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PHYSICS

2.MECHANICAL PROPERTIES OF FLUIDS

Single Correct Answer Type

1. The work done in blowing a soap bubble of volume 'V' is 'W'. The work required to blow a soap bubble of volume '2V' is
[T = surface tension of soap solution]
a) $2^{2/3}$ W
b) 2 W
c) W
d) $2^{1/3}$ W

2. Two soap bubbles of radii r_1 and r_2 in vacuum collapse under isothermal conditions. The resulting bubble has radius equal to
a) $r_1 + r_2$
b) $\sqrt{r_1^2 + r_2^2}$
c) $\frac{r_1 + r_2}{2}$
d) $\frac{r_1 r_2}{r_1 + r_2}$

3. Due to surface tension, the excess pressure inside a smaller drop is 9 units. If 27 smaller drops combine, then the excess pressure inside the bigger drop is
a) 4 units
b) 1 unit
c) 2 units
d) 3 units

4. A water drop of radius 'r' and volume 'V' is kept in between the two identical glass plates such that it forms a thin layer of area 'A' between the plates. A force 'F' is applied such that the two plates separate from each other. The surface tension 'T' of the liquid is
a) $\frac{A^2}{FV}$
b) $\frac{FV}{2A^2}$
c) $\frac{FV}{4A^2}$
d) $\frac{AV}{F^2}$

5. A spherical ball of radius 'R' is falling through liquid of viscosity 'η' with velocity 'v'. The retarding force acting on the spherical ball is
a) Directly proportional to radius R and inversely proportional to velocity 'v'
b) Directly proportional to radius R and velocity 'v'
c) Inversely proportional to radius R' and velocity 'v'
d) Inversely proportional to radius 'R' and directly proportional to velocity 'v'

6. Angle of contact of a liquid with a solid depends on
a) solid only
b) liquid only
c) Both solid and liquid
d) orientation of the solid surface in liquid

7. 'n' small water drops of same size fall through air with constant velocity 'V'. They coalesce to form a big drop. The terminal velocity of the big drop is
a) $\frac{V}{n^{\frac{1}{3}}}$
b) $Vn^{1/3}$
c) $Vn^{2/3}$
d) $\frac{V}{n^{\frac{2}{3}}}$

8. On mixing highly soluble impurity in water, the surface tension 'T' and angle of contact 'θ',
a) Decreases and increases respectively
b) Both decrease
c) Increases and decreases respectively
d) Both increase

9. Water rises to a height of 2 cm in a capillary tube. If cross-sectional area of the tube is reduced to $1/16^{th}$ of initial area then water will rise to a height of
a) 4 cm
b) 8 cm
c) 12 cm
d) 16 cm

10. Let 'R_1' and 'R_2' are radii of two mercury drops. A big mercury drop is formed from them under isothermal conditions. The radius of the resultant drop is
a) $\sqrt{R_1^2 + R_2^2}$
b) $(R_1^3 + R_2^3)^{1/3}$
c) $\sqrt{R_1^2 - R_2^2}$
d) $\frac{R_1 + R_2}{2}$

11. A spherical solid ball of volume 'V' is made of a material of density 'ρ_1'. It is falling through a liquid of density $\rho_2 (\rho_2 < \rho_1)$. Assume that the liquid applies a viscous force on the ball that is proportional to the square of the speed V_t, i.e. $F_{viscous} = KV_t^2 [K > 0]$, then the terminal speed

of ball is
(g = acceleration due to gravity)

a) $\frac{V_g(\rho_1 - \rho_2)}{2K}$
b) $\frac{V_g(\rho_1 - \rho_2)}{K}$
c) $\sqrt{\frac{V_g(\rho_1 - \rho_2)}{K}}$
d) $\sqrt{\frac{K(\rho_1 - \rho_2)}{V_g}}$

12. The speed of a ball of radius 2 cm in a viscous liquid is 20 cm/s. What will be the speed of a ball of radius 1 cm in same liquid?
a) 10 cm/s
b) 4 cm/s
c) 5 cm/s
d) 8 cm/s

13. The amount of work done in blowing a soap bubble such that its diameter increases from d to D is (where, 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) $8\pi(D^2 - d^2)S$

14. The surface tension for pure water in a capillary tube experiment is
a) $\frac{\rho g}{2hr}$
b) $\frac{2}{hr\rho g}$
c) $\frac{r\rho g}{2h}$
d) $\frac{hr\rho g}{2}$

15. A square frame of each side 'L' is dipped in a soap solution and taken out. The force acting on the film formed is
(T = surface tension of soap solution)
a) $R = (R_1^3 + R_2^3)^{1/3}$
b) 2TL
c) 8TL
d) 12TL

16. Match the following columns.

Column I	Column II
A. Excess pressure inside a liquid drop	1. $\frac{2S}{R}$
B. Excess pressure inside a soap bubble	2. $\frac{3S}{R}$
C. Excess pressure inside air bubble	3. $\frac{4S}{R}$

Codes
a) A-1, B-3, C-1
b) A-1, B-2, C-3
c) A-1, B-1, C-3
d) A-2, B-1, C-3

17. A large number of liquid drops each of radius a are merged 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 the big drop is
[ρ = density of liquid, T = surface tension of liquid]
a) $\left[\frac{6T}{\rho}\left(\frac{1}{a} - \frac{1}{b}\right)\right]^{1/2}$
b) $\left[\frac{6T}{\rho}\left(\frac{1}{b} - \frac{1}{a}\right)\right]^{1/2}$
c) $\left[\frac{\rho}{6T}\left(\frac{1}{a} - \frac{1}{b}\right)\right]^{1/2}$
d) $\left[\frac{\rho}{6T}\left(\frac{1}{b} - \frac{1}{a}\right)\right]^{1/2}$

18. In a capillary tube having area of cross-section A, water rises to a height h. If cross-sectional area is reduced to $\frac{A}{9}$, the rise of water in the capillary tube is
a) 4h
b) 3h
c) 2h
d) h

19. A large vessel completely filled with water has two holes 'A' and 'B' at depths 'h' and '4h' from the top. Hole 'A' is a square of side 'L' and hole 'B' is circle of radius 'R'. If from both the holes same quantity of water is flowing per second, then side of square hole is
a) $2\pi R$
b) $\sqrt{2\pi}.R$
c) $\frac{R}{2}$
d) $\sqrt{2\pi R}$

20. If the terminal speed of a sphere A [density $\rho_A = 7.5 \text{ kg m}^{-3}$] is 0.4 ms^{-1}, in a viscous liquid [density $\rho_L = 1.5 \text{ kg m}^{-3}$], the terminal speed of sphere B [density $\rho_B = 3 \text{ kg m}^{-3}$] of the same size in the same liquid is
a) 0.3 ms^{-1}
b) 0.1 ms^{-1}
c) 0.2 ms^{-1}
d) 0.4 ms^{-1}

21. If excess pressure inside a water drop is 60 N/m^2, the diameter of water drop is [surface tension of water = 0.072 N/m]
a) 1.2 mm
b) 2.4 mm
c) 3.6 mm
d) 4.8 mm

22. A water barrel stands on a table of height 'h'. A small hole is made on the wall of barrel at its bottom. If the stream of water coming out of the hole strikes the ground at horizontal distance 'R' from the table, the depth 'd' of water in the barrel is
a) $\frac{h}{4R^2}$
b) $\frac{R^2}{2h}$
c) $\frac{R^2}{4h}$
d) $\frac{4h}{R^2}$

23. If the work done in blowing a bubble of volume V is W, then the work done in blowing a soap bubble of volume 2 V will be
a) W
b) 2W
c) $\sqrt{2}$W
d) $4^{1/3}$W

24. The work done in blowing a soap bubble of 10 cm radius is (Take, surface tension of soap bubble = $3/100 \text{Nm}^{-1}$)
a) 37.68×10^{-4} J
b) 75.36×10^{-4} J
c) 75.36 J
d) 150.72×10^{-4} J

25. Water rises to a height of 10.3 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,

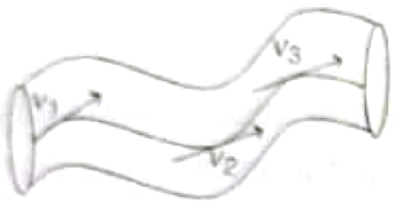
a) water will come as a fountain from the capillary tube
b) water will stay at a height of 12 cm in the capillary tube
c) the height of water in the capillary tube will be 10.3 cm
d) water height flow down the sides of the capillary tube

26. The excess pressure inside a soap bubble of radius 2 cm is 50 dyne/cm^2. The surface tension is
a) 50 dyne/cm
b) 75 dyne/cm
c) 25 dyne/cm
d) 60 dyne/cm

27. The work done in blowing a soap bubble of radius 'R' is 'W_1' at room temperature. Now the soap solution is heated. From the heated solution another soap bubble of radius '2R' is blown and the work done is 'W_2', Then
a) $W_2 = 0$
b) $W_2 < 4W_1$
c) $W_2 = 4W_1$
d) $W_2 = W_1$

28. Water rises upto a height 'h' in a capillary tube on the surface of the earth. The value of 'h' increases, if the capillary tube apparatus is kept
a) In a lift going upward with acceleration
b) On the sun
c) In a lift going downward with acceleration (a) where a < g (acceleration due to gravity)
d) On the poles

29. Consider streamline flow of a liquid flowing through a tube as shown in the figure. Which of the following is correct regarding velocities of liquid at different points?



a) $v_1 =$ constant, $v_2 =$ constant, $v_3 =$ constant
b) $v_1 \neq v_2 = v_3$
c) $v_1 = v_2 = v_3$
d) Both (a) and (b) are correct

30. Pascal's law is not applied in
a) An atomizer
b) A hydraulic jack
c) A hydraulic press
d) Hydraulic breaks

31. A water film is formed between the two straight parallel wires, each of length 10 cm, kept at a separation of 0.5 cm. Now, the separation between them is increased by 1mm without breaking the water film. The work done for this is
(surface tension of water= 7.2×10^{-2} Nm^{-1})
a) 1.44×10^{-5} J
b) 5.76×10^{-5} J
c) 7.22×10^{-6} J
d) 2.88×10^{-5} J

32. A steel coin of thickness 'd' and density 'ρ' is floating on water of surface tension 'T'. The radius of the coin (r) is
a) $\frac{4T}{3\rho gd}$
b) $\frac{T}{\rho gd}$
c) $\frac{2T}{\rho gd}$
d) $\frac{3T}{4\rho gd}$

33. The surface tension of a soap solution is 'T'. The work done in blowing a soap bubble of diameter 'd' to that of a diameter '2d' is
a) $4\pi d^2T$
b) $2\pi d^2T$
c) $8\pi d^2T$
d) $6\pi d^2T$

34. If 'T' is the surface tension of a soap solution, then the work done in blowing a soap bubble from diameter 'D' to diameter '2D' is
a) $6\pi TD^2$
b) $8\pi TD^2$
c) $2\pi TD^2$
d) $4\pi TD^2$

35. A ball rises to the surface of a liquid with constant velocity. The density of the liquid is four times the density of the material of the ball. The viscous force of the liquid on the rising ball is greater than the weight of the ball by a factor of
a) 4
b) 3
c) 2
d) 5

36. A glass capillary of radius 0.4 mm is inclined at 60° with the vertical in water. Find the length of water in the capillary tube.
(Given, surface tension of water = 7×10^{-2}Nm^{-1})
a) 7.1 cm
b) 3.6 cm
c) 1.8 cm
d) 0.9 cm

37. Water rises in a capillary tube of radius r upto a height h. The mass of water in a capillary is m. The mass of water that will rise in a capillary of radius $\frac{r}{4}$ will be
a) 4 m
b) $\frac{m}{4}$
c) m
d) $\frac{4}{m}$

38. Work done in increasing the size of a soap bubble from radius of 3 cm to 5 cm in milijoule

is nearly (surface tension of soap solution= $0.03\ Nm^{-1}$)

a) $0.4\ \pi$ b) $0.2\ \pi$
c) $4\ \pi$ d) 2π

39. In a capillary tube of area of cross-section 'a' water rises to height 'h'. In a capillary tube of area of cross-section '4a' water will rise upto height

a) 2h b) 4h
c) $\frac{h}{4}$ d) $\frac{h}{2}$

40. At critical temperature, the surface tension of a liquid is

a) zero b) infinity
c) the same as that at any other temperature d) cannot be determined

41. For the given solid-liquid pair,
T_1 is the force due to surface tension at liquid-solid interface,
T_2 is the force due to surface tension at air-solid interface and
T_3 is the force due to surface tension at air-liquid interface
For equilibrium of drop, if $(T_2 - T_1) < T_3$ and $\cos\theta$ is positive then angle of contact will be

a) Acute b) Zero
c) Obtuse d) 90^0

42. Two very wide parallel glass plates are held vertically at a small separation r and dipped in water of surface tension S. Some water climbs up in the gap between the plates. If p_0 is the atmospheric pressure, then the pressure of water just below the water surface in the region between the two plates is

a) $p_0 - \frac{2S}{r}$ b) $p_0 + \frac{2S}{r}$
c) $p_0 - \frac{4S}{r}$ d) $p_0 + \frac{4S}{r}$

43. Work done in increasing the size of a soap bubble from radius of 3 cm to 5 cm in milli-joule is nearly (surface tension of soap solution= $0.03\ Nm^{-1}$)

a) $0.4\ \pi$ b) $0.2\ \pi$
c) 4π d) 2π

44. 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 of water (in Nm^{-1}) is

a) 0.002 b) 0.001
c) 0.2 d) 0.1

45. The Reynold's number for a liquid flow in a tube does NOT depend on

a) The velocity of the liquid b) The viscosity of the liquid
c) The length of the tube d) The diameter of the tube

46. We have three beakers A, B and C containing three different liquids. They are stirred vigorously and placed on a table, then liquid which is

a) most viscous comes to rest at the earliest b) most viscous comes to rest at the last
c) most viscous slows down earliest but comes to rest at the last d) All of them come to rest at the same time

47. When a liquid rises inside a capillary tube, the weight of liquid column inside the capillary tube is supported

a) Entirely by the force due to surface tension b) Partly by atmospheric pressure and partly by force due to surface tension
c) By atmospheric pressure d) Partly by the force due to surface tension

48. Let 'W' be the work, when a bubble of volume 'V' is formed from a solution. How much work is required to be done to form a bubble of volume 3 V from the same solution?

a) $9^{2/3}W$ b) $9^{1/3}W$
c) $3^{1/3}W$ d) $3^{-2/3}W$

49. A capillary tube is vertically immersed in water, water rises upto a height 'h_1'. When the whole arrangement is taken to a depth 'd' in a mine, the water level rises upto height 'h_2'. The ratio $\frac{h_1}{h_2}$ is (R = radius of earth)

a) $\left(1 + \frac{d}{R}\right)$ b) $\left(1 - \frac{2d}{R}\right)$
c) $\left(1 - \frac{d}{R}\right)$ d) $\left(1 + \frac{2d}{R}\right)$

50. The soap bubble in air has surface tension $0.027\ Nm^{-1}$. The excess pressure inside a bubble of diameter 30 mm, in SI unit is

a) 14.4 b) 36
c) 72 d) 7.2

51. The surface tension of most of the liquid

decreases with rise in

a) Viscosity of the liquid
b) Diameter of capillary
c) Temperature of the liquid
d) Density of the liquid

52. If R is the radius of a soap bubble and S its surface tension, then the excess pressure inside is

a) $\frac{2S}{R}$
b) $\frac{3S}{R}$
c) $\frac{4S}{R}$
d) $\frac{S}{R}$

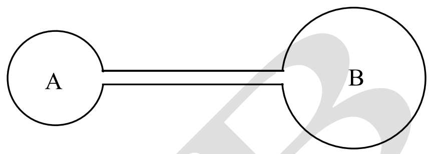
53. If the terminal speed of a sphere A [density $\rho_A = 7.5 \text{ kg m}^{-3}$] is 0.4 ms^{-1}, in a viscous liquid [density $\rho_L = 1.5 \text{ kg m}^{-3}$], the terminal speed of sphere B [density $\rho_B = 3 \text{ kg m}^{-3}$] of the same size in the same liquid is

a) 0.3 ms^{-1}
b) 0.1 ms^{-1}
c) 0.2 ms^{-1}
d) 0.4 ms^{-1}

54. A wooden stick 'h' meter long is floating on the surface of water. Surface tension of water is 'T_1'. On one side of the stick soap solution is spread, the surface tension of water is reduced to 'T_2'. The net force on the stick is

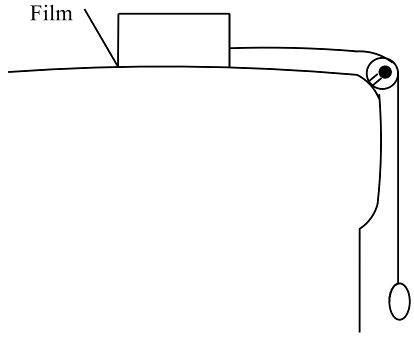
a) $(T_1 - T_2)h$
b) $(T_1 + T_2)h$
c) $\frac{T_1 h}{T_2}$
d) $\frac{T_2}{T_1 h}$

55. There is a small bubble at one end and bigger bubble at other end of a rod. What will happen?



a) Smaller will grow until they collapse
b) Bigger will grow until they collapse
c) Remain in equilibrium
d) None of the above

56. A metal block of area 0.10 m^2 is connected to a 0.010 kg mass via a string that passes over an ideal pulley (considered massless and frictionless), as in figure. A liquid with a film thickness of 0.30 mm is placed between the block and the table. When released the block moves to the right with a constant speed of 0.085 ms^{-1}, find the coefficient of viscosity of the liquid.



a) 4×10^{-2} Pa − s
b) 3.45×10^{-3} Pa − s
c) 5×10^{-2} Pa − s
d) 7×10^{-7} Pa − s

57. Two drops of equal radius coalesce to form a bigger drop. What is ratio of surface energy of bigger drop to smaller one?

a) $2^{1/2}:1$
b) 1:1
c) $2^{2/3}:1$
d) None of these

58. When a capillary is dipped vertically in water, rise of water in capillary is 'h'. The angle of contact is zero. Now the tube is depressed so that its length above the water surface is $\frac{h}{2}$. The new apparent angle of contact is $\cos 0^0 = 1$

a) $\sin^{-1}(0.5)$
b) $\cos^{-1}(0.5)$
c) $\cos^{-1}(0.7)$
d) $\sin^{-1}(0.7)$

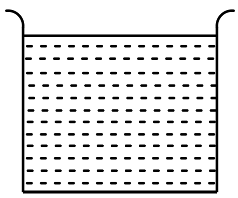
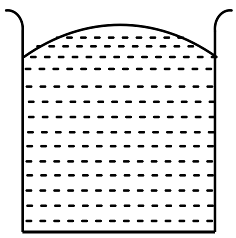
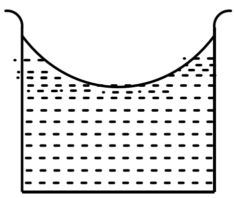
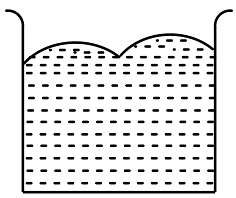
59. If the surface area of any liquid surface is increased by 50%, then its surface tension will

a) Increase by 50%
b) Decrease by 50%
c) Not change
d) Be doubled

60. A spherical ball of radius 3.0×10^{-4} m and density 10^4kgm^{-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, what is the value of h? (Viscosity of water is $9.8 \times 10^{-6} \text{ Nsm}^{-2}$)

a) 1.65×10^3 m
b) 2.65×10^2 m
c) 3.65×10^4 m
d) 1.45×10^2 m

61. 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) 

62. For which two liquid-solid contact pairs, the

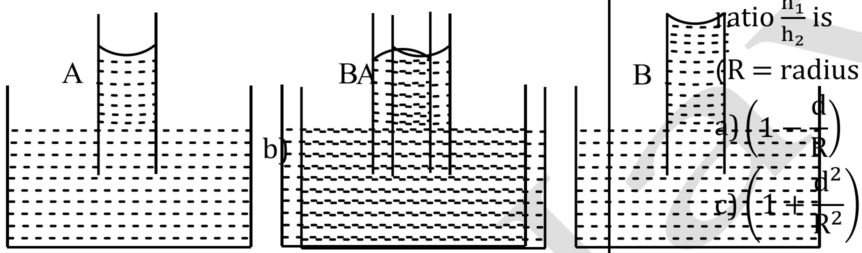
angle of contact is same?

