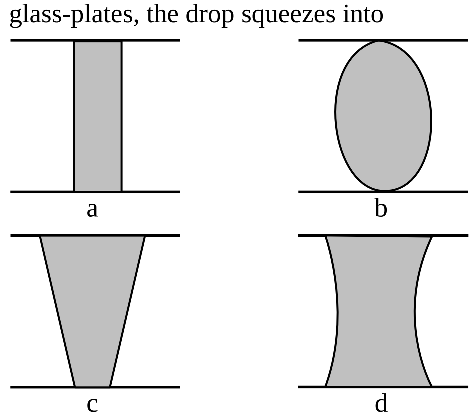
Q.12 Two spherical soap bubbles coalesce. If V is the consequent change in volume of the contained air and S is the change in the total surface area, then

(A) 3PV + 4ST = 0 (B) 4PV + 3ST = 0

(C) PV + 4ST = 0 (D) 4PV + ST = 0

[A]

Q.13 When a drop of water is placed between two glass-plates, the drop squeezes into



(A) d (B) c

(C) b (D) a **[A]**

Q.14 The surface energy of a small liquid drop is U. It is sprayed into 1000 small and equal drops. The surface energy will be

(A) U (B) 10 U

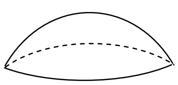
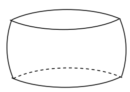
(C) 100 U (D) 1000 U **[B]**

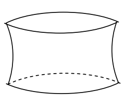
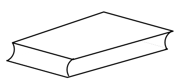
Q.15 Hair of shaving brush cling together when it is removed from water, due to

(A) surface tension (B) viscosity

(C) friction (D) elasticity **[A]**

Q.16 A mercury pallet is trapped between two horizontal glass plate having small space between them. The shape of mercury pallet is best described by -

(A)  **(B)** 

(C)  **(D)** 

[B]

Sol. Contact angle between mercury and glass plate is acute.

Q.17 The pressure inside two soap bubbles are 1.02 atm. and 1.03 atm. respectively. The ratio of their volumes is -

(A) 102 : 103 (B) 103 : 102

(C) $(103)^3 : (102)^3$ (D) 27 : 8 **[D]**

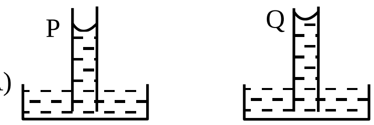
Sol. $P_{in} - P_{atm}$ = excess pressure = $\frac{4T}{R}$

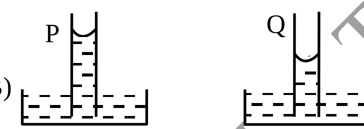
[$P_{in} - P_{atm}$ = nkc vkf/kD; = $\frac{4T}{R}$]

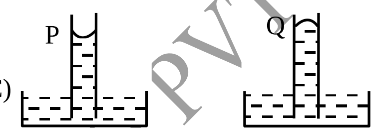
$$\therefore \frac{R_1}{R_2} = \frac{\Delta P_2}{\Delta P_1} = \frac{3}{2}$$

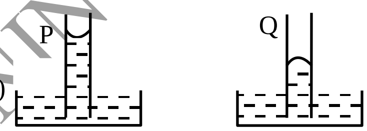
$$\therefore \frac{V_1}{V_2} = \frac{R_1^{\,3}}{R_2^{\,3}} = \frac{27}{8}$$

Q.18 A capillary tube (P) is dipped in water. Another identical tube (Q) is dipped in a soap water solution. Which of the following shows the relative nature of the liquids columns in the two tubes ?

(A) 

(B) 

(C) 

(D) 

[B]

Sol. Meniscus will be concave from upside and in soap solution it should decrease.

