2. Mechanical Properties of Fluids

Important Formulae and Shortcut Methods

1. $T = \dfrac{F}{\ell} = \dfrac{W}{dA}$

2. Work done in blowing a soap bubble by increasing its radius from r_1 to r_2,
   $W = 8\pi T\left(r_2^2 - r_1^2\right)$

3. When n drops (each of radius r) coalesce into a single drop of radius R, or a single drop of radius R breaks into n drops (each of radius r),
   $R^3 = nr^3$
   Energy released/ absorbed $= 4\pi T\,(nr^2 - R^2) = 4\pi TR^2(n^{1/3} - 1)$

4. For a cavity (gas bubble inside a liquid), $p - p_0 = \dfrac{2T}{R}$

5. For a soap bubble, $p - p_0 = \dfrac{4T}{R}$

6. $h = \dfrac{2T\cos\theta}{\rho r g}$, $(h \gg r)$

7. The surface tension of most of the liquids decreases with temperature

8. The surface tension of molten copper or cadmium increases with temperature.

9. The surface tension of a liquid becomes zero at critical temperature.

10. $\dfrac{F}{A} = \eta\dfrac{dv}{dy}, \eta = \dfrac{\frac{F}{A}}{\frac{dv}{dy}}$

11. $|f| = 6\pi\eta r v_0$

12. $v_t = \dfrac{2}{9}\dfrac{r^2(\rho - \rho_L)g}{\eta}$

13. $N = \dfrac{v_c d\rho}{\eta}$

Multiple Choice Questions

MHT-CET 2004

1. 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°

MHT-CET 2005

2. For a liquid which is rising in a capillary, the angle of contact is
   (A) obtuse (B) 180° (C) acute (D) 90°

MHT-CET 2005

3. Work done in forming a liquid drop of radius R is W_1 and that of radius 3R is W_2. The ratio of work done is
(A) 1 : 3 (B) 1 : 2 (C) 1 : 4 (D) 1 : 9

MHT-CET 2008

4. 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

MHT-CET 2010

5. On the surface of the liquid in equilibrium, molecules of the liquid possess
(A) maximum potential energy (B) minimum potential energy
(C) maximum kinetic energy (D) minimum kinetic energy

6. With an increase in temperature, surface tension of liquid (except molten copper and cadmium)
(A) increases (B) remain same
(C) decreases (D) first decreases, then increases

MHT-CET 2011

7. The wettability of a surface by a liquid depends primarily on
(A) viscosity
(B) surface tension
(C) density
(D) angle of contact between the surface and the liquid

MHT-CET 2014

8. In air, a charged soap bubble of radius 'r' is in equilibrium having outside and inside pressures being equal. The charge on the drop is (ϵ_0 = permittivity of free space, T = surface tension of soap solution)
(A) $4\pi r^2\sqrt{\frac{2T\epsilon_0}{r}}$ (B) $4\pi r^2\sqrt{\frac{4T\epsilon_0}{r}}$ (C) $4\pi r^2\sqrt{\frac{6T\epsilon_0}{r}}$ (D) $4\pi r^2\sqrt{\frac{8T\epsilon_0}{r}}$

MHT-CET 2015

9. 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

10. 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
σ = density of liquid, T = surface tension of liquid
(A) $\left[\frac{6T}{\rho}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{\frac{1}{2}}$ (B) $\left[\frac{6T}{\rho}\left(\frac{1}{b}-\frac{1}{a}\right)\right]^{\frac{1}{2}}$ (C) $\left[\frac{\rho}{6T}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{\frac{1}{2}}$ (D) $\left[\frac{\rho}{6T}\left(\frac{1}{b}-\frac{1}{a}\right)\right]^{\frac{1}{2}}$

MHT-CET 2016

11. In a capillary tube of radius 'R', a straight thin metal wire of radius 'r' (R > r) is inserted symmetrically and one end of the combination is dipped vertically in water such that the lower end of the combination is at same level. The rise of water in the capillary tube is
T = surface tension of water, ρ = density of water, g = gravitational accel^n

(A) $\frac{T}{(R+r)\rho g}$ (B) $\frac{R\rho g}{2T}$ (C) $\frac{2T}{(R-r)\rho g}$ (D) $\frac{(R-r)\rho g}{T}$

12. 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

MHT-CET 2017

13. When one end of the capillary is dipped in water, the height of water column is 'h'. The upward force of 105 dyne due to surface tension is balanced by the force due to the weight of water column. The inner circumference of the capillary is
(Surface tension of water = 7×10^{-2} N/m)
(A) 1.5 cm (B) 2 cm (C) 2.5 cm (D) 3 cm

14. A big water drop is formed by the combination of 'n' small water drops of equal radii. The ratio of the surface energy of 'n' drops to the surface energy of big drop is
(A) $n^2 : 1$ (B) $n : 1$ (C) $\sqrt{n} : 1$ (D) $\sqrt[3]{n} : 1$

MHT-CET 2018

15. 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 (T = surface tension of water, g = gravitational acceleration)

(A) $\sqrt{\frac{T}{\pi\rho g}}$ (B) $\sqrt{\frac{\pi\rho g}{T}}$ (C) $\frac{T}{\pi\rho g}$ (D) $\frac{\pi\rho g}{T}$

16. 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

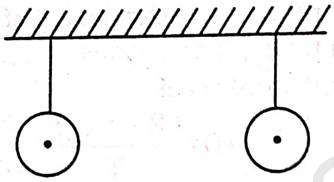
*17. A vessel completely filled with water has holes 'A' and 'B' at depths 'h' and '3h' from the top respectively. Hole 'A' is a square of side 'L' and 'B' is circle of radius 'r'. The water flowing out per second from both the holes is same. Then 'L' is equal to

(A) $r^{\frac{1}{2}}(\pi)^{\frac{1}{2}}(3)^{\frac{1}{2}}$ (B) $r\cdot(\pi)^{\frac{1}{4}}(3)^{\frac{1}{4}}$ (C) $r\cdot(\pi)^{\frac{1}{2}}(3)^{\frac{1}{4}}$ (D) $r^{\frac{1}{2}}\cdot(\pi)^{\frac{1}{3}}(3)^{\frac{1}{2}}$

