MECHANICAL PROPERTIES OF FLUIDS

FACT/DEFINITION TYPE QUESTIONS

1. The most characteristic property of a liquid is
   (a) elasticity (b) fluidity
   (c) formlessness (d) volume conservation
2. _________ and _________ play the same role in case of fluids as force and mass play in case of solids.
   (a) Thrust and density (b) Pressure and density
   (c) Pressure and thrust (d) thrust and volume
3. Which of the following is a unit of pressure?
   (a) atm (b) pascal
   (c) bar (d) All of these
4. Which of the following pressure-measuring device measures the guage pressure?
   (a) Mercury barometer (b) Sphygmomanometer
   (c) Both (a) & (b) (d) None of these
5. Liquid pressure depends upon
   (a) area of the liquid surface
   (b) shape of the liquid surface
   (c) height of the liquid column
   (d) directions
6. Hydraulic lifts and hydraulic brakes are based on
   (a) Archimedes' principle (b) Bernoulli's principle
   (c) Stoke's law (d) Pascal's law
7. According to archimedes' principle, loss of weight of a body immersed in a liquid is equal to
   (a) weight of the liquid displaced
   (b) weight of the total liquid
   (c) weight of the body
   (d) None of these
8. Specific gravity of a body is numerically equal to
   (a) weight of the body in air
   (b) weight of the body in water
   (c) relative density of the body
   (d) density of body in water
9. Which of the following parameters decrease as we go up?
   (a) Density of air (b) Acceleration due to gravity
   (c) Atmospheric pressure (d) All of these
10. Which liquid is used in an open-tube manometer for measuring small pressure differences?
    (a) Oil (b) Mercury
    (c) Water (d) None of these
11. If a solid floats with 1/4th of its volume above the surface of water, then density of the solid (ρ_s) is related to density of water (ρ_w) as
    (a) $\rho_s = \rho_w$ (b) $\rho_s = \frac{1}{4}\rho_w$
    (c) $\rho_s = \frac{3}{4}\rho_w$ (d) $\rho_s = \frac{4}{3}\rho_w$
12. Smaller the area on which the force acts, greater is the impact. This concept is known as
    (a) impulse (b) pressure
    (c) surface tension (d) magnus effect
13. Pressure in a fluid at rest is same at all points which are at the same height. This is known as
    (a) Archemedes'. Principle (b) Bernoulli's principle
    (c) Stoke's law (d) Pascal's law
14. The excess pressure at depth below the surface of a liquid open to the atmosphere is called
    (a) atmospheric pressure (b) hydrostatic paradox
    (c) gauge pressure (d) None of these
15. A pressure equivalent to 1 mm is called
    (a) 1 Pa (b) 1 torr
    (c) 1 atm (d) 1 N/m^2
16. When a body is wholly or partially immersed in a fluid at rest, the force working on it in upward direction is called
    (a) buoyant force (b) surface tension
    (c) viscous force (d) None of these
17. Pressure applied to enclosed fluid is
    (a) increased and applied to every part of the fluid
    (b) diminished and transmitted to wall of container
    (c) increased in proportion to the mass of the fluid and then transmitted
    (d) transmitted unchanged to every portion of the fluid and wall of containing vessel.
18. The pressure at the bottom of a tank containing a liquid does not depend on
    (a) acceleration due to gravity
    (b) height of the liquid column
    (c) area of the bottom surface
    (d) nature of the liquid

19. Streamline flow is more likely for liquids with
(a) high density and low viscosity
(b) low density and high viscosity
(c) high density and high viscosity
(d) low density and low viscosity

20. Beyond the critical speed, the flow of fluids becomes
(a) streamline (b) turbulent
(c) steady (d) very slow

21. For flow of a fluid to be turbulent
(a) fluid should have high density
(b) velocity should be large
(c) reynold number should be less than 2000
(d) both (a) and (b)

22. In a stream line (laminar flow) the velocity of flow at any point in the liquid
(a) does not vary with time
(b) may vary in direction but not in magnitude
(c) may vary in magnitude but not in direction
(d) may vary both in magnitude and direction