Q.19 The angle of contact between liquid and solid doesn't depend upon –

(A) nature of liquid and solid

(B) impurity on the surface of contact

(C) third medium or atmosphere

(D) inclination of solid **[D]**

Q.20 A metallic wire of density ρ floats horizontal in water. The maximum radius of the wire sothat the wire may not sink will be : (surface tension of water = T and angle of contact θ = 0º) -

(A) $\sqrt{\frac{2T}{\pi\rho g}}$ (B) $\sqrt{\frac{4T}{\rho g}}$

(C) $\sqrt{\frac{T}{\pi\rho g}}$ (D) $\sqrt{\frac{T\rho}{\pi g}}$ **[A]**

Sol. $2T\ell \cos\theta = mg = \pi r^2 \ell \rho g$

$$\therefore r = \sqrt{\frac{2T}{\pi\rho g}}$$

Q.21 In the bottom of a vessel with mercury of density ρ there is a round hole of radius r. At what maximum height of the mercury layer will the liquid still not flow out through this hole? (Surface tension = T) -

(A) $\frac{T}{r\rho g}$ (B) $\frac{T}{2r\rho g}$

(C) $\frac{2T}{r\rho g}$ (D) $\frac{4T}{r\rho g}$ **[C]**

Sol. Because mercury meniscus is convex. The pressure just inside the hole will be less than the outside pressure by $\frac{2T}{r}$

$\therefore h\rho g = \frac{2T}{r}$ or $h = \frac{2T}{r\rho g}$

Q.22 In a U-tube the radii of two columns are respectively r_1 and r_2. When a liquid of density ρ (θ = 0°) is filled in it, a level difference of h is observed on two arms, then the surface tension of the liquid is -

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

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

Sol. $\rho g h = 2T\left(\frac{1}{r_1} - \frac{1}{r_2}\right) = 2T\left(\frac{r_2 - r_1}{r_1 r_2}\right)$

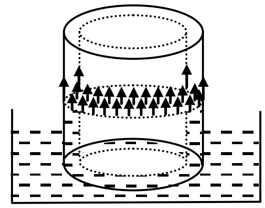
$\therefore T = \frac{\rho g h r_1 r_2}{2(r_2 - r_1)}$

Q.23 A coaxial cylinder made of glass is immersed in liquid of surface tension 'S'. Radius of inner and outer surface of cylinder are R_1 and R_2 respectively. Height till which liquid will rise is (Density of liquid is ρ)-

(A) $\frac{2S}{R_2\rho g}$ (B) $\frac{2S}{R_1\rho g}$

(C) $\frac{S}{(R_2 - R_1)\rho g}$ (D) $\frac{2S}{(R_2 - R_1)\rho g}$ **[D]**

Sol.



Net upward force

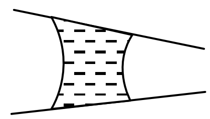
$= 2\pi R_2 S + 2\pi R_1 S$ contact angle = 0°

∴ Capillary rise is given by

$h = \frac{2\pi S(R_1 + R_2)}{\pi(R_2^2 - R_1^2)\rho g}$

$= \frac{2S}{(R_2 - R_1)\rho g}$

Q.24 A conical pipe shown in figure have a water drop. The drop will tend to move towards -



(A) tapered end (B) wider end

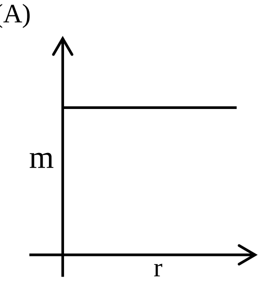
(C) in any direction (D) no tendency to move

[A]

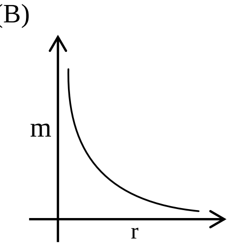
Sol. Excess pressure is directed towards centre of curvature and inversely proportional to radius of curvature.