MHT-CET 2019

18. A metal sphere of radius 'R' and density 'ρ_1' is dropped in a liquid of density 'σ' 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) $V(\rho_2 - \sigma)/(\rho_1 - \sigma)$ (B) $V(\rho_2 + \sigma)/(\rho_1 + \sigma)$
(C) $V(\rho_1 + \sigma)/(\rho_2 + \sigma)$ (D) $V(\rho_1 - \sigma)/(\rho_2 - \sigma)$

*19. 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 decrease, depending on speed of air
(B) increase
(C) decrease
(D) remain same

*20. 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) $\sqrt{2\pi}\cdot R$
(D) $2\pi R$

21. 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 $\eta_{water} = 10^{-3}$ 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

*22. In hydraulic press, the diameters of piston in smaller cylinder and larger cylinder are 'd_1' and 'd_2' respectively. If 'F_1' is the force applied on smaller piston, the force 'F_2' on the larger piston is
(A) $F_2 = \left(\frac{d_2}{d_1}\right)^2 \frac{1}{F_1}$
(B) $F_2 = \left(\frac{d_1}{d_2}\right)^2 F_1$
(C) $F_2 = \left(\frac{d_1}{d_2}\right)^2 \frac{1}{F_1}$
(D) $F_2 = \left(\frac{d_2}{d_1}\right)^2 F_1$

23. Eight identical drops of water falling through air with uniform velocity of 10 cm/s combine to form a single drop of big size, then terminal velocity of the big drop will be
(A) 30 cm/s
(B) 80 cm/s
(C) 10 cm/s
(D) 40 cm/s

24. Two small drops of mercury each of radius 'R' coalesce to form a large single drop. The ratio of the total surface energies before and after the change is
(A) $2^{1/3} : 1$
(B) $2^{2/3} : 1$
(C) $2 : 1$
(D) $\sqrt{2} : 1$

25. Two capillary tubes of different diameters are dipped in water. The rise of water is
(A) more in the tube of larger diameter
(B) zero in both the tubes
(C) same in both the tubes
(D) more in the tube of smaller diameter

26. 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

27. The excess of pressure, due to surface tension, on a spherical liquid drop of radius 'R' is proportional to
(A) R^2
(B) R^{-2}
(C) R
(D) R^{-1}

28. A molecule of water on the surface experiences a net
(A) downward resultant unbalanced adhesive force
(B) upward resultant unbalanced cohesive force
(C) upward resultant unbalanced adhesive force
(D) downward resultant unbalanced cohesive force

29. 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) H (B) 4 H (C) 7 H (D) 2 H

30. 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) $\frac{hg(r_2-r_1)}{2r_1r_2}$

31. A capillary tube is vertically immersed in water, water raises upto height 'h_1'. When the whole arrangement is taken 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) $\left(1+\frac{2d}{R}\right)$ (D) $\left(1+\frac{d}{R}\right)$

32. Two soap bubbles have radii in the ratio 4 :3. What is the ratio of work done to blow these bubbles?
(A) 3 : 2 (B) 4 : 3 (C) 8 : 3 (D) 16 : 9

33. 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

34. One end of towel dips in a bucket with full of water and other end hangs over the bucket. It is found that after sometime 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

35. SI unit of surface tension is
(A) N/m^2 (B) N/m^3 (C) N/m (D) kg/m

MHT-CET 2020

36. 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) 2 TL (B) 4 TL (C) 8 TL (D) 6 TL

*37. A large vessel completely filled with water has two holes 'A' and 'B' at the depths 'h' and 4 'h' 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) $\sqrt{2\pi}\,R$

38. Two small drops of mercury each of radius 'R' coalesce to form a large single drop. The ratio of the total surface energies before and after the change is

(A) 2 : 1 (B) $\sqrt{2}$: 1 (C) $2^{\frac{2}{3}}:1$ (D) $2^{\frac{1}{3}}:1$

39. 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) $\left[\frac{3T}{\rho}\left(\frac{1}{r}+\frac{1}{R}\right)\right]^{\frac{1}{2}}$

40. 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

41. A capillary tube is dipped into a liquid. If the levels of liquid inside and outside the tube are same, then the angle of contact is

(A) 0° (B) 60° (C) 45° (D) 90°

***42.** A force of 50N is applied to the smaller piston of a hydraulic press. If the diameters of the piston are in the ratio 5 : 1, the force on the larger piston is

(A) 250 N (B) 1000 N (C) 1250 N (D) 100 N

43. When 'n' number of liquid droplets each of radius 'r' are merged to from a single drop of radius 'R', the energy loss is '4E'. where E is the energy of the bigger drop. Then, the number of droplets 'n' is

(A) $\frac{5R}{r}$ (B) $\frac{5R}{r^2}$ (C) $\frac{4R^2}{r^2}$ (D) $\frac{5R^2}{r^2}$

44. 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) $\left(1-\frac{d^2}{R^2}\right)$

45. Which one of following statements about the angle of contact (θ), is wrong ?

(A) θ > 0° for pure water - glass pair.
(B) θ is not constant for particular solid - liquid pair.
(C) θ < 90° for kerosene - glass pair.
(D) θ > 90° for mercury - glass pair.

46. A metal coin of thickness 'd' and density 'ρ' is floating on water of surface tension 'T'. The radius of the coin is g = acceleration due to gravity

(A) $\frac{4T}{3\rho g d}$ (B) $\frac{3T}{4\rho g d}$ (C) $\frac{2T}{\rho g d}$ (D) $\frac{T}{\rho g d}$

47. 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) $8\pi R^3 T\left(1-\frac{r}{R}\right)$ (B) $8\pi R^3 T\left(1+\frac{r}{R}\right)$ (C) $4\pi R^3 T\left(\frac{1}{r}+\frac{1}{R}\right)$ (D) $4\pi R^3 T\left(\frac{1}{r}-\frac{1}{R}\right)$

48. The upward fore 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

49. 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

50. 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) $\pi(D^2 - d^2)T$

51. The work done in splitting a water drop of radius R into 64 droplets is (T = surface tension of water)

(A) $6\pi T R^2$ (B) $4 \pi T R^2$ (C) $12 \pi T R^2$ (D) $8 \pi T R^2$

52. 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) 4 TL (B) 8 TL (C) 2 TL (D) 6 TL

53. 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) $V(\rho_1 + \sigma)/(\rho_2 + \sigma)$

54. 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.