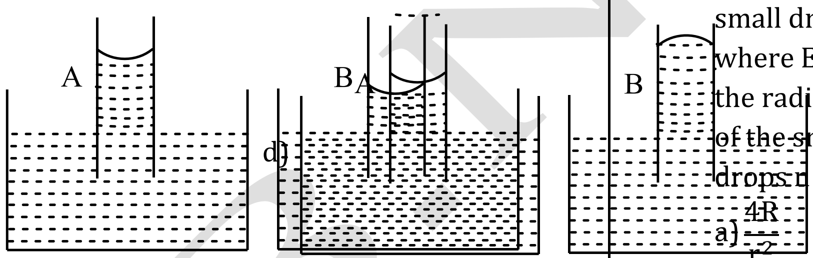
a) Pure water and clean glass, ether and clean glass
b) Ether and clean glass, kerosene and clean glass
c) Pure water and clean glass, chloroform and clean glass
d) Ether and clean glass, mercury and clean glass

63. The radii of the two spheres P and Q of same material falling in the viscous liquid are in the ratio 3:2, their terminal velocities (P to Q) are in the ratio

a) 9:4
b) 3:2
c) 2:3
d) 2:9

64. A capillary tube A is dipped in water. Another identical tube B is dipped in a soap-water solution. Which of the following shows the relative nature of the liquid columns in the two tubes?

a) b)


c) d)


65. 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) $\frac{S}{\rho\, gt}$

66. Water rises upto a height of 4 cm in a capillary tube. The lower end of the capillary tube is at a depth of 8 cm below the water level. The mouth pressure required to blow an air bubble at the lower end of the capillary will be 'X' cm of water, where X is equal to

a) 10
b) 8
c) 6
d) 12

67. The work done in blowing a soap bubble of radius R is 'W_1' at room temperature. Now the soap solution is heated. From the heated solution another soap bubble of radius 2R is blown and the work done is 'W_2'. Then

a) $W_2 = 4W_1$
b) $W_2 < 4W_1$
c) $W = 0$
d) $W_2 = W_1$

68. In air, a charged soap bubble of radius R breaks into 27 small soap bubbles of equal radius r. Then the ratio of mechanical force acting per unit area of big soap bubble to that of a small soap bubble is

a) $\frac{1}{81}$
b) $\frac{3}{1}$
c) $\frac{1}{3}$
d) $\frac{9}{1}$

69. If a capillary tube is immersed vertically in water, rise of water in capillary is 'h_1'. When the whole arrangement is taken to a depth 'd' in a mine, the water level rises to 'h_2'. The ratio $\frac{h_1}{h_2}$ is
(R = radius of earth)

a) $\left(1-\frac{d}{R}\right)$
b) $\left(1+\frac{d}{R}\right)$
c) $\left(1+\frac{d^2}{R^2}\right)$
d) $\left(1-\frac{d^2}{R^2}\right)$

70. When a big drop of water is formed from n small drops of water, the energy loss is 3E, where E is the energy of the bigger drop. If R is the radius of the bigger drop and r is the radius of the smaller drop, then number of smaller drops n is

a) $\frac{4R}{r^2}$
b) $\frac{4R}{r}$
c) $\frac{2R^2}{r}$
d) $\frac{4R^2}{r^2}$

71. If the excess pressure inside a soap bubble of radius 3 mm is equal to the pressure of a water column of height 0.8 cm, then the surface tension of the soap solution is ($\rho_{water} = 1000\,\frac{kg}{m^3}, g = 9.8\ m/s^2$)

a) 79.2×10^{-3} N/m
b) 94.8×10^{-3} N/m
c) 58.8×10^{-3} N/m
d) 100.2×10^{-3} N/m

72. Water rises upto a height 10 cm in a capillary tube. It will rise to a height which is much more than 10 cm in a very long capillary tube if the apparatus is kept.

a) On the surface of the moon
b) At the north pole
c) In a lift moving up with an acceleration
d) On the equator

73. A drop of liquid of density ‘ρ’ is floating half immersed in a liquid of density ‘d’. If ‘T’ is the surface tension, then the diameter of the drop of the liquid is

a) $\sqrt{\dfrac{6T}{g(2\rho - d)}}$ b) $\sqrt{\dfrac{T}{g(2\rho - d)}}$

c) $\sqrt{\dfrac{2T}{g(2\rho - d)}}$ d) $\sqrt{\dfrac{12T}{g(2\rho - d)}}$

74. The lower end of a glass capillary tube is dipped in water. Water rises to a height of 8 cm. The tube is then broken at a height of 6 cm. Then the height of water column and the angle of contact will be $(\cos 0^0 = 1)$

a) 6 cm, $\cos^{-1}(0.75)$ b) 6 cm, $\sin^{-1}(0.75)$

c) 4 cm, $\cos^{-1}(0.5)$ d) 4 cm, $\sin^{-1}(0.5)$

75. A metal wire of density ‘ρ’ floats on water surface horizontally. If it is NOT to sink in water, then maximum radius of wire is (T = surface tension of water, g = gravitational acceleration)

a) $\sqrt{\dfrac{2T}{\pi\rho g}}$ b) $\sqrt{\dfrac{\pi\rho g}{T}}$

c) $\dfrac{T}{\pi\rho g}$ d) $\dfrac{\pi\rho g}{T}$

76. A mercury drop of radius ‘R’ is divided into 27 droplets of same size. The radius ‘r’ of each droplet is

a) $r = \dfrac{R}{3}$ b) $r = \dfrac{R}{9}$

c) $r = \dfrac{R}{27}$ d) $r = 3R$

77. Three liquids have same surface tension and densities ρ_1, ρ_2 and $\rho_3 [\rho_1 > \rho_2 > \rho_3]$. In three identical capillaries, rise of liquid is same. The corresponding angles of contact ‘θ_1’, ‘θ_2’ and ‘θ_3’ are related as

a) $\theta_1 < \theta_2 > \theta_3$ b) $\theta_1 > \theta_2 > \theta_3$

c) $\theta_1 < \theta_2 < \theta_3$ d) $\theta_1 > \theta_2 < \theta_3$

78. A thin metal of disc of radius ‘r’ floats on water surface and bends the surface downwards along the perimeter making an angle ‘θ’ with the vertical edge of the disc. If the weight of water displaced by the disc is ‘W’, the weight of the metal disc is
[T = surface tension of water]

a) $2\pi rT\cos\theta + W$ b) $W - 2\pi rT\cos\theta$

c) $2\pi T + W$ d) $2\pi T\cos\theta - W$

79. The capillary tube of same diameter are put vertically one each in two liquids whose relative densities are 0.8 and 0.6 and surface tensions are 60 and 50 dyne cm^{-1}, respectively. Ratio of heights of liquids in the two tubes $\frac{h_1}{h_2}$ is

a) $\dfrac{10}{9}$ b) $\dfrac{3}{10}$

c) $\dfrac{10}{3}$ d) $\dfrac{9}{10}$

80. The average velocity of water flowing through a pipe of radius 0.5 cm is 10 cm/s. The nature of flow is
(Coefficient of viscosity $\eta_{water} = 10^{-3}\frac{Ns}{m^2}$, density $\rho_{water} = 10^3\ kg/m^3$)

a) Turbulent b) Neither turbulent nor streamline

c) Streamline d) Either turbulent or streamline

81. A capillary tube when immersed vertically in liquid records a rise of 3 cm. If the tube is immersed in the liquid at an angle of 60° with the vertical, the length of the liquid column along the tube is

a) 9 cm b) 6 cm

c) 3 cm d) 2 cm

82. A metallic wire of length ‘L’ and density ‘ρ’ floats horizontally on the surface of water. What should be the radius of wire, so that the wire will not sink in the water? (g = acceleration due to gravity)

a) $\sqrt{\dfrac{2\rho g}{\pi T}}$ b) $\sqrt{\dfrac{2T}{\pi\rho g}}$

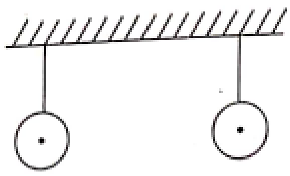
c) $\sqrt{\dfrac{T}{\pi\rho g}}$ d) $\sqrt{\dfrac{\pi\rho g}{2T}}$

83. Water rises to a height 3 cm in a capillary tube. If cross-sectional area of capillary tube is reduced to $\frac{1}{9}$th of the initial area then water will rise to a height of

a) 7 cm b) 9 cm

c) 8 cm d) 6 cm

84. Two light balls are suspended as shown in figure. When a stream of air passes through the space between them, the distance between the balls will



a) May increase or b) Increase

decrease, depending on speed of air
c) Decrease
d) Remain same

85. Select the correct statement out of the following. On a liquid surface, the pressure on
a) Concave side is less than that on convex side
b) Convex side is the atmospheric pressure
c) Concave side is equal to that on the convex side
d) Concave side is more than that on convex side

86. If 500 erg of work is done in blowing a soap bubble of radius 'r' then the additional work required to be done to blow it to a radius equal to '3r' will be
a) 4000 erg
b) 4500 erg
c) 1500 erg
d) 3000 erg

87. Water flows through a horizontal pipe at a speed 'V'. Internal diameter of the pipe is 'd'. If the water is emerging at a speed 'V_1' then the diameter of the nozzle is
a) $\frac{dV_1}{V}$
b) $\frac{V}{V_1}$
c) $d\sqrt{\frac{V}{V_1}}$
d) $d\sqrt{\frac{V_1}{V}}$

88. Which one of the following statement is correct?
a) Surface tension is work done per unit length
b) Surface energy is work done per unit force
c) Surface tension is work done per unit area
d) Surface energy is potential energy per unit length

89. A glass rod of radius 'r_1' is inserted symmetrically into a vertical capillary tube of radius 'r_2' ($r_1 < r_2$) such that their lower ends are at same level. The arrangement is dipped in water. The height to which water will rise into the tube will be
(ρ = density of water, T = surface tension in water, g = acceleration due to gravity)
a) $\frac{2T}{(r_2 - r_1)\rho g}$
b) $\frac{2T}{(r_2^2 - r_1^2)\rho g}$
c) $\frac{T}{(r_2 - r_1)\rho g}$
d) $\frac{2T}{(r_2^2 - r_1^2)\rho g}$

90. Water is flowing through a horizontal pipe of non-uniform cross-section. In the region of narrowest part inside the pipe, the water will have
a) Both the pressure and velocity minimum
b) Maximum pressure and minimum velocity
c) Both the pressure and velocity maximum
d) Maximum velocity and minimum pressure

91. A large number of liquid drops each of radius 'r' coalesce to form a big drop of radius 'R'. The energy released in the process in converted into kinetic energy of the big drop. The speed of the big drop is (T = surface tension of liquid, ρ = density of liquid)
a) $\left[\frac{3T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)\right]^{\frac{1}{2}}$
b) $\left[\frac{6T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)\right]^{\frac{1}{2}}$
c) $\left[\frac{6T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)\right]^{\frac{1}{2}}$
d) $\left[\frac{3T}{\rho}\left(\frac{1}{r} + \frac{1}{R}\right)\right]^{\frac{1}{2}}$

92. In a streamline flow, velocity of a fluid at given point
a) Is always constant
b) Does not remain constant
c) Changes from low value to high value
d) Changes from high value to low value

93. A fix number of spherical drops of a liquid of radius 'r' coalesce to form a large drop of radius 'R' and volume 'V'. If 'T' is the surface tension then energy
a) $4VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released
b) $3VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is released
c) Is neither released nor absorbed
d) $3VT\left(\frac{1}{r} - \frac{1}{R}\right)$ is absorbed

94. A metal wire of density ρ floats on water surface horizontally. If it is not to sink in water, then maximum radius of wire is proportional to (where, T = surface tension of water and g = gravitational acceleration)
a) $\sqrt{\frac{T}{\pi\rho g}}$
b) $\sqrt{\frac{\pi\rho g}{T}}$
c) $\frac{T}{\pi\rho g}$
d) $\frac{\pi\rho g}{T}$

95. A liquid drop having surface energy 'E' is spread into 216 droplets of the same size. The final surface energy of the droplets is
a) 8E
b) 3E
c) 2E
d) 6E

96. When a mercury drop of radius R, breaks into 'n' droplet of equal size, the radius (r) of each droplet is
a) $\frac{R}{n^{\frac{1}{3}}}$
b) $\left(\frac{R}{n}\right)^{\frac{1}{3}}$

c) $\frac{R}{n}$ d) $Rn^{\frac{1}{3}}$

97. Water rises to a height of 2 cm in a capillary tube. If cross-sectional area of the tube is reduced to 1/16th of initial area then water will rise to a height of
a) 4 cm b) 8 cm
c) 12 cm d) 16 cm

98. A flow of liquid is streamline, if the Reynolds' number is
a) less than 1000 b) greater than 1000
c) between 2000 to 3000 d) between 4000 to 5000

99. A big water drop is divided into 8 equal droplets. ΔP_s and ΔP_B be the excess pressure inside a smaller and bigger drop respectively. The relation between ΔP_s and ΔP_B is
a) $\Delta P_B = \Delta P_s$ b) $\Delta P_B = \frac{1}{2}\Delta P_s$
c) $\Delta P_B = \frac{1}{4}\Delta P_s$ d) $\Delta P_B = 2\Delta P_s$

100. 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 contact angle for mercury and water are 135° and 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

101. If detergent is dissolved in water, the surface tension of water
a) Decreases b) Becomes zero
c) Remains constant d) Increases

102. Pressure inside two soap bubbles are 1.01 atm and 1.03 atm. The ratio between their volumes is (Pressure outside the soap bubble is 1 atmosphere)
a) 9:1 b) 27:1
c) 81:1 d) 3:1

103. Under isothermal conditions, two soap bubbles of radii 'r_1' and 'r_2' combine to form a single soap bubble of radius 'R'. The surface tension of soap solution is
(P = outside pressure)
a) $P(R^3 - r_1^3 - r_2^3)/4(r_1^2 + r_2^2 - R^2)$ b) $P(r_1^3 - R^3 - r_2^3)/4(R^2 - r_1^2 - r_2^2)$
c) $P(R^3 + r_1^3 + r_2^3)/4(r_1^2 + r_2^2 - R^2)$ d) $P(r_1^3 - r_2^3 + R^3)/4(r_1^2 + r_2^2 + R^2)$

104. A capillary tube is vertically immersed in water, water raises upto height 'h_1'. When the whole arrangement is take upto depth 'd' in a mine, the water level rises upto height 'h_2'. The ratio of $\frac{h_1}{h_2}$ is (R = radius of earth)
a) $\left(1 - \frac{2d}{R}\right)$ b) $\left(1 - \frac{d}{R}\right)$
c) $\left(1 + \frac{d}{R}\right)$ d) $\left(1 + \frac{d}{R}\right)$

105. The speed of a ball of radius 2 cm in a viscous liquid is 20 cm/s. What will be the speed of a ball of radius 1 cm in same liquid?
a) 10 cm/s b) 4 cm/s
c) 5 cm/s d) 8 cm/s

106. A vessel whose bottom has round hole with diameter of 1 mm is filled with water. Assuming that surface tension acts only at hole, then the maximum height to which the water can be filled in vessel without leakage is (Given, surface tension of water $= 7.5 \times 10^{-2}\,Nm^{-1}$ and $g = 10\,ms^{-2}$)
a) 0.3 cm b) 3 mm
c) 3 cm d) 3 m

107. Water rises to a height of 20 mm in a capillary tube of cross-sectional area 'A'. If the area of cross-section of the tube is made $\left(\frac{A}{4}\right)$, then water will rise to a height of
a) 6 cm b) 2 cm
c) 3 cm d) 4 cm