Q.25 Graph between the mass of liquid inside the capillary and radius of capillary is –

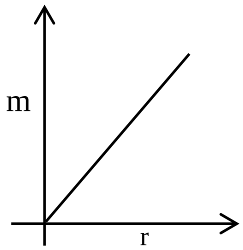
(A)



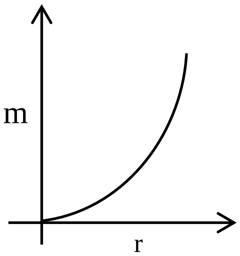
(B)



(C)



(D)



[C]

Sol. Mass of liquid inside the capillary = $\pi r^2 h\, d$

$= (\pi r\, h\, d).\, r$

since, hr = constant

$\therefore$ mass of liquid inside α r

Q.26 If one increases the volume of a soap bubble the surface tension of the bubble -

(A) increase

(B) decrease

(C) remains the same

(D) becomes zero **[C]**

Sol. Surface tension does not depend upon area of surface.

Q.27 Molecular force are -

(A) only adhesive

(B) only cohesive

(C) only repulsive

(D) cohesive and adhesive **[D]**

Q.28 Forces responsible for surface tension differ from that of gravitational and electrostatic force because these are -

(A) electromagnetic

(B) weak forces

(C) obeying inverse square law

(D) both attractive and repulsive in character

[B]

Q.29 The net force acting on a molecule inside the liquid is -

(A) directed upwards at the liquid surface

(B) directed inwards at the liquid surface

(C) zero

(D) infinite **[C]**

Q.30 Free surface of a liquid behaves as a stretched membrane and tends to assume the smallest possible area due to the-

(A) cohesive force

(B) adhesive force

(C) centrifugal force

(D) centripetal force **[A]**

Q.31 The liquid surfaces have a tendency to contract, this phenomenon is due to-

(A) surface tension (B) viscosity

(C) friction (D) dispersion **[A]**

Q.32 Surface tension may be defined as the mechanical work required to create an additional unit area of the liquid under-

(A) isobaric conditions

(B) isothermal conditions

(C) adiabatic conditions

(D) isometric conditions. **[B]**

Q.33 The surface tension of a liquid depends on -

(A) contamination

(B) impurity dissolved in the liquid

(C) temperature

(D) all of the above **[D]**

Q.34 If we increase the surface area of a soap film, the surface tension of the film -

(A) increases (B) decreases

(C) remains the same (D) becomes infinite

[C]

Q.35 When the temperature of liquid is increased/current flows through a liquid, then its surface tension -

(A) remains constant

(B) increases

(C) decreases

(D) first increases then decreases **[C]**

Q.36 The soap and the detergent make water suitable for washing clothes because they-

(A) make it rich in lather

(B) increase its density

(C) reduce its hardness

(D) reduce its surface tension **[D]**

Q.37 Which of the following liquids has the maximum value of surface tension-

(A) water (B) soap-solution

(C) alcohol (D) mercury **[D]**

Q.38 The surface tension of mercury at normal temperature and pressure is-

(A) 72 dyne/cm (B) 72 N/m.

(C) 453 dyne/cm (D) 435×10^{-3} N/m

[D]

Q.39 At critical temperature, the surface tension of a liquid-

(A) is zero

(B) is infinity

(C) is the same as that any other temperature

(D) can not be determined. **[A]**

Q.40 On wearing a rain coat on which some greasy material is coated, a person does not wet in rain because-

(A) the rain coat absorbs water

(B) the cohesive force of water is more

(C) the adhesion between the rain coat and water becomes less

(D) none of these **[C]**

Q.41 Few drops of alcohols are poured on the surface of water contained in a tube. The water goes away from the side from which alcohol is being poured. This shows that -

(A) the surface tension of the alcohol solution is more than that of water

(B) the viscosity of the alcohol solution is more than that of water

(C) the surface tension of the alcohol solution is less than that of water

(D) the viscosity of the alcohol solution is less than that of water **[C]**

Q.42 It is possible to join two metals by soldering due to the property of-

(A) diffusion (B) elasticity

(C) viscosity (D) surface tension

[D]

Q.43 If there is a thin layer of water between two parallel plates then it is easier to separate the plates by-