23. In Bernoulli's theorem which of the following is conserved?
(a) Mass (b) Linear momentum
(c) Energy (d) Angular momentum

24. Bernoulli's equation is important in the field of
(a) electrical circuits (b) magnetism
(c) flow of fluids (d) photoelectric effect

25. Paint-gun is based on
(a) Bernoulli's theorem (b) Archimedes' principle
(c) Boyle's law (d) Pascal's law

26. Magnus effect is very near to the
(a) magnetic field (b) electric field
(c) bernoulli's theorem (d) magnetic effect of current

27. A liquid is allowed to flow into a tube of truncated cone shape. Identify the correct statement from the following:
(a) the speed is high at the wider end and high at the narrow end.
(b) the speed is low at the wider end and high at the narrow end.
(c) the speed is same at both ends in a stream line flow.
(d) the liquid flows with uniform velocity in the tube.

28. Toricelli's theorem is used to find
(a) the velocity of efflux through an orifice.
(b) the velocity of flow of liquid through a pipe.
(c) terminal velocity
(d) critical velocity

29. The device which measures the flow speed of incompressible fluid is
(a) sphygmomanometer (b) open-tube manometer
(c) venturimeter (d) mercury barometer

30. As the temperature of a liquid is raised, the coefficient of viscosity
(a) decreases (b) increases
(c) remains the same
(d) may increase or decrease depending on the nature of liquid

31. After terminal velocity is reached, the acceleration of a body falling through a fluid is
(a) equal to g (b) zero
(c) less than g (d) greater than g

32. Choose the correct statement from the following.
(a) Terminal velocities of rain drops are proportional to square of their radii
(b) Water proof agents decrease the angle of contact between water and fibres
(c) Detergents increase the surface tension of water
(d) Hydraulic machines work on the principle of Torricelli's law

33. According to stokes law, the relation between terminal velocity (v_t) and viscosity of the medium (n) is
(a) $v_t = n$ (b) $v_t \propto n$
(c) $v_t \propto \frac{1}{n}$ (d) v_t is independent of n.

34. When the temperature increases, the viscosity of
(a) gases decreases and liquid increases
(b) gases increases and liquid decreases
(c) gases and liquids increases
(d) gases and liquids decreases

35. Fevicol is added to paint to be painted on the walls, because
(a) it increases adhesive force between paint and wall.
(b) it decreases adhesive force between paint and wall molecules.
(c) it decreases cohesive force between paint molecules
(d) None of these

36. A rectangular glass plate is held vertically with long side horizontal and half the plate immersed in water. Which of the following forces is acting on the plate?
(a) Weight of the plate acting vertically upwards
(b) Force of surface tension acting vertically downwards
(c) Force of viscosity acting horizontally
(d) All of these

37. Which of the following expressions represents the excess of pressure inside the soap bubble?
(a) $P_i - P_o = \frac{s}{r}$ (b) $P_i - P_o = \frac{2s}{r}$
(c) $P_i - P_o = \frac{2s}{r} + h\rho g$ (d) $P_i - P_o = \frac{4s}{r}$

38. For a given volume which of the following will have minimum energy?
(a) Cube (b) Cone
(c) Sphere (d) All have same energy

39. If a soap bubble formed at the end of the tube is blown very slowly, then the graph between excess pressure inside the bubble with time will be a
(a) straight line sloping up
(b) straight line sloping down
(c) parabolic curve sloping down
(d) parabolic curve sloping up

40. Surface tension of a liquid is due to
(a) gravitational force between molecules
(b) electrical force between molecules
(c) adhesive force between molecules
(d) cohesive force between molecules

41. Surface tension may be defined as
(a) the work done per unit area in increasing the surface area of a liquid under isothermal conditions
(b) the work done per unit area in increasing the surface area of a liquid under adiabatic conditions
(c) the work done per unit area in increasing the surface area of a liquid under adiabatic conditions
(d) free surface energy per unit volume

42. At critical temperature, the surface tension of a liquid is
(a) zero
(b) infinity
(c) the same as that at any other temperature
(d) None of these

43. If two soap bubbles of different radii are in communication with each other then
(a) air flows from the larger bubble into the smaller one until the two bubbles are of equal size
(b) the size of the bubbles remains the same
(c) air flows from the smaller bubble into the larger one and the larger one grows at the expense of the smaller one
(d) the air flows from the larger into the smaller bubble until the radius of the smaller one becomes equal to that of the larger one and of the larger one equal to that of the smaller one.