55. 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

56. 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

57. 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) $mg\left(1-\frac{\sigma_2}{\sigma_1}\right)$

58. Water rises to height 2.2 cm in glass capillary tube. The height to which same water rises in another capillary having $\frac{1}{4}^{th}$ area of cross-section is

(A) 4.4 cm (B) 2.2 cm (C) 16.4 cm (D) 8.4 cm

59. In a sphere of influence, the liquid molecule at its centre is
(A) repelled by other molecules in the sphere of influence
(B) repelled by other molecules lying outside the sphere of influence
(C) attracted by other molecules lying outside the sphere of influence
(D) attracted by other molecules in the sphere of influence.

60. 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) $R=\left(R_1^3+R_2^3\right)^{\frac{1}{3}}$ (B) 2 TL (C) 8 TL (D) 12 TL

61. 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

62. Two small drops of mercury each of radius 'R' coalesce to form a large single drop. The ratio of the total surface energies before and after the change is

(A) $\sqrt{2}:1$ (B) $2^{\frac{2}{3}}:1$ (C) $2^{\frac{1}{3}}:1$ (D) 2 : 1

63. 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) $\frac{m}{4}$

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

(A) $Mg\left(\frac{d_2}{d_1}\right)$ (B) $Mg\left(1-\frac{d_2}{d_1}\right)$ (C) $Mg\left(\frac{d_1}{d_2}\right)$ (D) $Mg\left(1-\frac{d_1}{d_2}\right)$

65. When a capillary tube is immersed in water vertically, water rises to a height 'h' inside the tube. If the radius of another capillary tube is 1/3rd that of the previous, the height to which water will rise in this tube, is

(A) $h\sqrt{3}$ (B) $\frac{h}{3}$ (C) 3h (D) h

66. 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) $4\pi TD^2$

67. A metal sphere of radius 'R', density 'ρ_1' moves with terminal velocity 'v_1' through a liquid of density 'σ'. Another sphere of same radius but of density 'ρ_2' moves through same liquid. Its terminal velocity will be
(A) $\left[\frac{\rho_2+\sigma}{\rho_1+\sigma}\right]v_1$ (B) $\left[\frac{\rho_1+\rho_2}{\sigma}\right]v_1$ (C) $\left[\frac{\rho_1-\rho_2}{\sigma}\right]v_1$ (D) $\left[\frac{\rho_2-\sigma}{\rho_1-\sigma}\right]v_1$

68. 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

69. 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.

70. 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) $P\left(R^3-r_1^3-r_2^3\right)/4\left(r_1^2+r_2^2-R^2\right)$ (B) $P\left(r_1^3-R^3+r_2^3\right)/4\left(R^2-r_1^2-r_2^2\right)$
(C) $P\left(R^3+r_1^3+r_2^3\right)/4\left(r_1^2+r_2^2-R^2\right)$ (D) $P\left(r_1^3-r_2^3+R^3\right)/4\left(r_1^2+r_2^2+R^2\right)$

*71. A spray pipe has a cylindrical tube of radius 'R'. It has 'n' small holes of radius 'r' at one end. The liquid flows through the tube with velocity 'V'. The velocity of the liquid through the holes is
(A) $\frac{VR^2}{nr^2}$ (B) $\frac{Vr^2}{nR^2}$ (C) $\frac{Vr}{nR}$ (D) $\frac{VR}{nr}$

72. 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) $W_2 = 4W_1$

73. 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

74. Two capillary tubes of same diameter are immersed vertically in two liquids of surface tension 60 dyne cm^{-1} and 50 dyne cm^{-1} respectively. The rise of liquid in the capillaries is 'h_1' and 'h_2' respectively. If the densities of liquid are 0.8 g/cm^3 and 0.6 g/cm^3 respectively, then $\frac{h_1}{h_2}$ is
(Neglect the angle of contact)
(A) $\frac{10}{3}$ (B) $\frac{10}{9}$ (C) $\frac{9}{10}$ (D) $\frac{3}{10}$

75. 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) $\sqrt{\frac{\delta_B-\sigma}{\delta_A-\sigma}}$ (C) $\frac{\delta_B-\sigma}{\delta_A-\sigma}$ (D) $\frac{\delta_A-\sigma}{\delta_B-\sigma}$

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

(A) $r=\frac{R}{3}$ (B) $r=\frac{R}{9}$ (C) $r=\frac{R}{27}$ (D) $r = 3R$

77. A soap bubble of radius 'R' is blown. After heating the solution, a second bubble of radius '2R' is blown. The work required to blow the second bubble in comparison to that required for the first bubble is

(A) slightly more than 4 times (B) slightly less than 4 times
(C) slightly less than double (D) double

***79.** Pascal's law is not applied in

(A) an atomizer. (B) a hydraulic jack
(C) a hydraulic press (D) hydraulic breaks.

80. 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

81. Water rises in a capillary tube to a certain height such that the upward force due to surface tension is balanced by 63×10^{-4} N force due to the weight of the water. The surface tension of water is 7×10^{-2} N/m. The inner diameter of the capillary tube is nearly ($\pi = 22/7$)

(A) 7×10^{-2} m (B) 9×10^{-2} m (C) 6.3×10^{-1} m (D) 3×10^{-2} m

82. 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) $W_2 = W_1$

83. 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

84. If detergent is dissolved in water, the surface tension of water

(A) decreases. (B) becomes zero. (C) remains constant. (D) increases.