(A) displacing them

(B) applying force perpendicular to the surface of the plates

(C) applying force in the some direction

(D) none of the above **[A]**

Q.44 The writing of a fountain pen on a newspaper is not legible due to-

(A) cohesion

(B) adhesion

(C) capillary rise effect

(D) none of the above **[C]**

Q.45 The incorrect statement is -

(A) Tree gets water from earth through capillary action

(B) Towel absorbs water from our body by capillary action

(C) We get water in house tops through the action of surface tension

(D) Our teeth get blood from the body by capillary action **[C]**

Q.46 If a liquid is stirred for some time and then left. It comes to rest after some time. Its reason is-

(A) viscosity (B) surface tension

(C) gravitation (D) centripetal force

[A]

Q.47 Big liquid drops are not spherical due to -

(A) viscosity

(B) surface tension

(C) gravitational force

(D) atmospheric pressure **[C]**

Q.48 The length of a needle floating on water is 2.5 cm. The minimum force in addition to its weight needed to lift the needle above the surface of water will be -

(A) 36 N (B) 10 N

(C) 9 N (D) 6 N **[A]**

Q.49 W is the work done in forming a bubble of radius r, the work done in forming a bubble of radius 2r will be -

(A) 4W (B) 3W

(C) 2W (D) W **[A]**

Q.50 A big drop of water whose diameter is 0.2 cm, is broken into 27000 small drops of equal volume. Work done in this process will be - (surface tension of water is 7×10^{-2} N/m).

(A) 5×10^{5} joule (B) 2.9×10^{-5} joule

(C) 2.55×10^{-5} joule (D) zero **[C]**

Q.1 (i) Calculate the work done against surface tension forces in blowing a soap bubble of 1 cm diameter if the surface tension of soap solution is $2.5\times10^{-2}Nm^{-1}$.

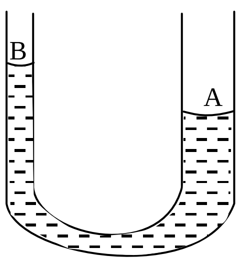
(ii) Find the work required to break up a drop of water of radius 0.5 cm into drops of water each of radius 1mm assuming isothermal conditions. (surface tension of water = $7 \times 10^{-2}Nm^{-1}$)

Ans. **[** (i) 1.57×10^{-5} J, (ii) 88×10^{-5} J **]**

Q.2 There is a soap bubble of radius 2.4×10^{-4} m in 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 0.08 Nm^{-1}.

Sol. 8.08×10^5 Nm^{-2}

Q.3 Calculate the difference in water levels in two communicating capillary tubes of diameter d = 1 mm and d = 1.5 mm. Surface tension of water =0.07 Nm^{-1} and angle of contact between glass and water = 0°



Sol. 4.76 mm

Q.4 A cube of mass m = 800 g floats on the surface of water. Water wets it completely. The cube is 10 cm on each edge. By what additional distance is it buoyed up or down by surface tension ?

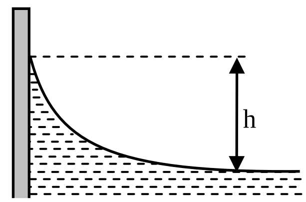
Surface tension of water = 0.07 N m^{-1}

Sol. 2.8×10^{-4} m

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

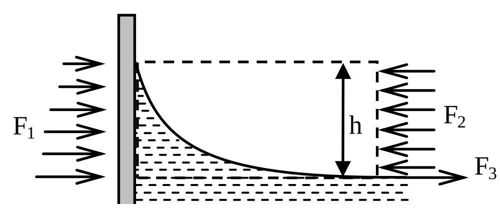
Sol. 1.4 kg

Q.6 Water in a clean aquarium forms a meniscus, as illustrated in the figure.



Calculate the difference in height **h** between the centre and the edge of the meniscus. The surface tension of water is $\gamma = 0.073$ N m^{-1}.