44. Two water droplets merge with each other to form a larger droplet. In this process
(a) energy is liberated
(b) energy is absorbed
(c) energy is neither liberated nor absorbed
(d) some mass is converted into energy

45. When a pinch of salt or any other salt which is soluble in water is added to water, its surface tension
(a) increases
(b) decreases
(c) may increase or decrease depending upon salt
(d) None of these

46. If more air is pushed in a soap bubble, the pressure in it
(a) decreases (b) becomes zero
(c) remains same (d) increases

47. A drop of oil is placed on the surface of water. Which of the following is correct?
(a) It will remain on it as a sphere
(b) It will spread as a thin layer
(c) It will partly be a spherical droplet and partly a thin film
(d) It will float as a distorted drop on the water surface

48. For which of the following liquids, the liquid meniscus in the capillary tube is, convex?
(a) Water (b) Mercury
(c) Both (a) & (b) (d) None of these

49. Kerosene oil rises up in a wick of a lantern because of
(a) diffusion of the oil through the wick
(b) capillary action
(c) buoyant force of air
(d) the gravitational pull of the wick

50. Due to capillary action, a liquid will rise in a tube if angle of contact is
(a) acute (b) obtuse
(c) 90^o (d) zero

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

STATEMENT TYPE QUESTIONS

52. Which of the following statements are true about streamline flow?
I. Path taken by a fluid particle under a steady flow is a streamline
II. No two streamlines can cross each other
III. Velocity increases at the narrower portions where the streamlines are closely spaced
(a) I & II only (b) II & III only
(c) I & III only (d) I, II & III

53. Select the correct statements from the following.
I. Bunsen burner and sprayers work on Bernoulli's principle
II. Blood flow in arteries is explained by Bernoulli's principle
III. A siphon works on account of atmospheric pressure.
(a) I & II only (b) II & III only
(c) I & III only (d) I, II & III

54. Consider the following statements : In a streamline flow of a liquid
I. the kinetic energies of all particles arriving at a given point are same.
II. the momenta of all particles arriving at a given point are same.
III. the speed of particles are below the critical velocity.
Which of the statements given above are correct?
(a) I & II only (b) II & III only
(c) I &III only (d) I, II & III

55. Consider the following statements :
I. Magnus effect is a consequence of Bernoulli's principle.
II. A cricketer, while spinning a ball makes it to experience magnus effect.
Which of the statements given above is/are correct?
(a) I only (b) II only
(c) Both I & II (d) Neither I nor II

56. Consider the following statements :
There is a small hole near the bottom of an open tank filled with water. The speed of water ejected depends on
I. area of the hole
II. density of liquid
III. height of liquid from the hole
IV acceleration due to gravity
Which of the statements given above are correct
(a) I & II only (b) I, III & IV
(c) III & IV only (d) II, III & IV

57. Which of the following statement(s) is/are true?
I. For gases, in general, viscosity increases with temperature
II. For liquids, viscosity varies directly with pressure
III. For gases, viscosity is independent of pressure
(a) I & II (b) II & III
(c) I & III (d) I, II, & III

58. Which of the following statements is/are true?
I. Solid friction is independent of area of surface in contact and viscous drag is also independent of area of layers in contact.
II. Solid friction depends on the relative velocity of one body on the surface of another body while viscous drag is independent of the relative velocity between two layers of the liquid.
III. Solid friction is directly proportional to the normal reaction while viscosity is independent of the normal reaction between two layers of the liquid.
(a) I, II & III (b) I & II
(c) III only (d) II only