108. Two rain drops of same radius r falling with terminal velocity v merge and form a bigger drop of radius R. The terminal velocity of the bigger drop is
a) $v\frac{R}{r}$ b) $v\frac{R^2}{r^2}$
c) v d) 2v

109. In a streamline flow
a) the speed of a particle always remains same
b) the velocity of a particle always remains same
c) the kinetic energies of all particles arriving at a given point are the same
d) the potential energies of all the particles arriving at a given point are the same

110. The excess pressure inside a spherical drop of water is four times that of another drop. Then, their respective mass ratio is
a) 1:16 b) 8:1
c) 1:4 d) 1:64

111. If the surface of a liquid is plane, then the angle of contact of the liquid with the walls of

container is

a) acute angle b) obtuse angle

c) 90° d) 0°

112. A number of droplets, each of radius ‘r’ combine to form a drop of radius ‘R’. If ‘T’ is the surface tension, the rise in temperature will be [Assume that the energy evolved is converted into heat]

a) $3T\left[\frac{1}{r}-\frac{1}{R}\right]$ b) $2T\left[\frac{1}{r}-\frac{1}{R}\right]$

c) $T\left[\frac{1}{r}-\frac{1}{R}\right]$ d) $4T\left[\frac{1}{r}-\frac{1}{R}\right]$

113. A water drop of radius ‘R’ splits into ‘n’ smaller drops, each of radius ‘r’. The work done in the process is T = surface tension of water

a) $8\pi R^3T\left(1-\frac{r}{R}\right)$ b) $8\pi R^3T\left(1+\frac{r}{R}\right)$

c) $4\pi R^3T\left(\frac{1}{r}+\frac{1}{R}\right)$ d) $4\pi R^3T\left(\frac{1}{r}-\frac{1}{R}\right)$

114. A small sphere of radius ‘r’ falls from rest in a viscous liquid. Due to friction heat is produced. The rate of production of heat $\frac{dQ}{dt}$ is proportional to

a) $\frac{1}{r^4}$ b) $\frac{1}{r^5}$

c) r^4 d) r^5

115. A soap bubble of radius $\frac{1}{\sqrt{\pi}}$ cm is expanded to have double the radius. If surface tension of soap solution is 30 dyne/cm, then the work done is

a) 720 erg b) 360 erg

c) 180 erg d) 960 erg

116. The pressure at the bottom of a tank containing liquid does not depend upon the

a) Area of bottom surface b) Height of liquid column

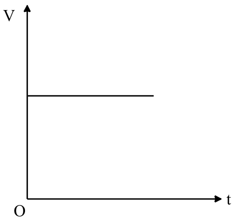
c) Density of liquid d) Acceleration due to gravity

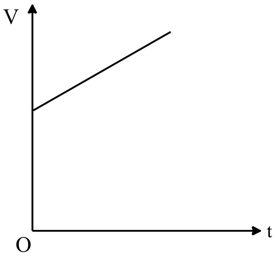
117. The work done in blowing a soap bubble of surface tension 0.06 Nm^{-1} from radius 2 cm to 5 cm is

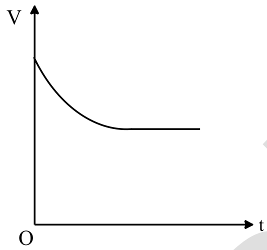
a) 0.004 168 J b) 0.003 168 J

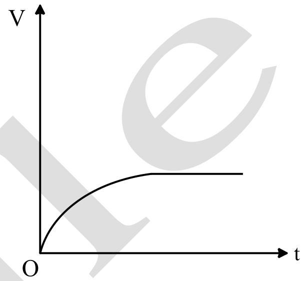
c) 0.003 158 J d) 0.004 568 J

118. Which one shows the variation of the velocity v with time t for a small sized spherical body falling in a column of a viscous liquid?

a) 

b) 

c) 

d) 

119. Water rises upto a height ‘h’ in a capillary tube on the surface of the earth. The value of ‘h’ will increase if the experimental setup is kept in g = acceleration due to gravity

a) A lift going upward with a certain acceleration b) Accelerating train

c) A satellite rotating close to earth d) A lift going down with acceleration $a < g$

120. Let ‘R_1’ and ‘R_2’ are radii of two mercury drops. A big mercury drop is formed from them under isothermal conditions. The radius of the resultant drop is

a) $R=\frac{R_1+R_2}{2}$ b) $R=\sqrt{R_1^2-R_2^2}$

c) $R=\sqrt{R_1^2+R_2^2}$ d) $R=(R_1^3+R_2^3)^{1/3}$

121. A frame made of 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 25%, the energy of the soap film will be changed by

a) 100% b) 75%

c) 50% d) 25%

122. A liquid rises to a height of 1.8 cm in a glass capillary A. Another glass capillary B having diameter 90% of capillary A is immersed in the same liquid. The rise of liquid in capillary B is

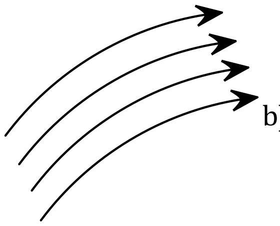
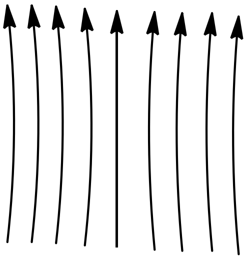
a) 1.4 cm b) 1.8 cm

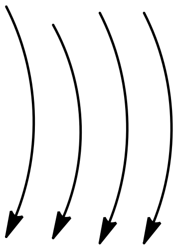
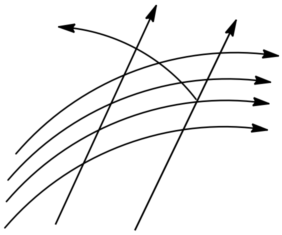
c) 2.0 cm d) 2.2 cm

123. The excess pressure inside a soap bubble of volume ‘V’ is three times the excess pressure inside a second soap bubble of volume ‘V_1’. The value $\left(\frac{V_1}{V}\right)$ is

a) 3:1　　b) 1:9
c) 1:3　　d) 27:1

124. Which of the following diagrams does not represent a streamline flow?

a) 　　b) 

c) 　　d) 

125. A ∪ tube with limbs of diameters 5mm and 2mm contains water of surface tension 7×10^{-2} N/m, angle of contact is zero and density 10^3 kg/m^3. The difference in the level in the two limbs is ($g = 10$ m/s^2)
a) 8.4 mm　　b) 7.7 mm
c) 9.5 mm　　d) 6.8 mm

126. The work done in blowing a soap bubble of radius 'R' is 'W_1' at room temperature. Now, the soap solution is heated. From the heated solution another soap bubble of radius '2R' is blown and the work done is 'W_2', Then
a) $W_2 = W_2$　　b) $W_2 = 0$
c) $W_2 < 4W_1$　　d) $W_2 = 4W_1$

127. When a mercury drop of radius 'R', breaks into 'n' droplets of equal size, the radius 'r' of each droplet is
a) $r = \frac{R}{\sqrt{n}}$　　b) $R = Rn^{1/3}$
c) $r = \frac{R}{n}$　　d) $r = \frac{R}{n^{\frac{1}{3}}}$

128. A large vessel completely filled with water has two holes 'A' and 'B' at the depths 'h' and '4h' from the top. Hole 'A' is square of side 'L' and hole 'B' is circular of radius 'R'. If from both the holes same quantity of water is flowing per second, then side of square hole is
a) $2\pi R$　　b) $\frac{R}{2}$
c) $\sqrt{2\pi R}$　　d) $\sqrt{2\pi}R$

129. A spherical solid ball of volume 'V' made up of a material of density 'ρ_1'. It is falling through a liquid of density 'ρ_2' ($\rho_2 < \rho_1$). Assume that the liquid applied a viscous force on the ball that is proportional to square of the terminal speed 'V_t'. $F = -KV_t^2 (K > 0)$, then the terminal speed of the ball is
(g = acceleration due to gravity)
a) $\frac{Vg\rho_1}{K}$　　b) $\frac{Vg(\rho_1 - \rho_2)}{K}$
c) $\left[\frac{Vg(\rho_1 - \rho_2)}{K}\right]^{1/2}$　　d) $\left[\frac{Vg\rho_1}{K}\right]^{1/2}$

130. A soap bubble is blown such that its diameter increases from 'd' to 'D'. The amount of work done is
(T = surface tension of soap solution)
a) $4\pi(D^2 - d^2)T$　　b) $2\pi(D^2 - d^2)T$
c) $8\pi(D^2 - d^2)T$　　d) $\pi(D^2 - d^2)T$

131. Surface tension vanishes at
a) Absolute zero temperature　　b) Transition temperature,
c) Critical temperature　　d) None of these

132. Which one of following statements about the angle of contact (θ), is wrong?
a) $\theta > 0^2$ for pure water – glass pair　　b) θ is not constant for particular solid – liquid pair
c) $\theta < 90^2$ for kerosene – glass pair　　d) $\theta > 90^2$ for mercury – glass pair

133. Pure water rises up to a height 'h' in a capillary tube of radius 'r'. What is the effect on the height of water column, if a detergent is dissolved in water?
a) 'h' is increased　　b) 'h' remain constant
c) 'h' is decreased　　d) 'h' may increase or decrease depending on the quantity of the detergent

134. The work done in blowing a soap bubble of radius R is 'W_1' at room temperature. Now the soap solution is heated. From the heated solution another soap bubble of radius '2R' is blown and the work done is 'W_2'. Then,
a) $W_2 = 4W_1$　　b) $W_2 < 4W_1$
c) $W_2 = 0$　　d) $W_2 = W_1$

135. A solid ball of volume 'V' is dropped in a viscous liquid. It experiences a viscous force F. If a solid ball of volume '2V' of same material is dropped in the same liquid, then the viscous force acting on it will be
a) $\frac{F}{2}$　　b) $\frac{F}{4}$
c) 2F　　d) 4F

136. Water rises to a height of 15 mm in a capillary tube having cross-sectional area ‘A’. If cross-sectional area of the tube is made ‘$\frac{A}{3}$’ then the water will rise to a height of

a) $5\sqrt{2} \times 10^{-3}$ m b) $20\sqrt{3} \times 10^{-3}$ m
c) $10\sqrt{3} \times 10^{-3}$ m d) $15\sqrt{3} \times 10^{-3}$ m

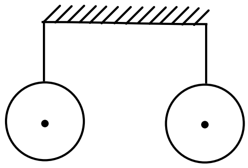
137. The pressure inside two soap bubbles is 1.01 and 1. 02 atm, respectively. The ratio of their respective volumes is

a) 2 b) 4
c) 6 d) 8

138. Speed of a ball of 2 cm radius in a viscous liquid is 20 cms^{-1}. Then the speed of 1 cm radius of ball in the same liquid is

a) 80 cms^{-1} b) 40 cms^{-1}
c) 10 cms^{-1} d) 5 cms^{-1}

139. Two light balls are suspended as shown in figure. When a stream of air passes through the space between them, the distance between the balls will



a) remain same b) increase
c) may increase or decrease, depending on speed of air d) decrease

140. Water rises upto a height h in a capillary tube on the surface of the earth. The value of h will increase, if the experimental set-up is kept in [g = acceleration due to gravity]

a) a lift going upward with a certain acceleration b) accelerating train
c) a satellite rotating close to earth d) a lift going down with acceleration $a < g$

141. In which one of the following cases, will the liquid flow in a pipe be most streamlined?

a) Liquid of high viscosity and high density flowing through a pipe of small radius b) Liquid of high viscosity and low density flowing through a pipe of small radius
c) Liquid of low viscosity and low density flowing through a pipe of large radius d) Liquid of low viscosity and high density flowing through a pipe of large radius

142. When a large bubble rises from bottom of a water lake to its surface, then its radius doubles. If the atmospheric pressure is equal to the pressure of height H of a certain water column, then the depth of lake will be

a) 2H b) H
c) 7H d) 4H

143. A metal sphere of mass ‘m’ and density ‘σ_1’ falls with terminal velocity through a container containing liquid. The density of liquid is ‘σ_2’. The viscous force acting on the sphere is

a) $mg\left(1 + \frac{\sigma_1}{\sigma_2}\right)$ b) $mg\left(1 - \frac{\sigma_1}{\sigma_2}\right)$
c) $mg\left(1 + \frac{\sigma_2}{\sigma_1}\right)$ d) $mg\left(1 - \frac{\sigma_2}{\sigma_1}\right)$

144. In a turbulent flow, velocity of a fluid at any point

a) In which, layers move parallel to each other b) Does not remain constant
c) Always remains constant d) Changes from high value to low value only

145. The potential energy of a molecule on the surface of a liquid compared to one inside the liquid is

a) zero b) lesser
c) equal d) greater

146. The work done in blowing a soap bubble of radius ‘R’ is ‘W_1’ and that of radius ‘2R’ is W_2. The ratio of W_1 to W_2 is

a) 1:4 b) 1:2
c) 4:1 d) 2:1

147. Under isothermal conditions, two soap bubbles of radii ‘r_1’ and ‘r_2’ combine to form a single soap bubble of radius ‘R’. The surface tension of soap solution is
(P = outside pressure)

a) $\frac{P(R^3 - r_1^3 - r_2^3)}{4(r_1^2 + r_2^2 - R^2)}$ b) $\frac{P(R^3 + r_1^2 + r_2^2)}{4(r_1^3 + r_2^3 - R^2)}$
c) $\frac{P(R^3 + r_1^3 - r_2^3)}{4(r_1^2 + r_2^2 - R^2)}$ d) $\frac{P(R^2 + r_1^2 - r_2^2)}{4(R^3 + r_1^3 + r_2^3)}$

148. T_{LA}, T_{SA} and T_{SL} be the value of surface tension at liquid-air, solid-air and solid-liquid interface, respectively. Match the following columns.

Column I	Colun
A. $T_{SA} > T_{sc}$	1. θ lies betwee
B. $T_{SA} < T_{se}$	2. θ lies betwee
C. $T_{sc} + T_{LA} \cos\theta > T_{SA}$	3. Molecules o

	not be in equilibrium

codes

a) A-1, B-2, C-3 b) A-2, B-3, C-1
c) A-1, B-3, C-2 d) A-3, B-1, C-2

149. A liquid drop of density ‘ρ’ is floating half immersed in a liquid of density ‘d’. Diameter of the liquid drop is ($\rho > d, g =$ acceleration due to gravity, $T =$ surface tension)

a) $\left[\frac{3T}{g(2\rho - d)}\right]^2$ b) $\left[\frac{12T}{g(2\rho - d)}\right]^{1/2}$
c) $\left[\frac{6T}{g(\rho - d)}\right]^{1/2}$ d) $\left[\frac{9T}{g(\rho - d)}\right]^{1/2}$

150. A solid sphere falls with a terminal velocity v in CO_2 gas. If it is allowed to fall in vacuum, then

a) terminal velocity of sphere $= v$ b) terminal velocity of sphere $< v$
c) terminal velocity of sphere $> v$ d) sphere never attains terminal velocity

151. A drop of some liquid of volume $0.04\ cm^3$ is placed on the surface of a glass slide. Then, another glass slide is placed on it in such a way that the liquid forms a thin layer of area $20\ cm^2$ between the surfaces of the two slides. To separate the slides a force of 16×10^5 dyne has to be applied normal to the surfaces. The surface tension of the liquid (in dyne cm^{-1}) is

a) 60 b) 70
c) 80 d) 90

152. In a capillary tube having area of cross-section A, water rises to a height ‘h’. If cross-sectional area is reduced to $\frac{A}{9}$, the rise of water in the capillary tube is

a) 3h b) 9h
c) h d) 6h

153. A liquid does not wet the solid surface, if the angle of contact is

a) zero b) equal to 45°
c) smaller than 90° d) greater than 90°

154. As the temperature of water increases, its viscosity

a) remains unchanged b) decreases
c) increases d) increases or decreases depending on the external pressure

155. A glass tube of uniform cross-section is connected to a tap with a rubber tube. The tap is opened slowly. Initially the flow of water in the tube is streamline. The speed of flow of water to convert it into a turbulent flow is [radius of tube $= 1$ cm, $\eta = 1 \times 10^{-3} \frac{Ns}{m^2}$, $R_n = 2500$ and density of water$= 10^3\ kg/m^3$]

a) 0.15 m/s b) 0.125 m/s
c) 0.3 m/s d) 0.2 m/s

156. A square frame of each side ‘L’ is dipped in a soap solution and taken out, the force acting on the film formed is T = surface tension of soap solution

a) 2TL b) 4TL
c) 8TL d) 6TL

157. A wire of length 10 cm is gently placed horizontally on the surface of water having surface tension of 75×10^3 N/m. What force is required to just pull up the wire from the water surface?

a) 15×10^{-2} N b) 1.5×10^{-2} N
c) 7.5×10^{-2} N d) 75×10^{-2} N

158. A large vessel completely filled with water has two holes ‘A’ and ‘B’ at depths ‘h’ and ‘4h’ from the top. Hole ‘A’ is a square of side ‘L’ and hole ‘B’ is circle of radius ‘R’. If from both the holes same quantity of water is flowing per second then side of square hole is

a) $\sqrt{2\pi R}$ b) R/2
c) $\sqrt{2\pi}.R$ d) $2\pi R$

159. A capillary tube is taken from the earth to the surface of the moon. The rise of the liquid column on the moon (acceleration due to gravity on the earth is 6 times that of the moon) is

a) six times that on the earth's surface b) $\frac{1}{6}$ that on the earth's surface
c) equal to that on the earth's surface d) zero

160. Let ‘R_1’ and ‘R_2’ be radii of two mercury drops. A big mercury drop is formed from them under isothermal conditions. The radius of the resultant drop is

a) $R = \sqrt{R_1^2 - R_2^2}$ b) $R = \sqrt{R_1^2 + R_2^2}$
c) $R = \frac{R_1 + R_2}{2}$ d) $R = (R_1^3 - R_2^3)^{1/3}$

161. If two soap bubbles of equal radii r coalesce, then the radius of curvature of interface between two bubbles will be

a) r b) Zero
c) infinity d) $\frac{1}{2r}$

162. Find the difference of air pressure between the inside and outside of a soap bubble is 5 mm in diameter, if the surface tension is $1.6\ Nm^{-1}$?