Sol. The pressure of the water changes linearly with the increase in height. At the bottom of the meniscus it is equal to the external atmospheric pressure $\mathbf{p_0}$, and at the top to $\mathbf{p_0 - \rho gh}$. The average pressure exerted on the wall is $\mathbf{p_{average} = p_0 - \rho gh/2}$. The force corresponding to this value, for an aquarium with side walls of length ℓ, is $\mathbf{F_1 = \ell\, p_{average} h}$.



Consider the horizontal forces acting on the volume of water enclosed by the dashed lines in the figure. The wall pushes it to the right with force $\mathbf{F_1}$, the external air pushes it to the left with force $\mathbf{F_2 = \ell p_0 h}$, and the surface tension of the rest of the water pulls it to the right with a force $\mathbf{F_3 = \ell\gamma}$. The resultant of these forces has to be zero, since the volume itself is at rest. This means that

$$\left(p_0 - \frac{1}{2}\rho g h\right)\ell h - p_0\ell h + \ell\gamma = 0,$$

which we can write as

$$h = \sqrt{\frac{2\gamma}{\rho g}} = \sqrt{\frac{2\times 0.073}{1000\times 10}} = 0.0038 \text{ m}.$$

Water rises by approximately 4 mm up the wall of the aquarium.

Q.7 A mixture of lead pellets 3 mm and 1mm in diameter is lowered into a tank with glycerin 1 m deep. How much later will the smaller pellets drop to the bottom than the greater ones ? At the temperature of the experiment the dynamic viscosity is 14.7 g/cm.s

Sol. 4 min

Q.8 A spherical ball of radius 1×10^{-4} m and of density 10^4 kg/m^3 falls freely under gravity through a distance h before entering a tank of water. If after entering the water, the velocity of the ball does not change find h. The coefficient of viscosity of water is 9.8×10^{-6} N-sec/m^2.

Sol. 20.41 m

Q.9 A vessel filled with air under pressure P_0 contains a soap bubble of diameter d. The air pressure having been reduced n-fold, and the bubble diameter increased r-fold isothermally. Find the surface tension of the soap-water solution.

Sol. $T = \frac{1}{8} P_0 d \times \frac{1 - \frac{r^3}{n}}{r^2 - 1}$

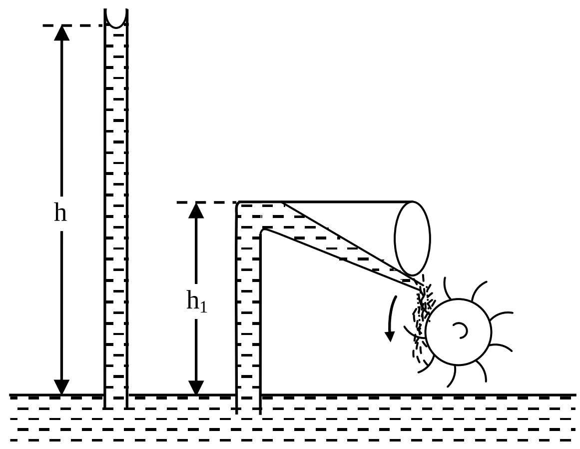
Q.10 There is air bubble of radius 1.0 mm in a liquid of surface tension 0.075 N/m and density 1000 kg/m. The bubble is at a depth of 10 cm below the free surface. By what amount is the pressure inside the bubble greater than the atmospheric pressure ? Take g = 9.8 m/s^2.

Sol. 1130 pascal

Q.11 A ball rises to the surface at a constant velocity in a liquid whose density is four times greater than that of the material of the ball. How many times is the force of friction acting on the rising ball greater than its weight ?

Sol. 3 times

Q.12 The following design of a perpetuum mobile has been suggested. A capillary of radius **r** is chosen which allows water to rise to a height **h** **(Fig.)**.



At a height **h_1**, smaller than **h**, the capillary is bent and its upper end is made into a broad funnel as shown in the diagram. The surface tension is enough to raise the liquid to the height **h_1** and introduce it into the funnel. The liquid in the broad part of the funnel detaches itself from its upper surface and flows down unimpeded. A water wheel can be installed in the path of the drops falling back into the vessel, thus providing a perpetuum mobile.