59. Which of the following are incorrect statement(s) about viscosity of liquids?
I. Viscosity decreases with increase in density
II. Viscosity decreases with increase in temperature
III. Viscosity of liquids (except water) decreases with increase in pressure
(a) I only (b) II only
(c) III only (d) I & III

60. Select the false statement(s) about surface tension from the following?
I. Surface tension is the extra energy that the molecules at the interface have as compared to the molecules in the interior
II. The value of surface tension is independent of the temperature
III. Surface tension causes capillary action
(a) I only (b) II only
(c) I & II (d) I, II & III

61. Consider the following statements and select the true statement(s)?
I. A large soap bubble shrinks while a small soap bubble expands when they are connected to each other by a capillary tube, in order to gain equilibrium
II. The raindrops fall on the surface of earth with the same constant velocity
III. A hydrogen filled balloon stops rising after it has attained a certain height in the sky
(a) I only (b) II only
(c) III only (d) I & III

MATCHING TYPE QUESTIONS

62. Match column I and column II.

Column I	Column II
(A) Barometer	(1) Law of conservation of energy
(B) Hydrometer	(2) To measure density
(C) Bernoulli's Principle	(3) To measure atmospheric pressure
(D) Archimedes' Principle	(4) upthrust

(a) (A)→(3); (B)→(2); (C)→(1); (D)→(4)
(b) (A)→(1); (B)→(2); (C)→(3); (D)→(4)
(c) (A)→(2); (B)→(1); (C)→(4); (D)→(3)
(d) (A)→(3); (B)→(4); (C)→(2); (D)→(1)

63.

Column I	Column II
(A) Stoke's law	(1) Pressure energy
(B) Turbulence	(2) Hydraulic lift
(C) Bernoulli's principle	(3) Viscous drag
(D) Pascal's law	(4) Reynold's number

(a) (A)→(3); (B)→(4); (C)→(1); (D)→(2)
(b) (A)→(1); (B)→(2); (C)→(3); (D)→(4)
(c) (A)→(2); (B)→(1); (C)→(2); (D)→(3)
(d) (A)→(3); (B)→(4); (C)→(2); (D)→(1)

64.

Column I	Column II
(A) Terminal velocity	(1) Average density becomes less than that of liquid
(B) Objects of high density can also float	(2) Upthrust is zero
(C) A beaker having a solid iron under free fall	(3) Varies with velocity
(D) Viscous drag	(4) Upthrust and viscous force

(a) (A)→(4); (B)→(2); (C)→(3); (D)→(1)
(b) (A)→(1); (B)→(2); (C)→(3); (D)→(4)
(c) (A)→(4); (B)→(1); (C)→(2); (D)→(3)
(d) (A)→(3); (B)→(4); (C)→(2); (D)→(1)

65.

Column I	Column II
(A) Bernoullis theorem	(1) Narrower pipes have less pressure
(B) Ball moving with spin	(2) Paint gun
(C) Artificial high pressure	(3) Non-viscous fluids
(D) Streamline flow	(4) Conservation of energy
	(5) Uplift due to pressure difference

(a) (A)→(3,4); (B)→(5); (C)→(2); (D)→(1,3)
(b) (A)→(1); (B)→(2); (C)→(3); (D)→(4)
(c) (A)→(2); (B)→(5); (C)→(4); (D)→(3)
(d) (A)→(3); (B)→(5); (C)→(2); (D)→(1)

66. **Column I** | **Column II**

(A) Magnus effect | (1) Pascal's law
(B) Loss of energy | (2) Archimede's principle
(C) Pressure is same at the same level in a liquid | (3) Viscous force
(D) Hydraulic machines | (4) Lifting of Asbestos roofs

(a) (A) → (4) ; (B) → (2) ; (C) → (5) ; (D) → (1)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (2) ; (B) → (5) ; (C) → (4) ; (D) → (3)
(d) (A) → (4) ; (B) → (3) ; (C) → (1) ; (D) → (2)