a) $2560\ Nm^2$ b) $3720\ Nm^2$
c) $1208\ Nm^2$ d) $10132\ Nm^2$

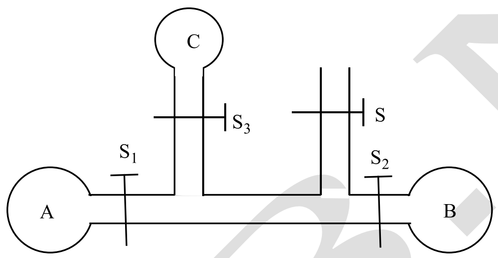
163. Two narrow tubes of diameters 'd_1' and 'd_2' are joined together to form a U tube open at both ends. If U tube contains water, the difference in water levels in the limb is (T is the surface tension of water, angle of contact = zero and density of water $=\rho$, g = acceleration due to gravity)

a) $\frac{2T}{\rho g}\left[\frac{d_1+d_2}{d_1 d_2}\right]$ b) $\frac{4T}{\rho g}\left[\frac{d_2-d_1}{d_1 d_2}\right]$
c) $\frac{2T}{\rho g}\left[\frac{d_2-d_1}{d_1 d_2}\right]$ d) $\frac{4T}{\rho g}\left[\frac{d_1 d_2}{d_1+d_2}\right]$

164. The surface tension of a liquid is $5\ Nm^{-1}$. If a film is heid on a ring of area $0.02\ m^2$, its total surface energy is about

a) 2×10^{-2} J b) 2.5×10^{-3} J
c) 2×10^{-1} J d) 3×10^{-1} J

165. The figure 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. Then,



a) B will start collapsing with volume 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

166. Water rises in a capillary tube of radius r upto a height 'h'. The mass of water in a capillary is 'm'. The mass of water that will rise in a capillary of radius $\frac{r}{4}$ will be

a) $\frac{4}{m}$ b) 4m
c) m d) $\frac{m}{4}$

167. A small metal sphere of mass M and denisty d_1, when dropped in a jar filled with liquid moves with terminal velocity after sometime. The viscous force acting on the sphere is (d_2 = density of liquid and g = gravitational acceleration)

a) $Mg\left(\frac{d_1}{d_2}\right)$ b) $Mg\left(1-\frac{d_2}{d_1}\right)$
c) $Mg\left(\frac{d_2}{d_1}\right)$ d) $Mg\left(1-\frac{d_1}{d_2}\right)$

168. A rain drop of radius 0.3 mm has a terminal velocity in air $1\ ms^{-1}$. The viscosity of air is 18×10^{-5} poise. Find the viscous force on the rain drops.

a) 5.02×10^{-7} N b) 1.018×10^{-7} N
c) 1.05×10^{-7} N d) 2.058×10^{-7} N

169. Air is pushed in a soap bubble to increase its radius from 'R' to '2R'. In this case, the pressure inside the bubble

a) Does not change b) Decrease
c) Becomes zero d) Increases

170. The output of OR gate is '1'

a) If either input is 'zero' b) Only if both inputs are '1'
c) If either or both inputs are '1' d) Only if both inputs are 'zero'

171. By inserting a capillary tube upto a depth / in water, 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 /> h ?

a) zero b) 1+h
c) 2 h d) h

172. A liquid drop of diameter 'D' breaks up into 27 tiny drops. If the surface tension of liquid is σ, the resulting change in energy is

a) $6\pi D^2\sigma$ b) $4\pi D^2\sigma$
c) $2\pi D^2\sigma$ d) $3\pi D^2\sigma$

173. A soap bubble A of radius 0.03 m and another bubble B of radius 0.04 m are brought together, so that the combined bubble has a common interface of radius r, then the value of r is

a) 0.24 m b) 0.48 m
c) 0.12 m d) None of these

174. A square frame of each side 'L' is dipped in a soap solution and taken out, the force acting on the film formed is
(T = surface tension of soap solution)

a) 4TL b) 8TL
c) 2TL d) 6TL

175. A small ball of mass 'M', radius 'R' and density 'ρ' moves with terminal velocity through a container filled with glycerin of density 'σ'. The viscous force acting on the ball is
(g = gravitational acceleration)

a) $\frac{Mg\rho}{\sigma}$
b) $Vg(\rho - \sigma)$
c) $Mg\left[1 - \frac{\sigma}{\rho}\right]$
d) $Vg\rho\sigma$

176. The work done in blowing a soap bubble of radius R is W. The work done in blowing a bubble of radius 2R of the same soap solution is

a) $\frac{W}{4}$
b) $\frac{W}{2}$
c) 4 W
d) 2 W

177. A liquid drop having surface energy E is spread into 512 droplets of same size. The final surface energy of the droplets is

a) 2E
b) 4E
c) 8E
d) 12E

178. The heat evolved for the rise of water when one end of the capillary tube of radius r is immersed vertically into water is (Assume, surface tension = S and density of water = ρ)

a) $\frac{2\pi S}{\rho g}$
b) $\frac{\pi S^2}{\rho g}$
c) $\frac{2\pi S^2}{\rho g}$
d) $\frac{4\pi S^2}{\rho g}$

179. In a sphere of influence, the liquid molecule at its centre is

a) Attracted by other molecules lying outside the sphere of influence
b) Repelled by other molecules lying outside the sphere of influence
c) Repelled by other molecules in the sphere of influence
d) Attracted by other molecules in the sphere of influence

180. The work done in blowing a soap bubble of radius 'R' is 'W'. The work done in blowing a bubble of radius '2R' of the same soap solution is

a) 2w
b) $\frac{w}{4}$
c) $\frac{w}{2}$
d) 4w

181. Due to surface tension, the excess pressure inside a smaller drop is 9 units. If 27 smaller drops of same liquid combine then the excess pressure inside the bigger drop is

a) 6 units
b) 3 units
c) 18 units
d) 9 units

182. 'n' small drops of same size fall through air with constant velocity 5 cm/s. They coalesce to form a big drop. The terminal velocity of the big drop is

a) $7n^{2/3}$ cm/s
b) $5n^{2/3}$ cm/s
c) $3n^{2/3}$ cm/s
d) $9n^{2/3}$ cm/s

183. The radii of two columns of a u-tube are r_1 and r_2 respectively. When the tube is filled with water, the difference in level of two arms is 'h'. The surface tension of water in dyne/cm is

a) $\frac{hgr_1r_2}{2(r_2 - r_1)}$
b) $hg(r_2 - r_1)$
c) $\frac{hgr_1r_2}{(r_1 - r_2)}$
d) $\frac{hg(r_2 - r_1)}{2r_1r_2}$

184. One end of towel dips in a bucket with full of water and other end hangs over the bucket. It is found that after something the towel becomes fully wet. It happens because

a) Viscosity of water is high
b) Of capillary action of cotton threads
c) Of gravitational force
d) Of evaporation of water

185. A metal sphere of radius 'R' and density 'ρ_1' is dropped in a liquid of density 'σ' and moves with terminal velocity 'V'. Another metal sphere of same radius and density 'ρ_2' is dropped in the same liquid, its terminal velocity will be

a) $V(\rho_1 - \sigma)/(\rho_2 - \sigma)$
b) $V(\rho_2 + \sigma)/(\rho_1 + \sigma)$
c) $V(\rho_2 - \sigma)/(\rho_1 - \sigma)$
d) $V(\rho_1 + \sigma)/(\rho_2 + \sigma)$

186. Several spherical drops of a liquid of radius r coalesce to form a single drop to radius R. If S is surface tension and V is volume under consideration, then the release of energy is

a) $3\ VS\left(\frac{1}{r} + \frac{1}{R}\right)$
b) $3\ VS\left(\frac{1}{r} - \frac{1}{R}\right)$
c) $VS\left(\frac{1}{r} - \frac{1}{R}\right)$
d) $VS\left(\frac{1}{r^2} + \frac{1}{R^2}\right)$

187. Two equal drops of water are falling through air with a steady velocityv. If the drops coalesced, what will be the new celocity?

a) $(2)^{1/3}v$
b) $(2)^{3/2}v$
c) $(2)^{2/3}v$
d) $(2)^{1/4}v$

188. One thousand small water drops of equal radii combine to form a big drop. The ratio of final surface energy to the total initial surface energy is

a) 1:1000
b) 1:10
c) 1:100
d) 1:1

189. Water rises in a capillary tube of radius 'r' upto

height 'h'. The mass of water in the capillary is 'm'. The mass of water that will rise in a capillary of radius '$\frac{r}{4}$' will be

a) m b) $\frac{4}{m}$

c) 4 m d) $\frac{m}{4}$

190. 8 identical small drops of water are falling down vertically through a medium, each with terminal velocity 'V'. If they combine to form a single drop, then its terminal velocity will be

a) 4V b) 3V

c) 6V d) 5V

191. A sphere liquid drop of radius R is divided into eight equal droplets. If surface tension is S, then the work done in this process will be

a) $2\pi R^2 S$ b) $3\pi R^2 S$

c) $4\pi R^2 S$ d) $2\pi RS^2$

192. Which one of the following statements is correct?

a) Surface energy is potential energy per unit length. b) Surface tension is work done per unit area.

c) Surface tension is work done per unit length. d) Surface energy is work done per unit force.

193. A 20 cm long capillary tube is dipped in water. The water rises upto 8 cm. If the entire arrangement is put in a freely falling elevator, the length of water column in the capillary tube will be

a) 8 cm b) 10 cm

c) 4 cm d) 20 cm

194. Soap solution is used for clearing dirty clothes because

a) Temperature of solution is decreased b) Surface tension of solution is increased

c) Surface tension of solution is decreased d) Viscosity of solution is increased

195. An ice cube of edge 1 cm melts in a gravity free container. The approximate surface area of water formed is (water is in the form of spherical drop)

a) $(36\pi)^{1/3}$ cm^2 b) $(24\pi)^{1/3}$ cm^2

c) $(28\pi)^{1/3}$ cm^2 d) $(12\pi)^{1/3}$ cm^2

196. Two metal spheres 'A' and 'B' are falling through liquid of density 'σ' with the same uniform speed 'v'. The density of material of sphere 'A' is 'δ_A' and that of sphere 'B' is 'δ_B'. The ratio of their radii is

a) $\sqrt{\frac{\delta_A - \sigma}{\delta_B - \sigma}}$ b) $\sqrt{\frac{\delta_A - \sigma}{\delta_B - \sigma}}$

c) $\frac{\delta_B - \sigma}{\delta_A - \sigma}$ d) $\frac{\delta_A - \sigma}{\delta_B - \sigma}$

197. Two capillary tubes of different diameters are dipped in water. The rise of water is

a) More in the tube of large diameter b) Zero in both the tubes

c) Same in both the tubes d) More in the tube of smaller diameter

198. Two small drops of mercury coalesce to form a single large drop. The ratio of total surface energy before and after the change is

a) $2^{\frac{1}{3}}:1$ b) $2:1$

c) 1:2 d) $2^{\frac{2}{3}}:1$

199. The upward force of 105 dyne due to surface tension is balanced by the force due to the weight of the water column and 'h' is the height of water in the capillary. The inner circumference of the capillary is (surface tension of water= 7×10^{-2} N/m)

a) 1 cm b) 2.5 cm

c) 1.5 cm d) 3 cm

200. Two glass plates of area 10^{-2} m^2 have 0.05 mm thick water film between them. The surface tension of water is 70×10^{-3} N/m. The force required to separate two glass plates from each other is

a) 30 N b) 28 N

c) 14 N d) 17 N

N.B.Navale

Date : 28.03.2025
Time : 03:00:00
Marks : 200

TEST ID: 48
PHYSICS

2.MECHANICAL PROPERTIES OF FLUIDS

: ANSWER KEY :

1)	a	2)	b	3)	d	4)	b	105)	c	106)	c	107)	d	108)	b
5)	b	6)	c	7)	c	8)	d	109)	c	110)	d	111)	c	112)	a
9)	b	10)	b	11)	c	12)	c	113)	d	114)	d	115)	a	116)	a
13)	b	14)	d	15)	c	16)	a	117)	b	118)	d	119)	d	120)	d
17)	a	18)	b	19)	b	20)	b	121)	b	122)	c	123)	d	124)	d
21)	d	22)	c	23)	d	24)	b	125)	a	126)	c	127)	d	128)	d
25)	c	26)	c	27)	b	28)	c	129)	c	130)	b	131)	c	132)	b
29)	d	30)	a	31)	a	32)	c	133)	c	134)	b	135)	c	136)	d
33)	d	34)	a	35)	b	36)	a	137)	a	138)	d	139)	d	140)	d
37)	b	38)	a	39)	d	40)	a	141)	b	142)	c	143)	d	144)	b
41)	a	42)	a	43)	a	44)	d	145)	d	146)	a	147)	a	148)	a
45)	c	46)	a	47)	a	48)	b	149)	b	150)	d	151)	c	152)	a
49)	c	50)	d	51)	c	52)	c	153)	d	154)	b	155)	b	156)	c
53)	b	54)	a	55)	b	56)	b	157)	b	158)	c	159)	a	160)	d
57)	c	58)	b	59)	c	60)	a	161)	c	162)	a	163)	b	164)	c
61)	c	62)	c	63)	a	64)	c	165)	b	166)	d	167)	b	168)	b
65)	c	66)	d	67)	b	68)	c	169)	b	170)	c	171)	c	172)	c
69)	a	70)	d	71)	c	72)	a	173)	c	174)	b	175)	b	176)	c
73)	d	74)	a	75)	a	76)	a	177)	c	178)	c	179)	d	180)	d
77)	c	78)	a	79)	d	80)	c	181)	b	182)	b	183)	a	184)	b
81)	b	82)	b	83)	b	84)	c	185)	c	186)	b	187)	c	188)	b
85)	d	86)	a	87)	c	88)	c	189)	d	190)	a	191)	c	192)	b
89)	a	90)	d	91)	c	92)	a	193)	d	194)	c	195)	a	196)	b
93)	b	94)	a	95)	d	96)	a	197)	d	198)	a	199)	c	200)	b
97)	b	98)	a	99)	b	100)	c								
101)	a	102)	b	103)	a	104)	b								

: HINTS AND SOLUTIONS :

Single Correct Answer Type

2 **(b)**
Under isothermal conditions the surface tension remains constant. If r is the radius of the bigger bubble then

Final surface energy = Initial surface energy

$8\pi r^2 T = 8\pi r_1^2 T + 8\pi r_2^2 T$

$\therefore r^2 = r_1^2 + r_2^2$

$\therefore r = \sqrt{r_1^2 + r_2^2}$

3 **(d)**
Given

$P_{in} - P_{out} = \frac{4T}{r} = 9$ units

If 27 such drop coalesce

$27\left(\frac{4}{3}\pi r^3\right) = \frac{4}{3}\pi r_b^3$

$\therefore 3r = r_b$

$\therefore$ Excess pressure

$\frac{4T}{r_b} = \frac{4T}{3r} = \frac{9}{3} = 3$ unit

4 **(b)**
Force $F = \frac{2TA}{d} = \frac{2TA^2}{V}$

$d = \frac{V}{A}$ = Thickness of the layer

$\therefore T = \frac{FV}{2A^2}$

5 **(b)**
The retarding viscous force acting on the sphere is given by

$F = 6\pi\eta r$

$\therefore F \propto rv$

6 **(c)**
Angle of contact is defined as the angle inside the liquid between the tangent to the solid surface and the tangent to the liquid surface at the point contact. It depends on nature of liquid and solid in contact.