Will this perpetuum mobile actually operate? Find the error in the reasoning above.

Sol. As soon as the water enters the funnel the radius of curvature of the meniscus will begin to increase and, correspondingly, the surface tension will gradually diminish. The water in the funnel will only reach the section with that radius R where the surface tension exactly equalizes the weight of the water column h.

The radius of this section can be determined from the ratio

$$2\pi R\alpha = \pi r^2 dgh \quad \text{or} \quad R = \frac{dghr^2}{2\alpha}$$

The perpetuum mobile will not operate and the water will not flow out of the funnel.

Q.13 A ring is cut from a platinum tube 8.5 cm internal and 8.7 cm external diameter. It is supported horizontally from a pan of a balance so that is comes in contact with the water in a glass vessel. What is the surface tension of water is an extra 3.97 gm weight is required to pull it away from water (g = 980 cm/sec^2).

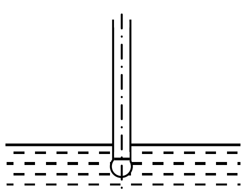
Sol. 72.13 dyne/cm

Q.14 Part of a capillary is lowered into a wetting agent. Can the loss of weight of the capillary be calculated by Archimedes' law? What will the answer be in the case of a non-wetting agent?

Sol. A force $F = 2\pi r\alpha$ is exerted by the walls of the capillary on the liquid. According to Newton's third law, a force of the same magnitude but in the opposite direction will be exerted by the liquid on the capillary. The loss of weight in the case of the wetting agent will be less than the loss calculated by Archimedes law and larger in case of a non-wetting agent.

It cannot. While calculating the loss in weight, a correction should be introduced for the action of surface tension.

Q.15 In a device designed by Academician Rebinder the surface tension is determined from the pressure difference 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.

Sol. The additional pressure produced in the bubbles of air inside the liquid by surface tension can be found from the following simple reasoning.

When the end of the capillary touches the surface of the liquid the latter will rise in the capillary to a height $h = \frac{2\alpha}{dgr}$ under the action of a surface tension $\mathbf{F = 2\pi r\alpha}$ directed upwards. In this case the force F is equalized by the weight of the liquid column.

If an additional pressure

$$\Delta P = \frac{F}{S} = \frac{2\pi r\alpha}{\pi r^2} = \frac{2\alpha}{r}$$

Is set up in the capillary above the surface of the liquid ($S = \pi r^2$ is the cross-sectional area of the capillary) the action of surface tension will be completely balanced by the excess pressure of the air in the capillary while the weight of the liquid column in the capillary will remain unequalized. Therefore, the level of the liquid in the capillary should go down to the initial height and a bubble of air—a hemisphere of radius R equal to the radius of the capillary r—will form at the end of the tube. The required pressure in the bubble will be

$$\Delta P = \frac{2\alpha}{R}$$

Where R is the radius of the bubble.

It can be shown that this expression always determines the excess pressure built up by the surface tension in closed bubbles inside a liquid. Formula (1) shows that the pressure in the bubble diminishes as the radius of the bubble increases. The formation of a bubble at the end of the capillary proves that the minimum radius of the bubble is equal to the radius of the capillary.

Therefore, when α is calculated from the data in the problem the radius of the capillary should be inserted, instead of R, in the calculation formula

$\alpha = \frac{\Delta PR}{2} \approx$ **70 dyn/cm.** Ans.

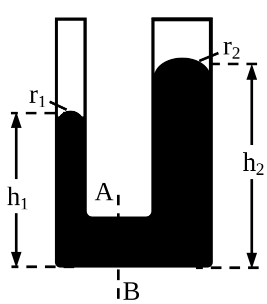
Q.16 The internal radius of one limb of a capillary U-tube is r_1 = 1 mm and the internal radius of the second limb is r_2 = 2 mm. The tube is filled with some mercury, and one of the limbs is connected to a vacuum pump.

What will be the difference in air pressure when the mercury levels in both limbs are at the same height? Which limb of the tube should be connected to the pump? The surface tension of mercury is 480 dyn/cm.