67. **Column I** | **Column II**

(A) Water proofing agents | (1) Increase in terminal velocity
(B) Sphygmomanometer | (2) Gauge pressure
(C) More than gauge pressure | (3) Actual pressure
(D) Mixing of drops of smaller dimension | (4) Increase the angle of contact

(a) (A) → (4) ; (B) → (2) ; (C) → (5) ; (D) → (1)
(b) (A) → (1) ; (B) → (2) ; (C) → (3) ; (D) → (4)
(c) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(d) (A) → (3) ; (B) → (5) ; (C) → (2) ; (D) → (1)

68. **Column I** | **Column II**

(A) Capillaries of smaller radii | (1) Flat meniscus
(B) $F_c > \sqrt{2}F_a$ where F_c and F_a are cohesive and adhesive force | (2) Greater height difference
(C) Angle of contact is zero | (3) Drop in level
(D) Lower angle of contact | (4) Welding agents

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (3) ; (B) → (4) ; (C) → (1) ; (D) → (2,3)
(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

69. Match the column I and column II

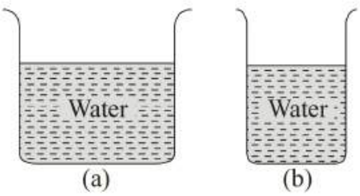
Column I | **Column II**

(A) Floating bodies | (1) Torricelli's law
(B) Capillarity | (2) Bernoulli's principle
(C) Energy conservation | (3) Archimedes principle
(D) Speed of efflux | (4) Pascal's law

(a) (A) → (4) ; (B) → (2) ; (C) → (3) ; (D) → (1)
(b) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)
(c) (A) → (2) ; (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3) ; (B) → (4) ; (C) → (2) ; (D) → (1)

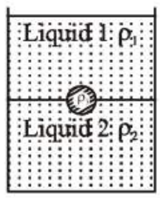
DIAGRAM TYPE QUESTIONS

70. From the figure, the correct observation is



(a) the pressure on the bottom of tank (a) is greater than at the bottom of (b)
(b) the pressure on the botttom of the tank (a) is smaller than at the bottom (b)
(c) the pressure depend on the shape of the container
(d) the pressure on the bottom of (a) and (b) is the same.

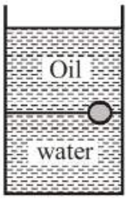
71. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and, ρ_2 respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_1 and ρ_3?

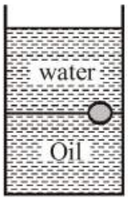


(a) $\rho_3 < \rho_1 < \rho_2$
(b) $\rho_1 > \rho_3 > \rho_2$
(c) $\rho_1 < \rho_2 < \rho_3$
(d) $\rho_1 < \rho_3 < \rho_2$

72. A ball is made of a material of density ρ where $\rho_{oil} < \rho < \rho_{water}$ with ρ_{oil} and ρ_{water} representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position?

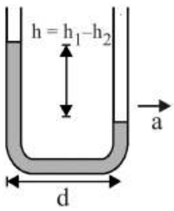
(a) 

(b) 

(c) 

(d) 

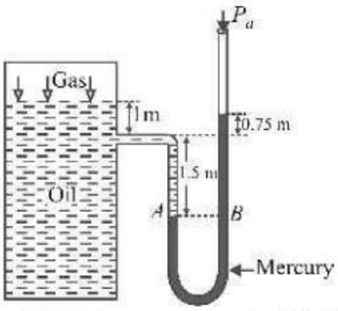
73. Figure shows a U-tube of uniform cross-sectional area A, accelerated with acceleration a as shown. If d is the separation between the limbs, then what is the difference in the levels of the liquid in the U-tube is



(a) $\frac{ad}{g}$ (b) $\frac{ag}{d}$

(c) $\frac{a}{d}$ (d) $\frac{dg}{a}$

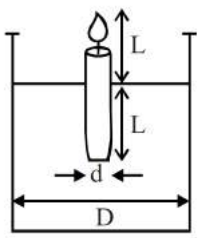
74. What is the absolute pressure of the gas above the liquid surface in the tank shown in fig. Density of oil = 820 kg/m^3, density of mercury = 13.6×10^3 kg/m^3. Given 1 atmospheric pressure = 1.01×10^5 N/m^2.