7 **(c)**
If r_1 is the radius of the smaller drop and r_2 that of bigger drop then

Terminal velocity $V \propto r^2$

$\therefore \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(n^{\frac{1}{3}}\right)^2 = n^{\frac{2}{3}}$

$\therefore V_2 = n^{\frac{2}{3}} V_1 = n^{2/3} V$

9 **(b)**
$h = \frac{2T\cos\theta}{r\rho g}$

$\therefore h \propto \frac{1}{r}$

$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2}$

Area $A = \pi r^2$

$\therefore A \propto r^2$

$\therefore \frac{A_1}{A_2} = \frac{r_1^2}{r_2^2}$ or $\frac{r_1}{r_2} = \sqrt{\frac{A_1}{A_2}} = \sqrt{16}$

$\frac{r_1}{r_2} = 4$

$\therefore \frac{h_2}{h_1} = 4$ or $h_2 = 4h_1 = 4 \times 2 = 8$ cm

10 **(b)**
The volume of the bigger drop will be equal to the sum of the volumes of the smaller drops

$$\therefore \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_1^3 + \frac{4}{3}\pi R_2^3$$

$$\therefore R = (R_1^3 + R_2^3)^{1/3}$$

11 **(c)**
When the ball is moving with terminal velocity, its weight is balanced by the up-thrust and the viscous force.

$$\therefore V\rho_1 g = V\rho_2 g + kv_1^2$$

$$\therefore kv_t^2 = v(\rho_1 - \rho_2)g$$

$$\therefore v_t = \sqrt{\frac{V_g(\rho_1 - \rho_2)}{K}}$$

12 **(c)**
Terminal velocity $V \propto r^2$

$$\therefore \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right) = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

$$\therefore V_2 = \frac{V_1}{4} = \frac{20}{4} = 5 \text{ cm/s}$$

13 **(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

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

14 **(d)**
Surface tension, $S = \frac{rh\rho g}{2\cos\theta} = \frac{rh\rho g}{2\cos 0°}$
($\because$ for pure water, $\theta = 0°$)

$$= \frac{rh\rho g}{2}$$

15 **(c)**
Total length $= 4L$

Total force$= 2 \times 4LT = 8LT$

16 **(a)**
Excess pressure inside a liquid drop $= \frac{2S}{R}$
Excess pressure inside a soap bubble $= \frac{4S}{R}$
Excess pressure inside an air bubble $= \frac{2S}{R}$
where, $S \rightarrow$ surface tension and $R \rightarrow$ radius
$\therefore$ $A \rightarrow 1, B \rightarrow 3, C \rightarrow 1$

17 **(a)**
Suppose n number of liquid are merged. Equating initial final volume, we have

$V_i = V_1$

$\Rightarrow n \times \frac{4}{3}\pi a^3 = \frac{4}{3}\pi b^3$

$\Rightarrow b = (n)^{\frac{1}{3}}a$

$\Rightarrow n = \left(\frac{b}{a}\right)^3$

Initial surface energy, $U_i = n \times 4\pi a^2 \times S$
Final surface energy, $U_f = 4\pi b^2 \times S$
Change in surface energy.

$$\Delta U = U_1 - U_f = 4\pi S[na^2 - b^2]$$

$$= 4\pi T\left[a^2\left(\frac{b}{a}\right)^3 - b^2\right] = 4\pi T\left[\frac{b^3}{a} - b^2\right]$$

Kinetic energy of the bigger drop,

$$K = \frac{1}{2}m v^2 = \frac{1}{2} \times \rho \times \frac{4}{3}\pi b^3 \times v^2$$

According to the question, $K = \Delta U$

$$\Rightarrow \frac{1}{2} \times \rho \times \frac{4}{3}\pi b^3 v^2 = 4\pi T\left[\frac{b^3}{a} - b^2\right]$$

$$\Rightarrow \rho b^3 v^2 = 2 \times 3T\left[\frac{b^3}{a} - b^2\right]$$

$$\Rightarrow v\frac{6T}{\rho}\left[\frac{1}{a} - \frac{1}{b}\right]^{\frac{1}{2}}$$

Speed of the bigger drop, $v = \left[\frac{6T}{\rho}\left(\frac{1}{a} - \frac{1}{b}\right)\right]^{1/2}$

18 **(b)**
For a capillary tube,

m = constant
where, r = radius of capillary tube
and h = height of rised water in capillary tube.
According to the question,

$$r_1 h_1 = r_2 h_2 \Rightarrow \frac{r_1}{r_2} = \frac{h_2}{h_1} \quad \text{...(i)}$$

In the first condition,

$$A_1 = \pi r_1^2 \quad \text{...(ii)}$$

In the second condition,

$A_2 = \pi r_2^2$

or $\frac{A_1}{9} = \pi r_2^2 \left[\text{as, } A_2 = \frac{A_1}{9}\right]$ ...(iii)

On dividing Eq. (ii) by Eq. (iii), we get

$$9 = \frac{r_1^2}{r_2^2}$$

or $\frac{r_1}{r_2} = \sqrt{9} \Rightarrow \frac{r_1}{r_2} = 3$

From Eq. (i), we get

$$\frac{h_2}{h_1} = 3 \Rightarrow h_2 = 3h_1$$
$$h_2 = 3h$$

19 **(b)**
The ratio of velocities of water is given by

$$\frac{V_A}{V_B} = \sqrt{\frac{h}{4h}} = \frac{1}{2}$$

$$\therefore V_B = 2V_A$$

Quantity of water flowing is same

$$\therefore V_A \times L^2 = V_B \times \pi R^2$$

$$\therefore V_A L^2 = 2V_A \times \pi R^2$$

$$\therefore L^2 = 2\pi R^2$$

$$L = \sqrt{2\pi}R$$

20 **(b)**
Terminal speed is given by

$$v = \frac{2}{9}\frac{r^2 g(\rho - \rho_L)}{\eta}$$

$$\therefore \frac{V_A}{V_B} = \frac{\rho_A - \rho_L}{\rho_B - \rho_L} = \frac{7.5 - 1.5}{3 - 1.5} = \frac{6}{1.5} = 4$$

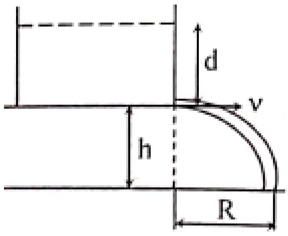
$$\therefore V_B = \frac{V_A}{4} = \frac{0.4}{4} = 0.1\ ms^{-1}$$

21 **(d)**
Excess pressure in a drop,

$$P = \frac{2T}{r}$$
$$\therefore r = \frac{2T}{P}$$
$$= \frac{2 \times 0.072}{60} = 2.4 \times 10^{-3}\ m = 2.4\ mm$$

Diameter $= 2r$
$= 2 \times 2.4 = 4.8$ mm

22 **(c)**



$$R = vt = \sqrt{2gd}t$$

$$h = \frac{1}{2}gt^2$$

$$\therefore t = \sqrt{\frac{2h}{g}}$$

$$\therefore R^2 = 2gd \times t^2 = 2gd \times \frac{2h}{g}$$

$$d = \frac{R^2}{4h}$$

23 **(d)**
We know that, surface tension is related to work as

$W = S \times \Delta A$
Since, surface area of a sphere is $4\pi R^2$ and there are two free surfaces, we have
$W = S \times 8\pi R^2$ ...(i)
i.e. $V = \frac{4}{3}\pi R^3 = R = \left(\frac{3V}{4\pi}\right)^{1/3}$ ...(ii)
From Eqs. (i) and (ii), we get

$$W = S \times 8\pi \times \left(\frac{3V}{4\pi}\right)^{2/3}, W \propto V^{2/3}$$

So, $\frac{W_2}{W_1} = \left(\frac{2V_1}{V_1}\right)^{2/3}$
$\Rightarrow W_2 = 2^{2/3}W_1 = 4^{1/3}W$

24 **(b)**
Work done, $W = SA = 4\pi r^2 \times S$
Since, soap bubble has two surfaces
$= 2 \times 4 \times \pi r^2 \times S$
$= 2 \times 4 \times 3.14 \times 0.1 \times 0.1 \times \frac{3}{100}$
$= 75.36 \times 10^{-4}$ J

25 **(c)**
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. Thus, height remains same.

26 **(c)**

Excess pressure $P = \frac{4T}{r}$

$\therefore T = \frac{pr}{4}$

$\therefore T = \frac{50 \times 2}{4} = \frac{100}{4} = 25$ dyne/cm

27 **(b)**
$W_1 = 8\pi R^2 T$

Where T is surface tension.

$W_2 = 8\pi(2R)^2 T = 8\pi R^2 T = 4W_1$

However, the solution is heated, the value of surface tension decreases.

Hence, $W_2 < 4W_1$

28 **(c)**
$h = \frac{2T\cos\theta}{r\rho g}$

$\therefore h \propto \frac{1}{g}$

In a lift going downwards with acceleration a, the apparent value of g decreases and hence h increases.

29 **(d)**
In streamline flow,

$v_1 =$ constant , $v_2 =$ constant, $v_3 =$ constant
But, $v_1 \neq v_2 \neq v_3$
So, both (a) and (b) are correct.

30 **(a)**
Atomizer is based on Bernoulli's principle.

31 **(a)**
Increase in the area of the film is

$\Delta A = 10 \text{ cm} \times 0.1 \text{ cm} = 1 \text{ cm}^2 = 10^{-4} \text{ m}^2$

work done $W = 2T.\Delta A = 2 \times 7.2 \times 10^{-2} \times 10^{-4}$ J
$= 1.44 \times 10^{-5}$ J

32 **(c)**
Weight of the coin = Force due to surface tension

$\pi r^2 d\rho g = 2\pi r T$

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

33 **(d)**

Work done to blow a soap bubble of diameter d is

$W_1 = 8\pi r^2 T = 2\pi d^2 T$

Work done to blow a soap bubble of diameter 2d is

$W_2 = 8\pi d^2 T$

Hence work done to blow a soap bubble of diameter d to diameter 2d is given by

$W = W_2 - W_1 = 6\pi d^2 T$

34 **(a)**
$W = \frac{4\pi}{4}(4D^2 - D^2)T \times 2$

$= 3D^2\pi T \times 2 = 6D^2\pi T$

35 **(b)**
The ball is moving with constant velocity.

Hence the net force acting on it is zero.

The weight of the ball

$= W = \frac{4}{3}\pi r^3 \rho_b g$ (in downward direction)

The viscous force F_v is in downward direction

The buoyant force

$F_B = \frac{4}{3}\pi r^3 \rho_l g$ (in upward direction)

$\therefore F_v + W = F_B$

$\therefore F_v = F_B - W$

$= \frac{4}{3}\pi r^3 g(\rho_l - \rho_b)$

$= \frac{4}{3}\pi r^3 g \times 3\rho_b \quad (\because \rho_l = 4\rho_b)$

$\therefore \frac{F_v}{W} = 3$

36 **(a)**
Use, $h = l\cos\alpha \Rightarrow l = \frac{h}{\cos\alpha}$
where, $h = \frac{2S\cos\theta}{\rho r g}$ $(\theta_{mine} = 0°)$

$\therefore$ The length of water in capillary tube

$$l = \frac{2S\cos\theta}{\rho rg\cos\alpha} = \frac{2\times 7\times 10^{-2}\cos 0^\circ}{10^3\times 0.4\times 10^{-3}\times 9.8\times \cos 6(}$$

$$= 7.1 \text{ cm}$$

37 **(b)**
The height of water column in a capillary tube is given by

$$\Rightarrow\ h = \frac{2T\cos\theta}{\rho rg}$$

$$\Rightarrow h \propto \frac{1}{r} \qquad \ldots\text{(i)}$$

Also, mass of liquid in a column of radius r and height h, is
$m = (\pi r^2 h)p$
$\Rightarrow\ m \propto r^2 h \quad \ldots\text{(ii)}$
From Eqs. (i) and (ii), we get

$$m \propto r^2 \times \frac{1}{r}$$
$m \propto r$
$$\Rightarrow \frac{m'}{m} = \frac{r}{r} \Rightarrow m' = \frac{m}{4}$$

38 **(a)**
$W = 8\pi T(r_2^2 - r_1^2)$

$= 8\pi \times 0.03(25-9)\times 10^{-4}$

$= 0.384\pi \times 10^{-3}$ J

$= 0.384\ \pi$ mJ

$= 0.4\ \pi$ mJ

39 **(d)**
If r_1 and r_2 are the radii, then

$a = \pi r_1^2$ and $4a = \pi r_2^2$

$$\therefore \frac{r_1^2}{r_2^2} = \frac{a}{4a} = \frac{1}{4}$$

$$\therefore \frac{r_1}{r_2} = \frac{1}{2}$$

$$h \propto \frac{1}{r}$$

$$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2} = \frac{1}{2}$$

$$\therefore h_2 = \frac{h_1}{2} = \frac{h}{2}$$

40 **(a)**
The surface tension of liquid at critical temperature is zero.

41 **(a)**
$$\cos\theta = \frac{T_2 - T_1}{T_3}$$

Since $T_2 - T_1 < T_3, \cos\theta < 1$ and positive.

Hence angle of contact lies between 0^0 and 90^0.
$0^0 < \theta < 90^0$

Hence the angle is acute.

42 **(a)**
Here, the free liquid surface between the plates will be cylindrical which is curved along one axis (parallel to the plates). The radius of curvature of meniscus, $R = r/2$. For cylindrical surface, $p_0 - p = \frac{S}{R} = \frac{S}{r/2} = \frac{2S}{r} \Rightarrow p = p_0 - \frac{2S}{r}$

43 **(a)**
$W = 8\pi T(r_2^2 - r_1^2)$

$= 8\pi \times 0.03(25-9)\times 10^{-4}$

$= 0.384\pi \times 10^{-3}$ J

$= 0.384\ \pi$ mJ

$= 0.4\ \pi$ mJ

44 **(d)**
We have, $2Sl = F$

$$\Rightarrow\ S = \frac{F}{2l} = \frac{(2\times 10^{-2})}{2}\times 0.10 = 0.1\ \text{Nm}^{-1}$$

45 **(c)**
Reynolds number $R_n = \dfrac{V_c\rho d}{n}$

Where V_c = Critical Velocity, ρ = density

η = coefficient of viscosity, d = diameter of the tube

It is independent of the length of the tube

46 **(a)**
Most viscous liquid comes to rest quickly due to dissipation of energy at a larger rate.
Hence, most viscous liquid comes to rest at the earliest.

47 **(a)**
Theory question

48 **(b)**

$W = 8\pi R^2 T, W' = 8\pi R'^2 T$

$\therefore \frac{W'}{W} = \left(\frac{R'}{R}\right)^2 \quad ...(1)$

$v = \frac{4}{3}\pi R^3$

$v' = 3v = \frac{4}{3}\pi R'^3$

$\therefore \left(\frac{R'}{R}\right)^3 = 3$

$\therefore \frac{R'}{R} = (3)^{\frac{1}{3}}$

$\therefore \left(\frac{R'}{R}\right)^2 = (9)^{\frac{1}{3}} \quad ...(2)$

$\therefore$ By eqs (1) and (2)

$\frac{W'}{W} = (9)^{\frac{1}{3}}$

49 **(c)**

$h = \frac{2T\cos\theta}{r\rho g}$

$\therefore h \propto \frac{1}{g}$

$\therefore \frac{h_1}{h_2} = \frac{g_2}{g_1} = 1 - \frac{d}{R}$

50 **(d)**

$T = 0.027\ Nm^{-1}, d = 30\ mm, r = 15\ mm$
$= 15 \times 10^{-3}\ m$

Excess pressure $P = \frac{4T}{r} = \frac{4 \times 0.027}{15 \times 10^{-3}} = 7.2$

52 **(c)**

If R is the radius of a soap bubble and S is its surface tension, then the excess pressure inside is $\frac{4S}{R}$.

53 **(b)**

Terminal speed is given by

$v = \frac{2}{9}\frac{r^2 g(\rho - \rho_L)}{\eta}$

$\therefore \frac{V_A}{V_B} = \frac{\rho_A - \rho_L}{\rho_B - \rho_L} = \frac{7.5 - 1.5}{3 - 1.5} = \frac{6}{1.5} = 4$

$\therefore V_B = \frac{V_A}{4} = \frac{0.4}{4} = 0.1\ ms^{-1}$

54 **(a)**

Net force on stick= $F_1 - F_2 = T_1 h - T_2 h = (T_1 - T_2)h$

55 **(b)**

Excess pressure inside the bubble is = 4 S/r. So, smaller the radius r, the larger is the excess pressure p. It means the pressure of air is more in bubble A than in bubble B. So, the air will go from bubble A to bubble B and B will grow more untii they colliapse.

56 **(b)**

Given, $A = 0.10\ m^2, m = 0.010\ kg, l = 0.30\ mm$
$= 0.30 \times 10^3\ m$ and $v = 0.085\ ms^{-1}$.

The metal block moves to the right, because of the tension in the string. The tension T is equal to the magnitude of the weight of the suspended mass m.

Thus, the shear force.

$F = T = mg = 0.010 \times 9.8 = 9.8 \times 10^{-2}\ N$

Shear stress on the fluid $= \frac{F}{A} = \frac{9.8 \times 10^{-2}}{0.10}$

Velocity gradient $= \frac{v}{l} = \frac{0.085}{0.30 \times 10}$

Coefficient of viscosity, $\eta = \frac{\text{Stress}}{\text{Velocity gradient}}$

$= \frac{(9.8 \times 10^2)(0.30 \times 10^{-3})}{(0.085)(0.10)}$

$= 3.45 \times 10^{-3}\ Pa - s$

57 **(c)**

Volume remains constant after coalescing.

Thus, $\frac{4}{3}\pi R^3 = 2 \times \frac{4}{3}\pi r^3$

where, R is radius of bigger drop and r is radius of each smaller drop.

$\therefore R = 2^{1/3} r$

Surface energy per unit surface area is the surface tension, so surface energy $E = \Delta A \cdot S = 4\pi A^2 S$.

For bigger drop, $E_1 = 4\pi(2^{1/3} r)^2 S = (2^{2/3})4\pi r^2 S$

For smaller drop, $E_2 = 4\pi r^2 S$

Hence, required ratio, $\frac{S_1}{S_2} = 2^{22} : 1$

58 **(b)**

$T = \frac{rh\rho g}{2\cos\theta} = \frac{rh'\rho g}{2\cos\theta'}$

$\therefore \frac{\cos\theta'}{\cos\theta} = \frac{h'}{h} = \frac{1}{2} = 0.5$

$\therefore \cos\theta' = 0.5\cos 0 = 0.5$

$\therefore \theta' = \cos^{-1}(0.5)$

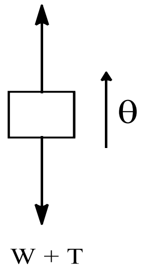
59 **(c)**

Surface tension does not depend on surface area.

60 **(a)**

Before entering the water the velocity of ball is

$\sqrt{2gh}$. If after entering the water this velocity does not change, then this value should be equal to the terminal velocity.
Therefore,



$$\sqrt{2gh} \quad = \frac{2}{9}\frac{r^2(p-\sigma)g}{\eta}$$

$$\therefore \qquad h = \frac{\left[\frac{2}{9}\frac{r^2(p-\sigma)g}{\eta}\right]^2}{2g} = \frac{2}{81} \times \frac{r^4(p-\sigma)^2 g}{\eta^2}$$

$$= \frac{2}{81} \times \frac{(3 \times 10^{-1})^4 (10^4 - 10^3)^2 \times 9.8}{(9.8 \times 10^{-6})^2}$$

$$= 1.65 \times 10^3 \text{ m}$$

61 **(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 as shown in option (c).

63 **(a)**
Terminal velocity $v \propto r^2$

$$\frac{v_1}{v_2} = (r_1/r_2)^2 = (3/2)^2 = \frac{9}{4}$$

64 **(c)**
Soap solution has lower surface tension S as compared to pure water and hence, from the formula of capillary rise, $h = \frac{2S\cos\theta}{p\,rg}$, h is less for soap solution with concave meniscus, which is shown in option (c).

65 **(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 $\pi R^2 t\rho g = S \times 2\pi R$
$\Rightarrow$ $R = 2\,S/pgt$

66 **(d)**
At the lower ends of the tube, the total pressure is due to height of water column in the container plus the height of water in the capillary.

$\therefore$ Total pressure is due to $8 + 4 = 12$ cm of water.