85. 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 $\cos 0° = 1$

(A) $\sin^{-1}(0.5)$ (B) $\cos^{-1}(0.5)$ (C) $\cos^{-1}(0.7)$ (D) $\sin^{-1}(0.7)$

86. 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) $R = (R_1^3 - R_2^3)^{1/3}$

*87. 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

88. Under isothermal conditions, two soap bubbles of radii 'r_1' and 'r_2' coalesce to form a big drop. The radius of the big drop is
(A) $(r_1 - r_2)^{\frac{1}{2}}$
(B) $(r_1 + r_2)^{\frac{1}{2}}$
(C) $(r_1^2 + r_2^2)^{\frac{1}{2}}$
(D) $(r_1^2 - r_2^2)^{\frac{1}{2}}$

89. 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) $r = R n^{\frac{1}{3}}$
(C) $r = \frac{R}{n}$
(D) $r = \frac{R}{n^{\frac{1}{3}}}$

*90. 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) $\frac{4h}{R^2}$

91. Two small drops of mercury each of radius 'R' coalesce to form a large single drop. The ratio of the total surface energies before and after the change is
(A) $2^{2/3} : 1$
(B) $2^{1/3} : 1$
(C) $2 : 1$
(D) $\sqrt{2} : 1$

92. 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

93. Two rain drops falling through air have radii in the ratio 1 : 2. They will have terminal velocity in the ratio
(A) 1 : 4
(B) 2 : 1
(C) 4 : 1
(D) 1 : 2

94. Two small drops of liquid of same radius coalesce to form a big drop. The ratio of the total surface energies after and before the change is
(A) $2^{-\frac{2}{3}} : 1$
(B) $2^{\frac{2}{3}} : 1$
(C) $2^{\frac{1}{3}} : 1$
(D) $2^{-\frac{1}{3}} : 1$

95. The excess pressure inside a spherical drop of water is three times that of another drop of water. The ratio of their surface area is
(A) 3 : 1
(B) 6 : 1
(C) 1 : 3
(D) 1 : 9

*96. 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

97. 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

98. 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) $5\sqrt{2}\times10^{-3}$m (B) $20\sqrt{3}\times10^{-3}$m (C) $10\sqrt{3}\times10^{-3}$m (D) $15\sqrt{3}\times10^{-3}$m

*99. 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) $d\sqrt{\frac{v_1}{v}}$

100. 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) $R=\left(R_1^3+R_2^3\right)^{\frac{1}{3}}$

101. 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) $\left(1+\frac{2d}{R}\right)$

*102. 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) $\sqrt{2\pi}\cdot R$ (C) $\frac{R}{2}$ (D) $\sqrt{2\pi R}$

103. 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

104. The excess pressure inside the first soap bubble of radius 'R_1' is two times, that inside the second soap bubble of radius 'R_2'. The ratio of volumes of the first bubble to that of second bubble is
(A) 1 : 2 (B) 1 : 8 (C) 1 : 1 (D) 1 : 4

105. 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

106.If the surface tension of a soap solution is 3×10^{-2} N/m, then the work done in forming a soap film of 20 cm × 5 cm will be
(A) 6×10^{-3} J (B) 6J (C) 6×10^{-4} J (D) 6×10^{-2} J

107.Two spherical rain drops reach the surface of the earth with terminal velocities having ratio 16 : 9. The ratio of their surface area is
(A) 4 : 3 (B) 16 : 9 (C) 64 : 27 (D) 9 : 16

108.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 1 mm without breaking the water film. The work done for this is
(surface tension of water $= 7.2 \times 10^{-2}\ \text{Nm}^{-1}$)
(A) 1.44×10^{-5} J (B) 5.76×10^{-5} J (C) 7.22×10^{-6} J (D) 2.88×10^{-5} J

109.Soap solution is used for cleaning dirty clothes because
(A) temperature of solution is decreased (B) surface tension of solution in increased
(C) surface tension of solution is decreased (D) viscosity of solution is increased

*110.A closed pipe containing liquid showed a pressure 'P_1' by gauge. When the valve is opened, pressure was reduced to 'P_2'. The speed of water flowing out of the pipe is ρ = density of water

(A) $\left[\dfrac{2(P_1+P_2)}{\rho}\right]^{\frac{1}{2}}$ (B) $\left[\dfrac{2(P_1-P_2)}{\rho}\right]^{\frac{1}{2}}$ (C) $\left[\dfrac{\rho}{2(P_1-P_2)}\right]^{\frac{1}{2}}$ (D) $\left[\dfrac{\rho}{2(P_1+P_2)}\right]^{\frac{1}{2}}$

*111.A large open tank containing water has two holes to its wall. A square hole of side 'a' is made at a depth 'y' and a circular hole of radius 'r' is made at a depth '16y' from the surface of water. If equal amount of water comes out through both the holes per second, then the relation between 'r' and 'a' will be

(A) $r = \dfrac{a}{2\sqrt{\pi}}$ (B) $r = \dfrac{a}{2\pi}$ (C) $r = \dfrac{2a}{\pi}$ (D) $r = \dfrac{2a}{\sqrt{\pi}}$

SOLUTIONS

1. (C)
When the surface of the liquid is plane, the angle of contact of the liquid with the wall is 90°.

2. (C)
The angle of contact is acute (less than 90°).

3. (D)
Surface energy (tension) is amount of work done.

$$W = S \times 4\pi R^2$$

$$\Rightarrow \quad \frac{W_1}{W_2} = \frac{S \times 4\pi R^2}{S \times 4\pi (3R)^2} = \frac{S \times 4\pi R^2}{S \times 36\pi R^2} = \frac{1}{9} \quad \therefore \quad W_1 : W_2 = 1 : 9$$

4. (D)
T The potential energy of the molecules lying in the surface is greater than that of the molecules in the interior of the liquid.

5. (A)
On the surface of the liquid in equilibrium, molecules of the liquid possess maximum potential energy.

6. (C)
The surface tension of liquid decreases with rise of temperature. The surface tension of liquid is zero at its boiling point and it vanishes at critical temperature.

7. (D)
The value of angle of contact determines whether a liquid will spread on the surface.