Sol. The pump should be connected to the narrow capillary.

Let us denote the heights of the mercury levels before the air is pumped out by h_1 and h_2.

The mercury in the tube will be in equilibrium if the pressures produced by the columns of mercury on the two sides are equal in the cross section AB (Fig.). The total pressure in the cross section AB is composed on each side of the pressure **gh** (mm Hg) created by the weight of the mercury column and the pressure produced by surface tension and equal to



$$\frac{F}{S} = \frac{2\pi r\alpha}{\pi r^2} = \frac{2\alpha}{r}$$

For this reason the condition of equilibrium may be written as:

$$gh_1 + \frac{2\alpha}{r_1} = gh_2 + \frac{2\alpha}{r_2}$$

or

$$h_1 - h_2 = \frac{2\alpha}{g}\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = \frac{2\alpha}{g}\left(\frac{r_1 - r_2}{r_1 r_2}\right)$$

The pressure difference of the air should compensate for this difference in the heights of the mercury columns, i.e., it should be equal (in mm Hg) to

$\Delta P = h_1 - h_2 = \frac{2\alpha}{g}\frac{r_1 - r_2}{r_1 r_2} \approx$ **3.6 mm Hg.**

Ans.

Q.17 A capillary tube sealed at the top has an internal radius of r = 0.05 cm. The tube is placed vertically in water, open and first.

What should be the length 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. The surface tension of water is α = 70 dyn/cm.

Sol. After rising to a height h in the tube the water will compress the air contained in it and produce an excess pressure ΔP which can be calculated by Boyle's law and will be equal to

$$\Delta P = P - P_0 = \frac{P_0 h}{l - h}$$

The pressure $P_1 = \frac{2\alpha}{r}$ produced by surface tension should in our case balance the sum of the pressures created by the weight of the water column and by the air compressed in the capillary, i.e., the following equality should hold

$\frac{2\alpha}{r} = \frac{P_0 h}{l - h}$ +dgh (d is the density of water)

From which the formula for *l* can be calculated.

$l = \frac{P_0 rh}{2\alpha - dg\,rh} + h \approx$ **552 cm.** Ans.

Q.18 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 gf is needed to regain equilibrium.

Determine the radius of the capillary. The surface tension of water is α = 70 dyn/cm.

Sol. The surface tension acts on the external and internal surfaces of the tube. Considering that the tube. Considering that the walls are thin and assuming to a first approximation that the radii of the liquid surfaces near the walls of the capillary are the same in size both outside and inside the tube the forces acting on the internal and external surfaces of the tube may also be considered the same. The force acting on the internal surface is equal to the weight of the water raised into the capillary by the surface tension, while the change in the weight of the capillary is equal to twice the weight of this water.

Hence,

$r = \frac{P}{4\pi\alpha}$, $r \approx$ **1.5 mm.** Ans.

Q.19 A capillary of radius **r** is lowered into a wetting agent with surface tension $\boldsymbol{\alpha}$ and density **d**. Determine the height $\mathbf{h_0}$ 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.

Sol. The height to which the liquid rises in the capillary is $h_0 = \frac{2\alpha}{dgr}$. The work done by surface tension in this case is $A = Fh_0 = \frac{4\pi\alpha^2}{dg}$. The potential energy of the liquid raised in the in the capillary is

$U = mg\frac{h_0}{2} = dg\pi r^2 h_0 \frac{h_0}{2} = \frac{2\pi\alpha^2}{dg}$

or $U = \frac{A}{2}$

Only half of the work done by surface tension is converted into the potential energy of the liquid. The other half is expended on the work against the forces of friction and is converted into heat. If there were no viscosity and friction against the walls, the liquid level would perform harmonic oscillations in the capillary with the height h_0 as the position of equilibrium.

Q.20 A soap bubble is slowly (under isothermal conditions) blown in air at N.T.P. to radius R, How much work is done ? Surface tension of the film is T.

Sol. $8\pi R^2 T$