67 **(b)**

$$W_1 = 8\pi R^2 T$$

$$\therefore 4W_1 = 32\pi R^2 T$$

$$W_2 = 8\pi(2R)^2 T' = 32\pi R^2 T'$$

On heating, the surface tension of the solution is reduced

$\therefore T' < T$

$\therefore W_2 < 4W_1$

68 **(c)**
Pressure inside a soap bubble, $p = \frac{4T}{R}$
where, T = surface tension and R = radius of the drop.
If a bubble breaks into 27 small soap bubbles, then the volume of single bubble of radius R and the combined volume of 27 bubbles of radius r would be constant.
27 × volume of small bubbles = volume of larger bubble

$\Rightarrow \quad 27\left(\frac{4}{3}\pi r^3\right) \quad = \frac{4}{3}\pi R^3$
$\Rightarrow \quad 27r^3 \quad = R^3$
$\Rightarrow \quad r \quad = \frac{R}{3} \qquad$ ...(i)

Now, the pressure inside smaller soap bubble,

$p_{small} = \frac{4T}{r} = \frac{12T}{R}$
(using the relation)

and similarly $P_{sepo} = \frac{4T}{R}$

$\therefore$ Ratio of pressure (mechanical force per unit area) of the smaller and larger soap bubble is given as

$$\frac{p_{lerge}}{D_{smal}} = \frac{4T}{R} \times \frac{R}{12T} = \frac{1}{3}$$

$P_{leger} : P_{small} = 1:3$

Hence, the ratio of mechanical force acting per unit area of big soap bubble to that of a small bubble is 1: 3.

69 **(a)**

$$\pi r^2 h_1 \rho g = 2\pi T\cos\theta$$

$$\therefore h_1 \propto \frac{1}{g}$$

$$\therefore \frac{h_1}{h_2} = \frac{g_2}{g_1} = \frac{g(1 - d/R)}{g} = \left(1 - \frac{d}{R}\right)$$

70 **(d)**

Energy of n small drop - Energy of the bigger drop= Energy loss by bigger drop

$\Rightarrow n \times 4\pi r^2 \times S - 4\pi R^2 \times S = 3 \times 4\pi R^2 \times S$

$n \times 4\pi r^2 \times S = 12\pi R^2 \times S + 4\pi R^2 \times S$

The number of smaller drops, $n = \frac{16\pi R^2 \times S}{4\pi r^2 \times S} = 4\frac{R^2}{r^2}$

71 **(c)**

Pressure of water column of height 0.8 cm is given by

$p = h\rho g = 0.8 \times 10^{-2} \times 1000 \times 9.8$

$= 78.4\ \text{Pa}$

Excess pressure $= P = \frac{4T}{r}$

$\therefore T = \frac{Pr}{4} = \frac{78.4 \times 3 \times 10^{-3}}{4} = 58.8 \times 10^{-3}\ \text{N/m}$

72 **(a)**

Rise in a capillary tube is given by

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\therefore h \propto \frac{1}{g}$$

Smaller the value of g, greater will be h. Out of the given options, value g will be minimum for option (A).

73 **(d)**

The drop is in equilibrium under the action of the following forces:

Weight of the liquid= $Mg = \frac{4}{3}\pi r^3 \rho g$ (downwards)

Upthrust = weight of the liquid displaced

$\therefore U = \frac{4}{6}\pi r^3 dg$ (upwards)

(since the drop is half immersed, the volume of the liquid displaced is half the volume of the drop)

Force due to surface tension

$F = 2\pi r T$ (upwards)

$\therefore Mg = F + U$

$\therefore F = Mg - U$

$$\therefore 2\pi T = \frac{4}{3}\pi r^3 \rho g - \frac{4}{6}\pi r^3 dg$$

$$\therefore T = \frac{2}{3}r^2 \rho g - \frac{1}{3}r^2 dg$$

$$= r^2 g\left(\frac{2}{3}\rho - \frac{1}{3}d\right)$$

$$= r^2 g\left(\frac{2\rho - \rho}{3}\right)$$

$$\therefore r^2 = \frac{3T}{g(2\rho - d)}$$

If D is the diameter of the drop then

$$r^2 = \frac{D^2}{4}$$

$$\therefore \frac{D^2}{4} = \frac{3T}{g(2\rho - d)}$$

$$\therefore D^2 = \frac{12T}{g(2\rho - d)}$$

$$\therefore D = \sqrt{\frac{12T}{g(2\rho - d)}}$$

74 **(a)**

If the tube is broken at a height of 6 cm, then water will rise upto a height of 6 cm and the angle of contact will change.

Initial angle of contact $\theta_1 = 0^0$. Let θ_2 be the new angle of contact. Then we have

$h_1 = \frac{2T\cos\theta_1}{r\rho g}$ and $h_2 = \frac{2T\cos\theta_2}{r\rho g}$

$\therefore \frac{h_2}{h_1} = \frac{\cos\theta_2}{\cos\theta_1} = \frac{\cos\theta_2}{\cos 0^0} = \cos\theta_2$

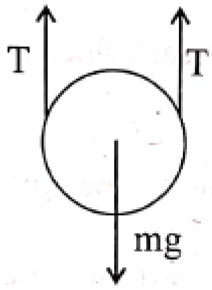
$\therefore \cos\theta_2 = \frac{h_2}{h_1} = \frac{6}{8} = \frac{3}{4} = 0.75$

$\therefore \theta_2 = \cos^{-1}(0.75)$

75 **(a)**

$2Tl = mg = \pi r^2 l \rho g$

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



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

76 **(a)**

$r = \frac{R}{(n)^{\frac{1}{3}}} = \frac{R}{(27)^{\frac{1}{3}}} = \frac{R}{3}$

77 **(c)**

The rise of liquids is given by

$h = \frac{2T\cos\theta}{r\rho g}$

h is smaller for all and surface tension in also same

$\therefore \frac{\cos\theta}{\rho} = \text{constant}$

or $\cos\theta \propto \rho$

since $\rho_1 > \rho_2 > \rho_3$, we get

$\cos\theta_1 > \cos\theta_2 > \cos\theta_3$

$\therefore \theta_1 < \theta_2 < \theta_3$

78 **(a)**

The weight of the disc is balanced by the force due to the surface tension and the upthrust of water.

The component of surface tension in vertically upward direction is $T\cos\theta$ and the force acting due to it is $2\pi r T\cos\theta$.

The up-thrust is equal to the weight of the water displaced (W).

$\therefore$ Weight of the disc$= 2\pi r\, T\cos\theta + W$

79 **(d)**

$h = \frac{2T\cos\theta}{rdg}$

$\frac{h_1}{h_2} = \frac{T_1}{T_2} \times \frac{d_2}{d_1} = \frac{60}{50} \times \frac{0.6}{0.8} = \frac{9}{10}$

80 **(c)**

$\text{Reynold's no.} = \frac{V_c\rho D}{\eta}$

$= \frac{10 \times 10^{-2} \times 10^3 \times 2 \times 0.5 \times 10^{-2}}{10^{-3}} = 1000$

$1000 \ll 2000$

$\therefore$ streamlined motion.

81 **(b)**

Length, $l = \frac{h}{\cos\theta} = \frac{3}{\cos 60°} = 6$ cm

82 **(b)**

Weight of the wire = upward force due to surface tension

$\therefore \pi r^2 l\rho g = 2Tl$

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

83 **(b)**

$h_1 r_1 = h_2 r_2$

$\frac{h_1}{h_2} = \frac{r_2}{r_1}$

$A \propto r^2$

$\sqrt{A} \propto r$

$\therefore h_2 = h_1\sqrt{\frac{A_1}{A_2}} = 3\sqrt{9} = 3 \times 3 = 9$ cm

86 **(a)**

Work done to form a soap bubble of radius r is given by $w_1 = 8\pi r^2 T$

Work done to form a soap bubble of radius 3r is given by $w_2 = 8\pi(3r)^2T = 8\pi(9r)^2T = 72\pi r^2 T$

$\therefore$ Additional work required $w = w_2 - w_1 = 72\pi r^2T - 8\pi r^2 T = 64\pi r^2 T$

$\therefore \frac{w^2}{w_1} = 8$

$\therefore w^2 = 8w_1 = 8 \times 500 = 4000$ erg

87 **(c)**

By equation of continuity $A_1V_1 = A_2V_2$

$\therefore \frac{V_2}{V_1} = \frac{A_1}{A_2} = \frac{d_1^2}{d_2^2}$

$\therefore A \propto d^2$

$\therefore \frac{d_2^2}{d_1^2} = \frac{v_1}{v_2}$

$\therefore \frac{d_2}{d_1} = \sqrt{\frac{v_1}{v_2}}$

$\therefore d_2 = d_1\sqrt{\frac{v_1}{v_2}} = d\sqrt{\frac{v}{v_1}}$

89 **(a)**

The force due to surface tension at the wall of the capillary is given by

$f_T = (\text{surface tension}) \times (\text{length in contact})$

$= T \times 2\pi r_2$

The vertical component of this force is

$f_v = T \times 2\pi r_2 \cos\theta$

where θ is the angle of contact.

Similarly the vertical component of the force at the surface of the rod is

$f_v' = T \times 2\pi r_1 \cos\theta$

Total force $F = f_v + f_v'$

$F = (r_2 + r_1)2\pi T\cos\theta$

Weight of the liquid in the capillary

$W = \pi(r_2^2 - r_1^2)h\rho g$

This is balanced by the vertical component of the face due to the surface tension

$\therefore \pi(r_2^2 - r_1^2)h\rho g = (r_2 - r_1) \times 2\pi T\cos\theta$

Simplifying and solving for h we get,

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

(For pure water, $\theta = 0^0, \cos\theta = 1$)

90 **(d)**

By equation of continuity

$A_1V_1 = A_2V_2$

Hence if area of cross-section decreases, the velocity increase.

By Bernoulli's equation

$p + \frac{1}{2}\rho V^2 = \text{constant}$

$\therefore$ if V increase pressure decreases.

Hence in the narrowest part, velocity is maximum and pressure is minimum.

91 **(c)**

$\rho\left(n \times \frac{4\pi}{3}r^3\right) = \rho\left(\frac{4\pi}{3}R^3\right)$

$\therefore n = \frac{R^3}{r^3}$

$\Delta A = 4\pi(nr^2 - R^2) = 4\pi\left(\frac{R^3}{r^3}.r^2 - R^2\right)$

$= 4\pi R^3\left[\frac{1}{r} - \frac{1}{R}\right]$

$\therefore E = T\Delta A = 4\pi TR^3\left[\frac{1}{r} - \frac{1}{R}\right]$

$\frac{1}{2}\rho\frac{4\pi}{3}R^3v^2 = 4\pi TR^3\left[\frac{1}{r} - \frac{1}{R}\right]$

$v^2 = \frac{6T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)$

$v = \left[\frac{6T}{\rho}\left(\frac{1}{r} - \frac{1}{R}\right)\right]^{1/2}$

92 **(a)**

In a streamline flow, velocity of a fluid at given point is always constant

93 **(b)**

When a number of drops coalesce, the energy is released, which is the difference of initial surface energy and final surface energy. The volume of liquid remains same.

$\therefore$ Initial energy $E_1 = 4\pi nr^2T$

Where n is the number of drops

If V is the volume then

$V = \frac{4}{3}\pi r^3 n$

$\therefore 4\pi r^2 n = \frac{3V}{r}$

$\therefore E_1 = \frac{3VT}{r}$

Final energy $E_2 = 4\pi R^2T$

$$V = \frac{4}{3}\pi R^3$$

$$\therefore 4\pi R^2 = \frac{3V}{R}$$

$$\therefore E_2 = \frac{3VT}{R}$$

$$\therefore E_1 - E_2 = 3VT\left(\frac{1}{r} - \frac{1}{R}\right)$$

94 **(a)**

Given, density of metal wire = ρ

Surface tension of water = T

If / is the length of the wire and F is the total force on either side of the wire, then

$F = Tl$ ... (i)

Also, $F = mg$ ... (ii)

From Eqs. (i) and (ii), we get

$Tl = mg$

$Tl = V\rho g$ [$\therefore$ Density (p) $= \frac{m}{v}$]

$$Tl = \frac{\pi r^2}{\rho g}$$

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

95 **(d)**

$$\frac{4}{3}\pi R^3 = 216 \times \frac{4}{3}\pi r^2$$

$$\therefore R = 6r$$

$$\therefore r = \frac{R}{6}$$

Initial energy $E = 4\pi R^2 T$

Final energy $E' = 216 \times 4\pi R^2 T$

$$= 216 \times 4\pi \frac{R^2}{36} T$$

$$= 6 \times 4\pi R^2 T$$

$$= 6E$$

96 **(a)**

Volume of mercury remains same.

$$\therefore \frac{4}{3}\pi R^3 = n \times \frac{4\pi}{3} \times r^3$$

$$\therefore R = n^{1/3} r \text{ or } r = R/n^{1/3}$$

97 **(b)**

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\therefore h \propto \frac{1}{r}$$

$$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2}$$

Area $A = \pi r^2$

$$\therefore A \propto r^2$$

$$\therefore \frac{A_1}{A_2} = \frac{r_1^2}{r_2^2} \text{ or } \frac{r_1}{r_2} = \sqrt{\frac{A_1}{A_2}} = \sqrt{16}$$

$$\frac{r_1}{r_2} = 4$$

$$\therefore \frac{h_2}{h_1} = 4 \text{ or } h_2 = 4h_1 = 4 \times 2 = 8 \text{ cm}$$

98 **(a)**

$R_e \leq 1000$: Streamlined flow

$1000 < R_e < 2000$; Unstable flow

$R_e \geq 2000$; Turbulent flow

99 **(b)**

Volume of 8 smaller drop = Volume of the bigger drop

$$\therefore 8 \times \frac{4}{3}\pi r^3 = \frac{4\pi}{3} R^3$$

$$\therefore 2r = R \text{ or } r = \frac{R}{2}$$

Excess pressure $\Delta P_x = \frac{T}{2r}, \Delta P_B = \frac{T}{2R}$

$$\therefore \frac{\Delta P_B}{\Delta P_s} = \frac{r}{R} = \frac{1}{2}$$

100 **(c)**

As, height raised in capillary tube, $h = \frac{2S\cos\theta}{r\rho g}$

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

$$\therefore \frac{S_w}{S_{H_B}} = \frac{h_w}{h_{H_g}} \times \frac{\cos\theta_2}{\cos\theta_1} \times \frac{\rho_w}{\rho_{H_{Hg}}}$$

$$= \frac{10}{3.42} \times \frac{\cos 135°}{\cos 0°} \times \frac{1 \times 10^3}{13.6 \times 10^3}$$

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

101 **(a)**

Theory question

102 **(b)**

Excess pressure inside a soap bubble is given by

$$\Delta P = P_i - P_0 = \frac{4T}{r}$$

$$\Delta P_1 = 1.01 \text{ atm} - 1 \text{ atm} = 0.01 \text{ atm}$$

$$\Delta P_2 = 1.03 \text{ atm} - 1 \text{ atm} = 0.03 \text{ atm}$$

$$\therefore \frac{\Delta P_i}{\Delta P_2} = \frac{r_2}{r_1}$$

$$\therefore \frac{0.03}{0.01} = 3 = \frac{r_2}{r_1}$$

$$\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^3 = (3)^3 = 27$$

103 **(a)**
Pressure inside the first bubble

$$= P + \frac{4T}{r_1}$$

Pressure inside the second bubble

$$= P + \frac{4T}{r_2}$$

Using the formula $PV = nR\theta$ $\theta =$ absolute temp.

We have:

$$\left(P + \frac{4T}{r_1}\right).\frac{4\pi}{3}r_1^3 = n_1R'\theta \text{ (R'is molar gas constant)}$$

$$\left(P + \frac{4T}{r_2}\right).\frac{4\pi}{3}r_2^3 = n_2R'\theta$$

and $\left(P + \frac{4T}{R}\right).\frac{4\pi}{3}R^3 = (n_1 + n_2)R'\theta$

$$\therefore \left(P + \frac{4T}{R}\right).\frac{4\pi}{3}R^3 = \left(\frac{P + 4T}{r_1}\right).\frac{4\pi}{3}r_1^3 + \left(P + \frac{4T}{r_2}\right).\frac{4\pi r^3}{3}$$

$$\therefore \left(p + \frac{4T}{R}\right)R^3 = \left(P + \frac{4T}{r_1}\right)r_1^3 + \left(p + \frac{4T}{r_2}\right)r_2^3$$

on solving: $T = \dfrac{p(R^3 - r_1^3 - r_2^3)}{4(r_1^2 + r_2^2 - R^2)}$

104 **(b)**
$hg =$ constant

$$h \propto \frac{1}{g}$$

$$\frac{h_1}{h_2} = \frac{g_2}{g_1} = \frac{g(1 - d/R)}{g} = 1 - \frac{d}{R}$$

105 **(c)**
Terminal velocity $V \propto r^2$

$$\therefore \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right) = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

$$\therefore V_2 = \frac{V_1}{4} = \frac{20}{4} = 5 \text{ cm/s}$$

106 **(c)**
Water will not leak out from the hole, if the weight of water in the water column is supported by the force due to surface tension.
Thus balancing these two forces, we can write

$$h = \frac{2S}{r\rho g} = \frac{2 \times 7.5 \times 10^{-2}}{0.5 \times 10^{-3} \times 10^3 \times 10}$$

$$= 3 \times 10^{-2} \text{ m} = 3 \text{ cm}$$

107 **(d)**

$$h \propto \frac{1}{r}$$

$$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2}$$

$$\frac{A_2}{A_1} = \frac{1}{4}$$

$$\therefore \frac{r_2}{r_1} = \frac{1}{2}$$

$$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2} = 2$$

$$\therefore h_2 = 2h_1 = 2 \times 20 \text{ mm} = 40 \text{ mm} = 4 \text{ cm}$$

108 **(b)**
Terminal velocity, $v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$

$$\therefore v \propto r^2 \Rightarrow \frac{v_1}{v_2} = \frac{r^2}{R^2} \Rightarrow v_2 = \frac{vR^2}{r^2}$$

109 **(c)**
In streamlined flow, velocity of all the particles arriving at a common point remains same with time (both in magnitude and direction), So, the $KE = \frac{1}{2}mv^2 =$ a constant for all the particles as all fluid particles have identical mass also.