(a) 3.81×10^5 N/m^2 (b) 6×10^6 N/m^2

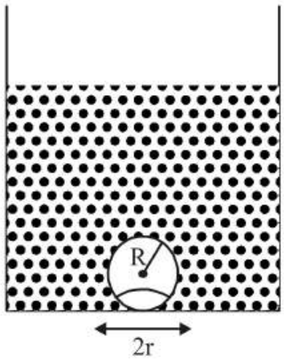
(c) 5×10^7 N/m^2 (d) 4.6×10^2 N/m^2

75. A candle of diameter d is floating on a liquid in a cylindrical container of diameter D (D >> d) as shown in figure. If it is burning at the rate of 2 cm/hour then the top of the candle will



(a) remain at the same height
(b) fall at the rate of 1 cm/hour
(c) fall at the rate of 2 cm/hour
(d) go up at the rate of 1 cm/hour

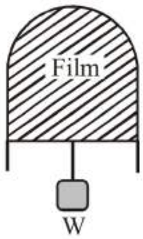
76. On heating water, bubbles being formed at the bottom of the vessel detach and rise. Take the bubbles to be spheres of radius R and making a circular contact of radius r with the bottom of the vessel. If r ≪ R and the surface tension of water is T, value of r just before bubbles detach is:
(density of water is ρ_w)



(a) $R^2\sqrt{\frac{\rho_w g}{3T}}$ (b) $R^2\sqrt{\frac{2\rho_w g}{3T}}$

(c) $R^2\sqrt{\frac{\rho_w g}{T}}$ (d) $R^2\sqrt{\frac{3\rho_w g}{T}}$

77. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is



(a) 0.0125 Nm^{-1} (b) 0.1 Nm^{-1}
(c) 0.05 Nm^{-1} (d) 0.025 Nm^{-1}

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

78. **Assertion:** Mercury is preferred as a barometric substance over water.
Reason: Mercury is opaque and shiny so it is easier to note the observation.

79. **Assertion:** A small iron needle sinks in water while a large iron ship floats.
Reason: The shape of iron needle is like a flat surface while the shape of a ship is that which makes it easier to float.

80. **Assertion:** The apparent weight of a floating body is zero.
Reason: The weight of the block acting vertically downwards is balanced by the buoyant force acting on the block upwards.

81. **Assertion :** Pascal's law is the working principle of a hydraulic lift.

Reason : Pressure is equal to the thrust per unit area.

82. **Assertion :** Imagine holding two identical bricks under water. Brick A is completely submerged just below the surface of water, while Brick B is at a greater depth. The magnitude of force exerted by the person (on the brick) to hold brick B in place is the same as magnitude of force exerted by the person (on the brick) to hold brick A in place.

Reason : The magnitude of buoyant force on a brick completely submerged in water is equal to magnitude of weight of water it displaces and does not depend on depth of brick in water.

83. **Assertion :** The blood pressure in humans is greater at the feet than at the brain

Reason : Pressure of liquid at any point is proportional to height, density of liquid and acceleration due to gravity

84. **Assertion :** Hydrostatic pressure is a vector quantity.

Reason : Pressure is force divided by area, and force is vector quantity.

85. **Assertion :** The velocity of flow of a liquid is smaller when pressure is larger and vice-versa.

Reason : According to Bernoulli's theorem, for the stream line flow of an ideal liquid, the total energy per unit mass remains constant

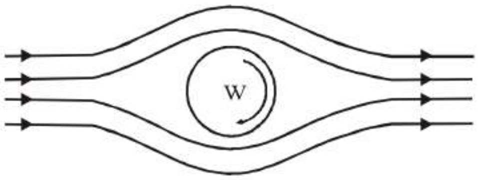
86. **Assertion :** A bubble comes from the bottom of a lake to the top.