8. (D)

Force per unit area due to charge $= \dfrac{\sigma^2}{2\epsilon_0}$

Excess pressure due to surface tension $= \dfrac{4T}{r}$

$$\therefore \frac{\sigma^2}{2\epsilon_0} = \frac{4T}{r}$$

$$\therefore \sigma^2 = \frac{8\epsilon_0 T}{r} \qquad \therefore \sigma = \sqrt{\frac{8\epsilon_0 T}{r}}$$

$$\frac{q}{4\pi r^2} = \sqrt{\frac{8\epsilon_0 T}{r}} \qquad \therefore q = 4\pi r^2 \sqrt{\frac{8\epsilon_0 T}{r}}$$

9. (C)

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

$$\therefore \frac{h_2}{h_1} = \frac{r_1}{r_2} = \frac{1}{0.9}$$

$$\therefore h_2 = \frac{h_1}{0.9} = \frac{1.8}{0.9} = 2 \text{ cm}$$

10. (A)
Let n be the number of drops.

$$\Delta W = 4\pi a^2 nT - 4\pi b^2 T$$

$$\therefore \frac{1}{2}mv^2 = 4\pi a^2 nT - 4\pi b^2 T$$

$$\therefore v^2 = \frac{8\pi a^2 nT}{m} - \frac{8\pi b^2 T}{m}$$

But $m = \dfrac{4}{3}\pi a^3 . n . \rho$, also $m = \dfrac{4}{3}\pi b^3 \rho$

Putting these values of m in the first and second terms of the above equation, we get

$$v^2 = \frac{8\pi a^2 nT}{\frac{4}{3}\pi a^3 n\rho} - \frac{8\pi b^2 T}{\frac{4}{3}\pi b^3 \rho} = \frac{6T}{a\rho} - \frac{6T}{b\rho}$$

$$\therefore v = \left[\frac{6T}{\rho}\left(\frac{1}{a} - \frac{1}{b}\right)\right]^{\frac{1}{2}}$$

11. (C)

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

For $\cos\theta = 1$, $h = \dfrac{2T}{\rho g(R-r)}$

12. (C)

The surface area of the liquid drop is $A_1 = 4\pi R^2$

Its surface energy is E

When the drop splits in 512 droplets, the surface area of droplets is $A_2 = 512 \times 4\pi r^2$

The volume of bigger drop is $\frac{4}{3}\pi R^3$ and Volume of small droplets is $512\times\frac{4}{3}\pi r^3$

$$\therefore \frac{4}{3}\pi R^3 = 512 \times \frac{4}{3}\pi r^3 \Rightarrow r = \frac{R}{8}$$

$$\therefore A_2 = 512 \times 4\pi r^2 = 512 \times 4\pi\left(\frac{R}{8}\right)^2 = 8A_1$$

Surface energy E = A.T (T is surface tension and A is area)

$$\therefore \frac{E_2}{E_1} = \frac{A_2 \cdot T}{A_1 \cdot T} = \frac{8 \cdot A_1}{A_1} = 8$$

$$\therefore E_n = 8E$$

13. (A)

$F = 105 \text{ dyne} = 105 \times 10^{-5} \text{ N}, T = 7 \times 10^{-2} \text{ N/m}$

$2\pi r T = F$

$$2\pi r = \frac{F}{T} = \frac{105\times10^{-5}}{7\times10^{-2}} = 15 \times 10^{-3} \text{ m} = 1.5 \times 10^{-2} \text{ m} = 1.5 \text{ cm}$$

14. (D)

Volume of big drop = n(Volume of small drop)

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

$$R^3 = nr^3$$

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

E_2 = Surface energy of n drops = $n\times4\pi r^2\times T$

E_1 = Surface energy of big drop = $4\pi R^2 T$

$$\therefore \frac{E_2}{E_1} = \frac{nr^2}{R^2} = \frac{nr^2}{(n^{\frac{1}{3}}\cdot r)^2} = \frac{nr^2}{n^{\frac{2}{3}}\cdot r^2} = n^{\frac{1}{3}} = \sqrt[3]{n} : 1$$

15. (A)

$\pi r^2\cdot L\cdot\rho\cdot g = LT$ L – length of the wire

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

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

16. (B)

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

$h \propto \frac{1}{r}$ $A = \pi r^2$

$h_1 r_1 = h_2 r_2 \qquad \sqrt{A} \propto r$

$$\frac{h_1}{h_2} = \frac{r_2}{r_1} = \sqrt{\frac{A_2}{A_1}} = \sqrt{\frac{A/9}{A}} = \frac{1}{3}$$

17. (C)

Velocity of efflux for A : $\upsilon_A = \sqrt{2gh}$

Velocity of efflux for B : $\upsilon_B = \sqrt{2g \times 3h} = \sqrt{6gh}$

Water flowing out from A = Water flowing out from B

$\upsilon_A \times (\text{Area of A}) = \upsilon_B (\text{Area of B})$

$\sqrt{2gh} \times L^2 = \sqrt{6gh} \times \pi r^2$

$$\therefore \quad L^2 = \frac{\sqrt{6gh}}{\sqrt{2gh}} \cdot \pi r^2 = \sqrt{3}\pi r^2$$

$$L = 3^{\frac{1}{4}} \cdot \pi^{\frac{1}{2}} \cdot r = r \cdot (\pi)^{\frac{1}{2}} \cdot (3)^{\frac{1}{4}}$$

18. (A)

$$V_1 = \frac{2}{9} \frac{(\rho_1 - \sigma) R^2 g}{\eta}$$

$$\therefore \quad \frac{V_1}{\rho_1 - \sigma} = \frac{2}{9} \frac{R^2 g}{\eta}$$

$$V_2 = \frac{2}{9} \frac{(\rho_2 - \sigma) R^2 g}{\eta} = \frac{\rho_2 - \sigma}{\rho_1 - \sigma} \cdot V_1$$

19. (C)

20. (C)

$L^2 V_1 = \pi R^2 V_2$

$\therefore \quad V_1 = \sqrt{2gh} \quad \Rightarrow V_2 = \sqrt{8gh}$

$L^2 \sqrt{2gh} = \pi R^2 \sqrt{8gh} \quad \Rightarrow L = \sqrt{2\pi}\, R$

21. (C)

$$\text{Reynold's no.} = \frac{V_c \rho D}{\eta} = \frac{10 \times 10^{-2} \times 10^3 \times 2 \times 0.5 \times 10^{-2}}{10^{-3}} = 1000$$

$1000 << 2000 \quad \therefore$ streamlined motion.