110 **(d)**

Excess pressure inside a spherical drop of water,

$$p = \frac{2T}{R}$$

Given, $p_1 = 4p_2$

$$\frac{2T}{R_1} = 4 \times \frac{2T}{R_2} \Rightarrow R_2 = 4R_1$$

Now, $\frac{m_1}{m_2} = \frac{4\pi R_1^3 d_1}{4\pi R_2^3 d_2} = \frac{R_1^3}{R_2^3} = \frac{1}{64}$

111 **(c)**

When the surface of the liquid is plane, the angle of contact of the liquid with the wall is 90°.

112 **(a)**

Let n be the number of droplets.

$$\therefore \frac{4}{3}\pi R^3 = n\left(\frac{4}{3}\pi r^3\right)$$

$$\therefore R^3 = nr^3$$

Initial surface energy

$$E_1 = 4\pi r^2 nT$$

Final surface energy

$$E_2 = 4\pi R^2 T$$

$$E_1 - E_2 = 4\pi(nr^2 - R^2)T$$

If $\Delta\theta$ is the rise in temperature then heat energy produced $Q = ms\Delta\theta = m\Delta\theta$

(taking $s = 1\ \mathrm{cal/g^0C}$)

$$\therefore Q = \frac{4}{3}\pi R^3 \Delta\theta \quad [\because m = \rho v \text{ and } \rho = 1\ \mathrm{g/cm^3}]$$

$$Q = E_1 - E_2$$

$$\therefore \frac{4}{3}\pi R^3 \Delta\theta = 4\pi(nr^2 - R^2)T$$

$$\therefore \Delta\theta = \frac{3}{R^3}(nr^2 - R^2)T$$

$$= 3\left(n\frac{r^2}{R^3} - \frac{1}{R}\right)T$$

$$= 3\left(\frac{1}{r} - \frac{1}{R}\right)T$$

$[\because R^3 = nr^3]$

113 **(d)**

$$\frac{4}{3}\pi R^3 \rho = \frac{4}{3}\pi n r^3 \rho$$

$$\therefore R^3 = nr^3$$

$$W = \Delta AT$$

$$= 4\pi T[nr^2 - R^2]$$

$$= 4\pi T\left[\frac{R^3}{r^3}.r^2 - R^2\right]$$

$$= 4\pi R^3 T\left[\frac{R}{r} - 1\right]$$

$$= 4\pi R^3 T\left[\frac{1}{r} - \frac{1}{R}\right]$$

114 **(d)**

The viscous force acting on the sphere is given by

$$F = 6\pi\eta rv$$

Rate of doing work = Power

$$= \frac{dQ}{dt}$$

$$\therefore \frac{dQ}{dt} = Fv = 6\pi\eta rv^2$$

$$\therefore \frac{dQ}{dt} \propto rv^2$$

But the terminal velocity

$$v \propto r^2 \text{ or } v^2 \propto r^4$$

$$\therefore dQ/dt \propto r^5$$

115 **(a)**

$$r_1 = \frac{1}{\sqrt{\pi}}\ \mathrm{cm}$$

$$r_2 = 2r_1 = \frac{2}{\sqrt{\pi}}$$

Work done in forming a bubble of radius r_1:

$$w_1 = 8\pi r_1^2 T = 8\pi\frac{1}{\pi}T = 8T$$

Work done in forming a bubble of radius r_2:

$$w_2 = 8\pi r_2^2 T = 8\pi.\frac{4}{\pi}T = 32T$$

$$\therefore w_2 - w_1 = 32\ T - 8\ T = 24\ T = 24 \times 30$$

$$= 720\ \mathrm{crg}$$

116 **(a)**

The pressure is given by

$$P = h\rho g$$

It does not depend on the area of the surface.

117 **(b)**

Given, $S = 0.06\mathrm{Nm^{-1}}, r_1 = 2\ \mathrm{cm} = 0.02\ \mathrm{m}, r_2 = 5\ \mathrm{cm} = 0.05\ \mathrm{m}$

Since, bubble has two surfaces.

Initial surface area of the bubble $= 2 \times 4\pi r_1^2$

$= 2 \times 4\pi \times (0.02)^2 = 32\pi \times 10^{-4}\ \mathrm{m^2}$

Final surface area of the bubble $= 2 \times 4\pi r_2^2$

$= 2 \times 4 \times \pi \times (0.05)^2$

$= 200 \times \pi \times 10^{-}\mathrm{m^2}$

So, work done = Surface tension × Increase in surface area

$= 0.06 \times (200 \times \pi \times 10^{-4} - 32\pi \times 10^{4})$

$= 0.06 \times 168\pi \times 10^{-4} = 0.003168$ J

118 **(d)**

According to Stoke's law, the retarding force is proportional to velocity.
Initially, when the spherical body is released in the fluid, it accelerates due to gravity. As the velocity increases, the retarding force also increases.

Finally, when viscous force plus buoyant force become equal to the force of gravity, the net force and hence acceleration become zero. The sphere then moves with a constant velocity called terminal velocity. This situation is correctly described by the v − t graph of option (d).

119 **(d)**

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$\therefore h \propto \frac{1}{g}$$

For a lift going down with acceleration a, the effective value of g is $g' = g - a$

$g' = g - a$

$g' < g$

∴ h will increase.

120 **(d)**

The volume of the bigger drop is equal to the sum of the volume of the smaller drops.

$$\frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_1^3 + \frac{4}{3}\pi R_2^3$$

$$\therefore R = \sqrt[3]{R_1^3 + R_2^3}$$

121 **(b)**

Surface energy = Surface tension × Surface area

$E = T \times 2A$

New surface energy, $E_1 = T \times 2\left(\frac{A}{4}\right) = T \times \frac{A}{2}$

% decrease in surface energy

$$= \frac{E \times E}{E} \times 100 = \frac{2TA - TA/2}{2TA} \times 100 = 75\%$$

122 **(c)**

Height of liquid in a capillary tube, $h = \frac{2S\cos\theta}{r\rho g}$

where, S = surface tension,

ρ = density of the liquid

and r = radius of the capillary tube.

For capillary A, $h_A = \frac{2S\cos\theta}{r_A\rho g}$ ...(i)

For capillary B, $h_b = \frac{2S\cos\theta}{r_E\rho g}$ ...(ii)

From Eqs. (i) and (ii), $h_A r_A = h_B r_B$

$\Rightarrow \quad (1.8)\,(r_A) = (h_B)\left(\frac{90}{100} \times r_A\right)$

or $\quad (1{,}8) = h_e \times \frac{9}{10}$

$\Rightarrow \quad h_B = \frac{10}{9} \times 1.8 = 2$ cm

123 **(d)**

$$V = \frac{4}{3}\pi r^3$$

$$V_1 = \frac{4}{3}\pi r_1^3$$

$$P = \frac{4T}{r}$$

$$P_1 = \frac{4T}{r_1}$$

$$\frac{4T}{r} = \frac{4T}{r_1} \times 3$$

$$\Rightarrow \frac{1}{r} = \frac{3}{r_1}$$

$$\therefore \frac{r}{r_1} = \frac{1}{3}$$

$$\frac{V_1}{V} = \frac{r_1^3}{r^3} = 27$$

124 **(d)**

In a streamline flow at any given point, the velocity of each passing fluid particles remains constant. If we consider a cross-sectional area, then a point on the area cannot have different velocities at the same time, hence two streamlines of flow cannot cross each other.

125 **(a)**

$$h = \frac{2T}{\rho g R}$$

$$h = h_1 - h_2 = \frac{2T}{\rho g}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= \frac{2 \times 7 \times 10^{-2}}{10^3 \times 10}\left(\frac{2}{5} - 1\right) = 8.4 \text{ mm}$$

126 **(c)**

$W = 8\pi R^2 T$

If temperature increases then

$$\frac{W_2}{W_1} = \frac{8\pi(2R)^2 T'}{8\pi R^2 T}$$

$$\therefore \frac{W_2}{W_1} = \frac{4T'}{T}$$

As temperature increases, the surface tension decreases. Therefore

$T' < T$

$\therefore W_2 < 4W_1$

127 **(d)**
Volume remains constant

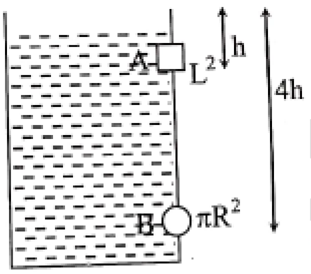
$$\therefore n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$$

$$\therefore nr^3 = R^3$$

$$\therefore n^{\frac{1}{3}} r = R$$

$$\therefore r = \frac{R}{n^{\frac{1}{3}}}$$

128 **(d)**



$v_1 = \sqrt{2\pi R}$

$v_2 = \sqrt{2g4h}$

$\therefore A_1 v_1 = A_2 v_2$

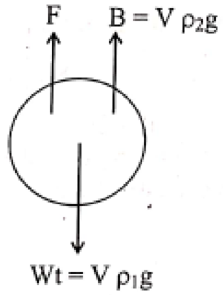
$L^2\sqrt{2gh} = \pi R^2\sqrt{2g4h}$

$L^2 = 2\pi R^2$

$\therefore L = \sqrt{2\pi R}$

129 **(c)**
$F \rightarrow$ viscous force, $B \rightarrow$ Buoyant force, $W \rightarrow$ weight

$W = F + B$



$V\rho_1 g = KV_t^2 + V\rho_2 g$

$V(\rho_1 - \rho_2)g = KV_t^2$

$$\therefore V_t = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{K}}$$

130 **(b)**
$$W = \frac{4\pi T}{4}(D^2 - d^2) \times 2 = 2\pi(D^2 - d^2)T$$

131 **(c)**
The surface tension of liquids decreases with increase of temperature. For small temperature differences, it decreases almost linearly. The surface tension of a liquid becomes zero at a particular temperature, called the critical temperature of that liquid.

133 **(c)**
$$h = \frac{2T\cos\theta}{h\rho g}$$

When detergent is dissolved in water, its surface tension (T) decreases. Hence h decreases.

134 **(b)**
$W_1 = 8\pi R^2 T$

If soap solution is heated, its surface tension decreases.

Hence work done in blowing a soap bubble of radius 2R will be

$W_2 = 8\pi(2R)^2 T'$

$= 32\,\pi R^2 T'$

since $T' < T, W_2 < 4W_1$

135 **(c)**
Viscous force $F = 6\pi\eta r v$

If velocity is same, then

$$\frac{F_2}{F_1} = \frac{2V}{V} = 2$$

136 **(d)**

$$h \propto \frac{1}{r}$$

since $A = \pi r^2$

$$\sqrt{A} \propto r$$

$$\therefore h \propto \frac{1}{\sqrt{A}}$$

$$\therefore \frac{h_2}{h_1} = \sqrt{\frac{A_1}{A_2}} = \sqrt{3}$$

$$\therefore \frac{A_1}{A_2} = 3$$

$$\therefore h_2 = \sqrt{3}h_1$$

$$= \sqrt{3} \times 15 \times 10^{-3} \text{ m}$$

$$= 15\sqrt{3} \times 10^{-3} \text{ m}$$

137 **(a)**

Excess pressure is given by $p = \frac{4S}{r} \Rightarrow r = \frac{4S}{p}$

$\therefore \frac{r_1}{r_2} = \frac{p_2}{p_t} = \frac{1.02}{1.01} = \frac{102}{101}$

Ratio of volumes $= \frac{\frac{4}{3}\pi r_1^3}{\frac{4}{3}\pi r_2^3} = \frac{(102)^3}{(101)^3} = 2$

138 **(d)**

Terminal velocity,

$$v = \frac{2}{9}\frac{r^2(\rho-\sigma)g}{\eta}$$

$\Rightarrow V \propto r^2$

Here $v_1 = 20 \text{ cms}^{-1}, r_1 = 2 \text{ cm}, r_2 = 1 \text{ cm}$

$\therefore \quad \frac{v_1}{v_2} = \frac{r_1^2}{r_2^2} = \frac{(2)^2}{(1)^2}$

$\rightarrow v_2 = 20/4 = 5 \text{ cms}^{-1}$

139 **(d)**

When a stream of air passes through the space between the balls, the pressure reduce between them as compared to the atmospheric pressure on either side. So, according to Bernoulli's theorem, the pressure energy should be constant and is compensated by movement of balls toward each other. So, the distance between the balls will decrease.

140 **(d)**

The height of liquid column in a capillary tube is

$$h = \frac{2T\cos\theta}{\rho r g} \Rightarrow h \propto \frac{1}{g}$$

$\therefore$ When the set-up is kept in a lift going down with acceleration $a < g$, then the height of water in the tube increases as net downward acceleration becomes $(g - a)$.

141 **(b)**

For streamline flow, Reynold's number $R_e, \sim \frac{p}{\eta}$ should be less. For less value of R_e, radius, density should be small and viscosity should be high.

142 **(c)**

When a large bubble rises from bottom of water lake to its surface, then its radius becomes double.

$r_2 = 2r_1$

Since, volume $V \propto r^3$

$\therefore \quad \frac{V_2}{V_1} = \left(\frac{r_2}{r_1}\right)^3 = \left(\frac{2r_1}{r_1}\right)^3 = 8$

$\Rightarrow \quad V_2 = 8V_1 \qquad$ ...(i)

From Boyle's law,

$p_1V_1 = p_2V_2$

$p_1V_1 = p_2 \cdot 8V_1 \qquad$ [from Eq. (i)]

$p_2 = \frac{p_1}{8} \qquad$ ...(ii)

where, $p_2 =$ atmospheric pressure

and $p_1 =$ pressure at depth d.

$\therefore \; p_1 = p_{\text{atmosshenc}} + pgd$

$p_1 = p_2 + \rho gd \qquad$ ...(iii)

From Eqs. (ii) and (iii), we have

$$p_2 = \frac{p_2 + \rho gd}{8}$$

$7p_2 = \rho gd$

$7H = d \Rightarrow d = 7H$

143 **(d)**

$$F_{\text{viscous}} + \frac{4}{3}\pi R^3\sigma_2 g = \frac{4}{3}\pi R^3\sigma_2 g$$

$$F_{\text{viscous}} = \frac{4}{3}\pi R^3 g(\sigma_1 - \sigma_2) = \frac{4}{3}\pi R^3 g\sigma_1\left(1 - \frac{\sigma_2}{\sigma_1}\right)$$

$$= mg\left(1 - \frac{\sigma_2}{\sigma_1}\right)$$

144 **(b)**

In a turbulent flow, velocity of a fluid at any point does not remain constant.

145 **(d)**
The potential energy of the molecules lying in the surface is greater than that of the molecules in the interior of the liquid.

146 **(a)**
The work done in blowing a soap bubble is given by

$W = 8\pi R^2 T$

$\frac{W_1}{W_2} = \frac{R_1^2}{R_2^2} = \frac{1}{4}$ $(\because R_2 = 2R_1)$

147 **(a)**
Pressure inside the first bubble

$= P + \frac{4T}{r_1}$

Pressure inside the second bubble

$= P + \frac{4T}{r_2}$

Using the formula $PV = nR\theta$ $\theta =$ absolute temp.

We have:

$\left(P + \frac{4T}{r_1}\right).\frac{4\pi}{3} r_1^3 = n_1 R'\theta$ ($R'$is molar gas constant)

$\left(P + \frac{4T}{r_2}\right).\frac{4\pi}{3} r_2^3 = n_2 R'\theta$

and $\left(P + \frac{4T}{R}\right).\frac{4\pi}{3} R^3 = (n_1 + n_2)\, R'\theta$

$$\therefore \left(P + \frac{4T}{R}\right).\frac{4\pi}{3} R^3 = \left(\frac{P + 4T}{r_1}\right).\frac{4\pi}{3} r_1^3 + \left(P + \frac{4T}{r_2}\right).\frac{4\pi r^3}{3}$$

$$\therefore \left(P + \frac{4T}{R}\right) R^3 = \left(\frac{P + 4T}{r_1}\right).r_1^3 + \left(P + \frac{4T}{r_2}\right) r_2^3$$

on solving:

$$T = \frac{P(R^3 - r_1^3 - r_2^3)}{4(r_1^2 + r_2^2 - R^2)}$$

148 **(a)**
According to the concept of surface tension.
(A)When $T_{SA} > T_{SL}$, θ will be the in between 0° to 90°.
(B)When $T_{SA} < T_{SL}$, θ lies between 90° to 180°.
(C)When $T_{SL} + T_{LA}\cos\theta > T_{SA}$, molecules of liquid will not be in equilibrium.

149 **(b)**
The drop is in equilibrium under the action of the following forces:

Weight of the liquid

$= Mg = \frac{4}{3}\pi r^3 \rho g$ (downwards)

Up-thrust = weight of liquid displaced

$\therefore U = \frac{4}{6}\pi r^3 dg$ (upwards)

(Since the drop is half immersed, the volume of the liquid displaced is half the volume of the drop)

Force due to surface tension

$F = 2\pi r T$ (upwards)

$Mg = F + U$

$F = Mg - U$

$2\pi r T = \frac{4}{3}\pi r^3 \rho g - \frac{4}{6}\pi r^3 dg$

$T = \frac{2}{3} r^2 \rho g - \frac{1}{3} r^2 dg$

$= \frac{r^2 g}{3}(2\rho - d)$

$r^2 = \frac{3T}{g(2\rho - d)}$

If D is the diameter then

$\frac{D^2}{4} = \frac{3T}{g(2\rho - d)}$

$\therefore D^2 = \frac{12T}{g(2\rho - d)}$

$\therefore D = \sqrt{\frac{12T}{g(2\rho - d)}}$

150 **(d)**
The terminal velocity of the sphere,

$$v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{n}$$

$\therefore$ $v = 0$ $(\because$ in vacuum, $g = 0)$

Hence, the sphere never attains terminal velocity in vacuum.

151 **(c)**

Let thickness of layer be x.

So, volume = area × thickness

$V = A \times x \Rightarrow x = \frac{V}{A}$ $(\because x = 2r)$

$\therefore 2r = \frac{V}{A} \Rightarrow r = \frac{V}{2A}$ ...(i)

and $\Delta p \frac{S}{R}$

we know that, $F = \Delta p \times A = \frac{S}{r} \times A$

$F = \frac{S}{\left(\frac{V}{2A}\right)} \times A$ [from Eq. (i)]

$S = \frac{F \times V}{2A^2}$

Given, $F = 16 \times 10^5$ dyne, $V = 0.04\ cm^3, A = 20\ cm^2$

$$S = \frac{16 \times 10^5 \times 0.04}{2 \times (20)^2} = \frac{8 \times 10^5 \times 4}{(20)^2 \times 100}$$

$= 8 \times 10^5 \times 10^{-4} = 80$ dynecm $^{-1}$

152 **(a)**

$A = \pi r^2$,

$\frac{A_2}{A_1} = \frac{1}{9}$

$\therefore \frac{r_2^2}{r_1^2} = \frac{1}{3}$

$h \propto \frac{1}{r}$

$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2} = 3$

$\therefore h_2 = 3h_1$

153 **(d)**

A liquid does not wet the solid surface, if the angle of contact is obtuse. i.e. greater than 90°. In this situation, cohesive force is much greater than adhesive force.

154 **(b)**

Viscosity of water decreases with rise of temperature.

155 **(b)**

Reynold number is given by

$R_n = \frac{v_c \rho d}{\eta}$

$\therefore v_c = \frac{R_n \eta}{\rho d}$

$R_n = 2500, \eta = 10^{-3} \frac{Ns}{m^2}, R_n = 2500, \rho = 10^3 \frac{kg}{m^3}$

$d = 2r = 2\ cm = 2 \times 10^{-2}\ m$

Substituting these values and calculating we get critical velocity $v_c = 0.125\ m/s$

156 **(c)**

Total length = 4L

$\therefore$ Surface tension $= 2T \times 4L = 8TL$

157 **(b)**

Error in question

158 **(c)**

$L^2 V_1 = \pi R^2 V_2$

$\therefore V_1 = \sqrt{2gh} \Longrightarrow V_2 = \sqrt{8gh}$

$L^2 \sqrt{2gh} = \pi R^2 \sqrt{8gh} \Longrightarrow L = \sqrt{2\pi} R$

159 **(a)**

By the relation, $h = \frac{2S\cos\theta}{rdg}$ and $\frac{h_2}{h_1} = \frac{g_1}{g_2}$

$\frac{h_2}{h} = \frac{g}{g/6} \Rightarrow h_2 = 6h$

Hence, the rise of the liquid column on the moon becomes six times that on the earth's surface.

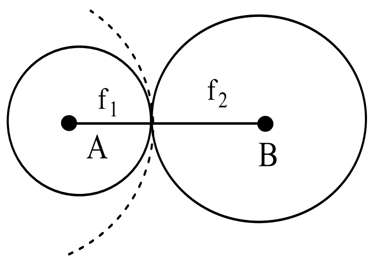
160 **(d)**

$\frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_1^3 + \frac{4}{3}\pi R_2^3$

$\therefore R = (R_1^3 + R_2^3)^{1/2}$

161 **(c)**

Excess pressure as compared to atmosphere inside A is $\frac{4S}{r_1}$ and B is $\frac{4S}{r_2}$,



The pressure difference is $\frac{4S}{r_1} - \frac{4S}{r_2} = \frac{4S}{r'} \Rightarrow r' = \frac{r_1 r_2}{r_2 - r_1}$

Given, $r_1 = r_2 = r$

$\therefore$ $r' = \frac{r^2}{0} = \infty$

162 **(a)**

The excess pressure p of bubble in air is given by

$$p = \frac{4S}{R} = \frac{4 \times 1.6}{2.5 \times 10^{-2}} = 2560\ \mathrm{Nm}^2$$

163 **(b)**

Height to which water rises in a capillary tube is given by

$$h = \frac{2T}{r\rho g} = \frac{4T}{d\rho g} \text{ where } d = 2r$$

$$\therefore h_1 - h_2 = \frac{4T}{\rho g}\left[\frac{1}{d_1} - \frac{1}{d_2}\right] = \frac{4T}{\rho g}\left[\frac{d_2 - d_1}{d_1 d_2}\right]$$

164 **(c)**

Surface energy is related to the surface tension by the relation, $U = \Delta A \cdot T$

Given, $T = 5\mathrm{Nm}^{-1}$

$$\Delta A \quad = 2A = 2 \times 0.02 = 0.04\ \mathrm{m}^2$$

$$\therefore U \quad = 5 \times 0.04 = 0.20\ \mathrm{J} = 2 \times 10^{-1}\ \mathrm{J}$$

165 **(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 bubbles B and C.

Therefore, C starts collapsing with volume of A and B increasing.

166 **(d)**

hr = constant

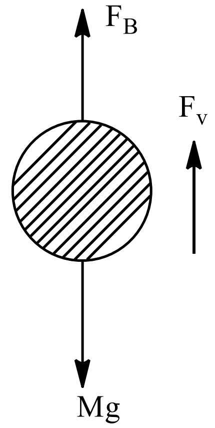
$\therefore$ rise of water in capillary of radius $\frac{r}{4}$ is 4h

Now, $\pi r^2 h\rho = m$

$$\therefore \pi\left(\frac{r}{4}\right)^2 \times 4h\rho = \frac{m}{4}$$

167 **(b)**

The motion of metal sphere is shown as



where, F_s = Buoyant force and F_v = viscous force.

At terminal velocity, the net force on the sphere is zero.

$$W = F_s + F_v$$

$$\Rightarrow Mg = d_2 V g + F_v$$

$$= d_2 \frac{M}{d_1} g + F_v$$

$$\therefore \quad F_v = Mg\left(1 - \frac{d_2}{d_1}\right)$$

168 **(b)**

Given, $r = 0.3\ \mathrm{mm} = 0.3 \times 10^{-2}\ \mathrm{m}, v = 1\ \mathrm{ms}^{-1}$

$\eta = 18 \times 10^{-5}$ poise $= 18 \times 10^{-6}$ decapoise

Viscous force, $F = 6\pi\,\eta\,rv$

$$= 6 \times \frac{22}{7} \times (18 \times 10^{-6}) \times (0.3 \times 10^{-3}) \times 1$$

$$= 1.018 \times 10^{-7}\ \mathrm{N}$$

169 **(b)**

Excess pressure in a soap bubble is given by

$$P = \frac{4T}{R}$$

Hence if radius is increased, the pressure will decrease.

170 **(c)**

The output of OR gate is '1' if either or both inputs are '1'.

171 **(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.

172 **(c)**

Let R be the radius of the bigger drop and r that of smaller drops.

$$r = \frac{R}{(27)^{\frac{1}{3}}} = \frac{R}{3}$$

Initial energy

$E_1 = 4\pi R^2\sigma = 4\pi \frac{D^2}{4}\sigma = \pi D^2\sigma$

Final energy

$E_2 = 27 \times 4\pi R^2\sigma$

$= 27 \times 4\pi \times \left(\frac{R}{3}\right)^2 \times \sigma$

$= 27 \times 4\pi \times \frac{R^2}{9} \times \sigma$

$= 12\pi R^2\sigma = 12\pi \frac{D^2}{4}\sigma = 3\pi D^2\sigma$

$\therefore E_2 - E_1 = 3\pi D^2\sigma - \pi D^2\sigma = 2\pi D^2\sigma$

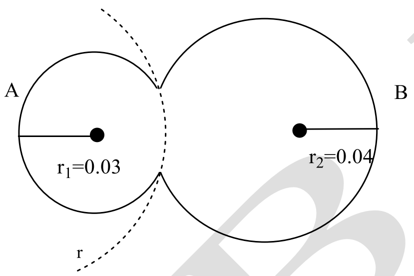
173 **(c)**

Let the radius of curvature of the common internal film surface of the double bubble formed by two bubbles A and B be r.

Excess pressure as compared to atmosphere inside A is

$p_1 = \frac{4S}{r_1} = \frac{4S}{0.03}$

Excess pressure inside B is $p_2 = \frac{4S}{r_2} = \frac{4S}{0.04}$



174 **(b)**

Length of four sides = 4L

$\therefore$ Force due to surface tension

$= 4L \times 2T = 8LT$

175 **(b)**

We have

$W = F + U$

Where W = weight of ball, F = Viscous force and U = up thrust

$\therefore F = W - U = Mg - U$

$= V\rho g - V\sigma g$

Where V = volume

$= Vg(\rho - \sigma)$

176 **(c)**

The work done in blowing a soap bubble,

$W = T \times A$

where, T is the surface tension and A is the area of soap bubble.

$W = T \times 4\pi R^2$

$W \propto R^2$

so $\frac{W_1}{W_2} = \frac{R_1^2}{R_2^2}$

$\Rightarrow W_2 = W_1\left(\frac{2R}{R}\right)^2 = 4W$

177 **(c)**

According to question, the surface area of the liquid drop is given by $A = 4\pi R^2$ and surface energy is E, then

$E = A \cdot S$

When the drop splits into 512 droplets, the surface area becomes

$A_2 = 512 \times 4\pi r^2$ [r = radius of smaller drop]

r can be calculated by comparing the total volume of bigger and all smaller droplets.

i.e. $\frac{4}{3}\pi R^3 = 512 \times \frac{4}{3}\pi r^3$

$\Rightarrow r = \frac{R}{8}$

Hence, total area of smaller droplets is given by

$A_1 = 512 \times 4 \times \pi \times \left(\frac{R}{8}\right)^2 = 8 \times 4\pi R^2 = 8A$

$\therefore$ Final surface energy of the droplets $= A_1 \times S$

$= 8$ AS

$= 8$ E [from Eq. (i)]

178 **(c)**

Here, surface tension = S

Density of water = ρ

Radius of capillary tube = r

Height of capillary rise, $h = \frac{2S\cos\theta}{r\rho g}$

$h = \frac{2S}{r\rho g} \cdots$ (i)

$\left(\begin{matrix} \because & \theta = 0^\circ \\ \therefore & \cos 0^\circ = 1 \end{matrix}\right)$

Work done by surface tension,

W = area $\times$ surface tension

$= (2\pi rh)S$

$= 2\pi r \times \frac{2S}{r\rho g} \times S$ [from Eq. (i)]

$W = \frac{4\pi S^2}{\rho g}$

Rise in potential energy, $U = mg\frac{h}{2} = \rho Vg\frac{h}{2}$

[where, V = volume]

$= \rho(\pi r^2 \times h)g\frac{h}{2}$ $(\because V = \pi r^2 \times h)$

$= \frac{\rho g \pi r^2}{4} \times h^2$

$= \frac{\rho g \pi r^2}{2} \times \frac{4S^2}{r^2 p^2 g^2}$ [from Eq. (i)]

$= \frac{2\pi S^2}{\rho g}$

$\therefore$ Work done = rise in potential energy + heat l

$\Rightarrow W = U + H$

$\Rightarrow H = W - U = \frac{4\pi S^2}{\rho g} - \frac{2\pi S^2}{\rho g} = \frac{2\pi S^2}{\rho g}$

180 **(d)**

$4\pi R^2 T = W$

$4\pi(2R)^2 T = 4(4\pi R^2 T) = 4W$

181 **(b)**

If r is the radius of the smaller drop and R is of bigger drop then

$r = \frac{R}{(27)^{\frac{1}{3}}} = \frac{R}{3}$

Excess pressure $P = \frac{2T}{r}$

$\therefore \frac{P_2}{P_1} = \frac{r_1}{r_2} = \frac{1}{3}$

$\therefore P_2 = \frac{P_1}{3} = \frac{9}{3} = 3$ units

182 **(b)**

Volume $= \frac{4}{3}\pi r^3 n = \frac{4}{3}\pi R^3$

$\therefore R = n^{\frac{1}{3}} r$

$\therefore \frac{R}{r} = n^{\frac{1}{3}}$

Terminal velocity $v \propto r^2$

$\frac{v_2}{v_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{R}{r}\right)^2 = n^{\frac{2}{3}}$

$\therefore v_2 = n^{\frac{2}{3}} v_1 = 5n^{\frac{2}{3}}$ m/s

183 **(a)**

$h = \frac{2T\cos\theta}{r\rho g} \approx \frac{2T}{rg}$

$h_1 = \frac{2T}{r_1 g}$

$h_2 = \frac{2T}{r_2 g}$

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

$\therefore T = \frac{hgr_1 r_2}{2(r_2 - r_1)}$

185 **(c)**

Terminal velocity for the 1st sphere

$V = \frac{\frac{2}{9}Rg(\rho_1 - \sigma)}{\eta}$

$\therefore V \propto (\rho_1 - \sigma)$

$\therefore \frac{V_1}{V_2} = \frac{\rho_1 - \sigma}{\rho_2 - \sigma}$

$\therefore V_2 = \left(\frac{\rho_2 - \sigma}{\rho_1 - \sigma}\right)V$

186 **(b)**

Energy released = S × change in surface area

Let n be the number of drops of radius r that coalesce to form single drop of radius A.

So, energy released = S × (increase in surface area)

Change in surface area $= 4\pi(nr^2 - R^2)$ ...(i)

$\therefore \quad n\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$

$\Rightarrow nr^3 = R^3$

or $nr^2 = \left(\frac{R^2}{r}\right)$ ...(ii)

On putting value of Eq. (ii) in Eq. (i), we get

Change in surface area $= 4\pi R^3\left(\frac{1}{r} - \frac{1}{R}\right)$

Energy released = S × change in surface area

$= S \times 4\pi R^3\left(\frac{1}{r} - \frac{1}{R}\right)$

$= 3S \times \frac{4}{3}\pi R^3\left(\frac{1}{r} - \frac{1}{R}\right) = 3VS\left(\frac{1}{r} - \frac{1}{R}\right)$

187 **(c)**

Let r be the radius of the each drop. The terminal velocity of drop will be given by

$v = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$ ...(i)

where, ρ is density of drop and σ is density of viscous medium of coefficient of viscosity η.

When two drop each of radius r coalesce to form a new drop, then the radius of coalesced drop will be

$R = (2)^{1/3}r$

Hence, new terminal velocity of coalesced drop will be

$$v' = \frac{2}{9}\left[\frac{(2^{1/3}r)^2(\rho-\sigma)g}{\eta}\right] \quad ...(ii)$$

From Eqs. (i) and (ii), we get

$$\frac{v'}{v} = (2)^{2/3} \text{ or } v' = (2)^{2/3}v$$

188 **(b)**

$U_1 = 1000 \times 4\pi r_1^2 \times T$

$$\frac{r_2}{r_1} = (1000)^{\frac{1}{3}} = 10$$

$U_2 = 4\pi r_2^2 T$

$$\frac{U_2}{U_1} = \frac{4\pi r_2^2 T}{1000 \times 4\pi r_1^2 \times T} = \frac{100}{1000} = \frac{1}{10}$$

189 **(d)**

$h \propto \frac{1}{r}$

$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2} = 4$

$\therefore h_2 = 4h_1$

Mass of water is proportional to its volume.

$$\therefore \frac{m_2}{m_1} = \frac{V_2}{V_1} = \frac{\pi r_2^2 h_2}{\pi r_1^2 h_1} = \frac{r_2^2}{r_1^2} . \frac{h_2}{h_1} = \left(\frac{1}{4}\right)^2 \times 4 = \frac{1}{4}$$

$$\therefore m_2 = \frac{m_1}{4} = \frac{m}{4}$$

190 **(a)**

Radius of the larger drop

$R = (8)^{\frac{1}{3}}r = 2r$

Terminal velocity $V \propto r^2$

$$\frac{V_2}{V_1} = \left(\frac{2r}{r}\right)^2 = 4$$

$V_2 = 4V_1 = 4V$

191 **(c)**

Volume of big drop = Volume of 8 small droplets

$$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3 \Rightarrow r = \frac{R}{2}$$

Work done $= S \times (4\pi r^2 \times 8 - 4\pi R^2)$

$$= S \times 4\pi\left(\frac{R^2}{4} \times 8 - R^2\right) = 4\pi R^2 S$$

192 **(b)**

Surface tension is the force applied per unit length or work done (or energy) per unit area of a liquid surface. While surface energy is the amount of work done per unit area by the force.

193 **(d)**

Water will fill in the tube entirely because in freely falling elevator, gravitational acceleration is zero. i.e. 20 cm.

195 **(a)**

$x = 1$ cm

$\therefore$ Volume of the cube $v = x^3 = 1\ cm^3$,

Volume of drop = volume of cube

$$\frac{4}{3}\pi r^3 = x^3 = 1\ cm^3$$

$$\therefore r^3 = \frac{3}{4\pi} \text{ or } r = \left(\frac{3}{4\pi}\right)^{\frac{1}{3}}$$

$$\therefore r^2 = \left(\frac{9}{16\pi r^2}\right)^{\frac{1}{3}}$$

$$= \left(64\ \pi^3 \times \frac{9}{16\pi^2}\right)^{\frac{1}{3}}$$

$$= (36\pi)^{1/3}$$

196 **(b)**

Terminal velocity is given by

$$V = \frac{2r^2(\rho-\sigma)g}{9\eta}$$

V is same

$$\therefore r_A^2(\rho_A - \sigma) = r_B^2(\rho_B - \sigma)$$

$$\therefore \frac{r_A}{r_B} = \sqrt{\frac{\delta_A - \sigma}{\delta_B - \sigma}}$$

197 **(d)**

$$h = \frac{2T\cos\theta}{r\rho g}$$

$$h \propto \frac{1}{r}$$

198 **(a)**

If r is the radius of the smaller drops and R that of larger drop then $R = 2^{\frac{1}{3}}r$

The surface energy is proportional to the surface area.

Area of two small drops $A_1 = 2 \times 4\pi r^2$

Area of the bigger drop $A_2 = 4\pi R^2 = 4\pi\left[2^{\frac{1}{3}} r\right]^2$

$\therefore \frac{A_1}{A_2} = \frac{2}{2^{\frac{2}{3}}} = 2^{\frac{1}{3}}$

199 **(c)**

$T = 7 \times 10^{-2}\frac{N}{m} = 70\frac{\text{dyne}}{\text{cm}}$

$2\pi RT = 105$

$2\pi R = \frac{105}{70} = \frac{21}{14} = \frac{3}{2} = 1.5 \text{ cm}$

200 **(b)**

$F = \frac{2TA}{d} = \frac{2 \times 70 \times 10^{-3} \times 10^{-2}}{0.05 \times 10^{-3}} = 28 \text{ N}$