22. (D)

$$\frac{F_1}{\pi d_1^2} = \frac{F_2}{\pi d_2^2} \quad \Rightarrow \quad F_2 = F_1 \left(\frac{d_2}{d_1}\right)^2$$

23. (D)

$v \propto r^2$

$$8 \times \frac{4}{3} \pi r_1^3 = \frac{4}{3} \pi r_2^3$$

$$\frac{v_1}{v_2} = \frac{r_1^2}{r_2^2} \qquad \therefore 2r_1 = r_2$$

$$\therefore \frac{\frac{10}{100}}{V^2} = \frac{r_1^2}{r_2^2} = \frac{1}{4}$$

$\therefore$ $v_2 = 0.4 \text{ m/s} = 40 \text{ cm/s}$

24. (A)

$$E_1 = 2\times 4\pi R_1^2 T$$

$$E_2 = 4\pi R_2^2 T$$

$$\frac{E_1}{E_2} = \frac{2R_1^2}{R_2^2}$$

$$2\times\frac{4}{3}\pi R_1^3 = \frac{4}{3}\pi R_2^3$$

$$\therefore \frac{2R_1^2}{R_2^2} = 2\left(\frac{1}{2^{1/3}}\right)^2 = \frac{2\times 1}{2^{2/3}} = \frac{2^{1-\frac{2}{3}}}{1} = \frac{2^{1/3}}{1}$$

25. (D)

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

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

26. (C)

27. (D)

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

28. (D)

29. (C)

$P_1V_1 = P_2V_2$ $\qquad$ $V \propto r^3$

$$\therefore \frac{V_2}{V_1} = \left(\frac{2r}{r}\right)^3$$

$V_2 = 8V_1$

$P_2 = P_1/8$

$$P_{atm} = \frac{P_{atm} + \rho gh}{8}$$

$\therefore$ $8P_{atm} = P_{atm} + \rho gh$

$7P_{atm} = \rho gh \quad \Rightarrow h = 7H$

30. (A)

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

$$h_1 = \frac{2T}{r_1 g} \qquad h_2 = \frac{2T}{r_2 g}$$

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

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

31. (B)

$hg = \text{constant} \qquad h \propto \frac{1}{g}$

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

32. (D)

$dW = T dA$

$$\frac{W_1}{W_2} = \frac{r_1^2}{r_2^2} = \frac{16}{9}$$

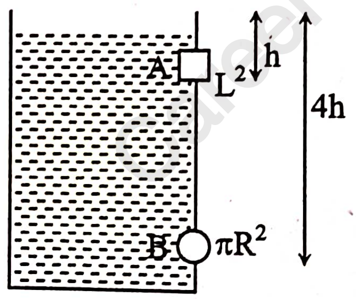
33. (D) **34.** (B) **35.** (C)

36. (C)

Total length = 4L

$\therefore$ Surface tension = $2T \times 4L = 8TL$

37. (D)



$v_1 = \sqrt{2gh}$

$v_2 = \sqrt{2g4h}$

$\therefore \quad A_1 v_1 = A_2 v_2$

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

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

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

38. (D)

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

$R' = 2^{1/3} R$

Total surface energy before $= 2 \times 4\pi R^2 T$ (T = surface tension)

Total surface energy after $= 4\pi R'^2 T$

$$\therefore \quad \text{Ratio} = \frac{2 \times R^2}{R'^2} = \frac{2 \times R^2}{2^{2/3} R^2} = \frac{2}{2^{2/3}} = 2^{1-\frac{2}{3}} = 2^{1/3}$$

$\therefore$ Ratio $= 2^{1/3} : 1$

39. (C)

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

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

$$\Delta A = 4\pi(nr^2 - R^2) = 4\pi\left(\frac{R^3}{r^3}\cdot r^2 - R^2\right) = 4\pi R^3\left[\frac{1}{r}-\frac{1}{R}\right]$$

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

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

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

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

40. (D)

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

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

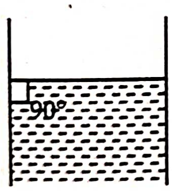
$$P = \frac{4T}{r} \qquad P_1 = \frac{4T}{r_1}$$

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

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

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

41. (D)



42. (C)

F = 50 N

$$\frac{D_s}{D_\ell} = \frac{1}{5} \quad \therefore \frac{\text{area (small)}}{\text{area (large)}} = \frac{1}{25}$$

$\therefore$ Pressure (small) = Pressure (large)

$$\frac{50}{1} = \frac{\text{force}}{25}$$

$\therefore$ Force on large piston = 50 × 25 = 1250 N

43. (D)

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

$$4E = 4\pi\left(r^2 n - R^3\right)T \qquad E = 4\pi R^2 T$$

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

$$4R^2+R^2=r^2n$$

$$n=\frac{5R^2}{r^2}$$

44. (A)

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

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

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

45. (B)

46. (C)

Let the radius of the coin be r

$\therefore\ m=\pi r^2\,d\,\rho$

Downward weight $mg=\pi r^2\,d\rho g$

Upward force due to tension $=2\pi rT$

$$\therefore\ \pi r^2d\rho g=2\pi rT$$

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

47. (D)

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

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

$$\begin{aligned}W&=\Delta AT\\&=4\pi T\left[nr^2-R^2\right]\\&=4\pi T\left[\frac{R^3}{r^3}\cdot r^2-R^2\right]\\&=4\pi R^3T\left[\frac{R}{r}-1\right]=4\pi R^3T\left[\frac{1}{r}-\frac{1}{R}\right]\end{aligned}$$

48. (C)

$T=7\times10^{-2}\,N/m=70$ dyne/cm

$2\pi RT=105$

$$2\pi R=\frac{105}{70}=\frac{21}{14}=\frac{3}{2}=1.5\text{ cm}$$

49. (A)

$$h=\frac{2T}{\rho gR}$$

$$h=h_1-h_2=\frac{2T}{\rho g}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)=\frac{2\times7\times10^{-2}}{10^3\times10}\left(\frac{2}{5}-1\right)=8.4\text{ mm}$$

50. (B)

$$W = \frac{4\pi T}{4}\left(D^2 - d^2\right)\times 2 = 2\pi\left(D^2 - d^2\right)T$$

51. (C)

$$\frac{4}{3}\pi R^3 = 64\times\frac{4}{3}\pi r^3$$

$$\therefore\ R = \sqrt[3]{64}\ r = 4r \qquad \therefore\ \frac{R}{r} = 4$$

$$\therefore\ W = \left(4\pi nr^2 - 4\pi R^2\right)T \ = 4\pi T\left(n\frac{r^2}{R^2} - 1\right)R^2$$

$$= 4\pi T\left(64\frac{1}{16} - 1\right)R^2 \ = 12\pi\ TR^2$$

52. (B)

Length of four sides = 4L

$\therefore$ Force due to surface tension = 4L $\times$ 2T = 8LT

53. (C)

Terminal velocity for the 1st sphere

$$V = \frac{\frac{2}{9}Rg(\rho_1 - \sigma)}{\eta}$$

$$\therefore\ V \propto (\rho_1 - \sigma)$$

$$\therefore\ \frac{V_1}{V_2} = \frac{\rho_1 - \sigma}{\rho_2 - \sigma}$$

$$\therefore\ V_2 = \left(\frac{\rho_2 - \sigma}{\rho_1 - \sigma}\right)V$$

54. (D)

55. (D)

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

If 27 such drop coalesee

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

$$\therefore\ 3r = r_b$$

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

56. (B)

$$h_1 r_1 = h_2 r_2$$

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

$$A \propto r^2$$

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

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

57. (D)

$$F_{viscous} + \frac{4}{3}\pi R^3 \sigma_2 g = \frac{4}{3}\pi R^3 \sigma_1 g$$

$$F_{viscous} = \frac{4}{3}\pi R^3 g(\sigma_1 - \sigma_2) = \frac{4}{3}\pi R^3 g\, \sigma_1\left(1 - \frac{\sigma_2}{\sigma_1}\right)$$

$$= mg\left(1 - \frac{\sigma_2}{\sigma_1}\right)$$

58. (A)

$h_1 = 2.2$ cm, $h_2 = ?$

$h_1 r_1 = h_2 r_2$

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

$$h_2 = \frac{h_1\sqrt{A_1}}{\sqrt{A_2}} = 2.2 \times 2 = 4.4 \text{ cm}$$

59. (D)

60. (C)

Total length = 4 L

Total force = 2 × 4LT = 8 LT

61. (D)

$4\pi R^2 T = W$

$4\pi(2R)^2\, T = 4(4\pi R^2 T) = 4\text{ W}$

62. (C)

Total surface energy before coalesce

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

But $\frac{4}{3}\pi R^2 \times 2 = \frac{4}{3}\pi R'^3$

Total surface energy after coalesce

$E_2 = 4\pi R'^2 T = 4\pi 2^{2/3} R^2 T$

$$\therefore \frac{E_1}{E_2} = \frac{2(4\pi R^2)T}{4\pi 2^{2/3} R^2 T} = 2^{1-\frac{2}{3}} = 2^{1/3}$$

63. (D)

hr = constant

$\therefore$ rise of water in capillary of radius $\frac{r}{4}$ is 4h

Now, $\pi r^2 h\rho = m$

$$\therefore \quad \pi\left(\frac{r}{4}\right)^2 \times 4h\rho = \frac{m}{4}$$

64. (B)

$$F = \frac{4}{3}\pi r^3 (d_1 - d_2) g$$

$$F = \frac{4}{3}\pi r^3 d_1\left(1 - \frac{d_2}{d_1}\right) g = M\left(1 - \frac{d_2}{d_1}\right) g$$

65. (C)

$$h_1r_1 = h_2r_2$$

$$h_2 = \frac{h_1r_1}{r_2} = 3h$$

66. (A)

$$W = \frac{4\pi}{4}\left(4D^2 - D^2\right)T \times 2$$

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

67. (D)

$$6\pi\eta R v_1 = \frac{4}{3}\pi R^3(\rho_1 - \sigma)$$

$$6\pi\eta R v_2 = \frac{4}{3}\pi R^3(\rho_2 - \sigma)$$

$$\therefore \frac{v_2}{v_1} = \frac{\rho_2 - \sigma}{\rho_1 - \sigma}$$

$$v_2 = \frac{\rho_2 - \sigma}{\rho_1 - \sigma} v_1$$

68. (C)

Reynolds number $R_n = \frac{V_c \rho d}{n}$

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.

69. (A)

Theory question

70. (A)

Pressure in side the first bubble $= P + \frac{4T}{r_1}$

Pressure inside the second bubble $= P + \frac{4T}{r_2}$

using the formula $PV = nR\theta$ θ = absolute temp.

we have : $\left(P + \frac{4T}{r_1}\right) \cdot \frac{4\pi}{3} r_1^3 = n_1 R'\theta$ (R' is molar gas constant)

$$\left(P + \frac{4T}{r_2}\right) \cdot \frac{4\pi}{3} r_2^3 = n_2 R'\theta$$

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

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

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

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

71.(A)

By equation of continuity

$A_1V_1 = A_2V_2$

$\therefore \pi R^2V = n\pi r^2V'$

$\therefore V'=\dfrac{VR^2}{nr^2}$

72. (C)

$W = 8\pi R^2T$

If temperature increases then

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

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

As temperature increases, the surface tension decreases. Therefore $T' < T$.

$\therefore W_2 < 4W_1$

73. (D)

74. (C)

The rise of liquid is given by

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

$$\therefore \frac{h_1}{h_2}=\frac{T_1}{T_2}\cdot\frac{\rho_2}{\rho_1}=\frac{60}{50}\cdot\frac{0.6}{0.5}=\frac{9}{10}$$

75. (B)

Terminal velocity is given by

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

V is same

$$\therefore r_A^2(\rho_A-\sigma)=r_B^2(\rho_B-\sigma)$$

$$\therefore \frac{r_A}{r_B}=\sqrt{\frac{\rho_B-\sigma}{\rho_A-\sigma}}$$

76. (A)

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

77. (B)

Work done $W = 8\pi R^2 T$

If radius is doubled, the work done will become four times provided surface tension T remains constant. But if the solution is heated, there is some decrease in surface tension and hence the work done will be slightly less than four times.

79. (A)

Atomizer is based on Bernoulli's principle.

80. (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 $E_1 = 4\pi n r^2 T$ 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 $E_2 = 4\pi R^2 T$

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

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

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

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

81. (D)

$W = 2\pi r T$

$$\therefore\ 2r = \frac{W}{\pi T} = \frac{63\times10^{-4}\times7}{22\times7\times10^{-2}}$$

$$\approx 3\times10^{-2}\ \text{m}$$

82. (B)

$W_1 = 8\pi R^2 T$ where T is surface tension.

If radius is doubled and surface tension remains same then

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

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

Hence, $W_2 < 4W_1$

83. (A)

Terminal velocity $v \propto r^2$

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

84. (A)

Theory question

85. (B)

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

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

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

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

86. (D)

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

$$\therefore \quad R = \left(R_1^3 + R_2^3\right)^{1/2}$$

87. (A)

The pressure is given by

$$P = h\rho g$$

It does not depend on the area of the surface.

88. (C)

Under isothermal conditions the surface tension remains constant. If r is the radius of the digger drop, then

Final surface energy = Initial surface energy

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

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

$$\therefore \quad r = \left(r_1^2 + r_2^2\right)^{\frac{1}{2}}$$

89. (D)

Volume remains constant

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

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

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

90. (C)

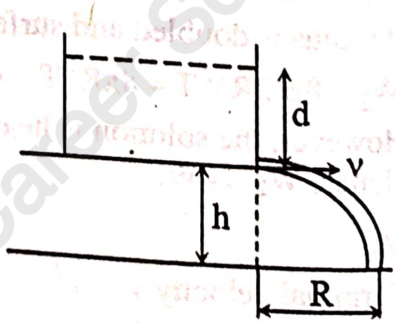
$$R = vt = \sqrt{2gd}\,t$$

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

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

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

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



91. (A)

The volume of mercury remains same.

$$\therefore \frac{4\pi}{3}R^3 = 2\left(\frac{4\pi}{3}r^3\right)$$

$$\therefore R^3 = 2r^3 \qquad \text{or} \qquad r^3 = \frac{R^3}{2}$$

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

Initial surface energy $E_1 = 4\pi R^2 \cdot T$

Final surface energy $E_2 = 4\pi r^2 T = 4\pi\left(\frac{R}{2^{\frac{1}{3}}}\right)^2 T = 4\pi\frac{R^2}{2^{\frac{2}{3}}}T$

$$\therefore \frac{E_1}{E_2} = 2^{\frac{2}{3}}$$

92. (B)

Error in question.

93. (A)

$V \propto r^2$

$$\frac{V_1}{V} = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$$

94. (D)

$$2\times\frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3 \quad \therefore R = 2^{\frac{1}{3}}r$$

Ratio of energies $\frac{E_2}{E_1} = \frac{4\pi R^2 T}{2\times\pi r^2\times T}$

$$\frac{E_2}{E_1} = \frac{R^2}{2r^2} = \frac{2^{\frac{2}{3}}r^2}{2r^2} = 2^{\frac{2}{3}-1} = 2^{-\frac{1}{3}}$$

95. (D)

Excess pressure $p = \frac{2T}{r}$

$$\frac{p_1}{p_2} = \frac{r_2}{r_1} = 3$$

$$\therefore r_2 = 3r_1$$

$$\frac{A_1}{A_2} = \frac{\pi r_1^2}{\pi r_2^2} = \left(\frac{r_1}{r_2}\right)^2 = \frac{1}{(3)^2} = \frac{1}{9}$$

96. (D)

By equation of continuity

$A_1V_1 = A_2V_2$

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

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.

97. (C)

$$h = \frac{2T\cos\theta}{r\rho g} \qquad \therefore h \propto \frac{1}{g}$$

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

98. (D)

$$h \propto \frac{1}{r} \quad \text{since} \quad A = \pi r^2, \quad \sqrt{A} \propto r$$

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

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

$$\therefore h_2 = \sqrt{3}\,h_1 = \sqrt{3}\times 15\times 10^{-3}\,m = 15\sqrt{3}\times 10^{-3}\,m$$

99. (C)

By equation of continuity $A_1 V_1 = A_2 V_2$

$$\therefore \frac{V_2}{V_1} = \frac{A_1}{A_2} = \frac{d_1^2}{d_2^2} \qquad \therefore A \propto d^2$$

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

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

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

100. (D)

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

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

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

101. (C)

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

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

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

102.(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

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

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

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

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

103.(B)

$U_1 = 1000 \times 4\pi r_1^2 \times T$

$\frac{r_2}{r_1} = (1000)^{1/3} = 10$

$U_2 = 4\pi\ r_2^2 T$

$$\frac{U_2}{U_1} = \frac{4\pi r_2^2 T}{1000 \times 4\pi r_1^2 \times T} = \frac{100}{1000} = \frac{1}{10}$$

104.(B)

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

$\therefore\ \frac{P_1}{P_2} = \frac{R_2}{R_1}$

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

$$\frac{V_1}{V_2} = \frac{\frac{4}{3}\pi R_1^2}{\frac{4}{3}\pi R_2^3} = \frac{R_1^3}{R_2^3} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

105.(D)

$h = \frac{2T\cos\theta}{r\rho g} \qquad \therefore\ h \propto \frac{1}{g}$

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

$g' = g - a$

$g' < g \qquad \therefore$ h will increase.

106.(C)

$W = 2T \times A$

$= 2 \times 3 \times 10^{-2} \times 100 \times 10^{-4}$

$= 6 \times 10^{-4}$ J

107.(B)

Terminal velocity $v \propto r^2$

$$\frac{v_1}{v_2} = \frac{r_1^2}{r_2^2} = \frac{16}{9}$$

surface areas $\frac{A_1}{A_2} = \frac{r_1^2}{r_2^2} = \frac{16}{9}$

108.(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 $W = 2\,T.\Delta A$

$$= 2 \times 7.2 \times 10^{-2} \times 10^{-4}\,\text{J}$$

$$= 1.44 \times 10^{-5}\,\text{J}$$

109.(C)

Theory question

110.(B)

By Bernoulli equation,

$$P_1 = P_2 + \frac{1}{2}\rho v^2$$

$$\therefore\ P_1 - P_2 = \frac{1}{2}\rho v^2$$

$$\therefore\ v = \sqrt{\frac{2(P_1 - P_2)}{\rho}}$$

111.(A)

$$v_1 A_1 = v_2 A_2$$

$$\sqrt{2gh_1}\,A_1 = \sqrt{2gh_2}\,A_2$$

$$\sqrt{y}\,a^2 = \sqrt{16y}\,\pi r^2$$

$$a^2 = 4\pi r^2$$

$$r = \frac{a}{2\sqrt{\pi}}$$