Reason : Its radius increases.

87. **Assertion :** Sudden fall of pressure at a place indicates storm.

Reason : Air flows from higher pressure to lower pressure.

88. **Assertion :** As wind flows left to right and a ball is spinned as shown, there will be a lift of the ball.



Reason : Decreased velocity of air below the ball increases the pressure more than that above the ball.

89. **Assertion :** Lifting of aircraft is caused by pressure difference brought by varying speed of air molecules.

Reason : As the wings/ aerofoils move against the wind, the streamlines crowd more above them than below, causing higher velocity above than below.

90. **Assertion:** The pressure of water reduces when it flows from a narrow pipe to a wider pipe.

Reason: Since for wider pipe area is large, so flow of speed is small and pressure also reduces proportionately.

91. **Assertion :** Falling raindrops acquire a terminal velocity.

Reason : A constant force in the direction of motion and a velocity dependent force opposite to the direction of motion, always result in the acquisition of terminal velocity.

92. **Assertion:** Surface tension of all lubricating oils and paints is kept high.

Reason: Due to high value of surface tension the fluids don't get damaged.

93. **Assertion :** If a body is floating in a liquid, the density of liquid is always greater than the density of solid.

Reason : Surface tension is the property of liquid surface.

94. **Assertion :** Smaller the droplets of water, spherical they are.

Reason : Force of surface tension is equal, and opposite to force of gravity.

95. **Assertion :** A large force is required to draw apart normally two glass plates enclosing a thin water film.

Reason : Water works as glue and sticks two glass plates.

96. **Assertion :** It is better to wash the clothes in cold soap solution.

Reason : The surface tension of cold solution is more than the surface tension of hot solution.

97. **Assertion :** The concept of surface tensiton is held only for liquid

Reason : Surface tension does not hold for gases.

98. **Assertion :** When height of a tube is less than liquid rise in the capillary tube, the liquid does not overflow

Reason : Product of radius of meniscus and height of liquid in capillary tube always remains constant.

CRITICAL THINKING TYPE QUESTIONS

99. Consider an iceberg floating in sea water. The density of sea water is 1.03 g/cc and that of ice is 0.92 g/cc. The fraction of total volume of iceberg above the level of sea water is near by

(a) 1.8% (b) 3%
(c) 8% (d) 11%

100. A block of ice floats on a liquid of density 1.2 in a beaker then level of liquid when ice completely melt

(a) remains same (b) rises
(c) lowers (d) either (b) or (c)

101. The total weight of a piece of wood is 6 kg. In the floating state in water its $\frac{1}{3}$ part remains inside the water. On this floating piece of wood what maximum weight is to be put such that the whole of the piece of wood is to be drowned in the water?

(a) 15 kg (b) 14 kg
(c) 10 kg (d) 12 kg

102. A vessel contains oil (density = 0.8 gm/cm^3) over mercury (denisty = 13.6 gm/cm^3). A homogeneous sphere floats with half of its volume immersed in mercury and the other half in oil. The density of the material of the sphere in gm/cm^3 is

(a) 3.3 (b) 6.4
(c) 7.2 (d) 12.8

103. In a hydraulic lift, compressed air exerts a force F_1 on a small piston having a radius of 5 cm. This pressure is transmitted to a second piston of radius 15 cm. If the mass of the load to

be lifted is 1350 kg, find the value of F_1 ? The pressure necessary to accomplish this task is
(a) 1.4×10^5 Pa (b) 2×10^5 Pa
(c) 1.9×10^5 Pa (d) 1.9 Pa

104. The two thigh bones, each of cross - sectional area 10 cm^2 support the upper part of a human body of mass 40 kg. Estimate the average pressure sustained by the bones. Take $g = 10$ m/s^2
(a) 2×10^5 N/m^2 (b) 5×10^4 N/m^2
(c) 2×10^7 N/m^2 (d) 3×10^6 N/m^2

105. A hemispherical bowl just floats without sinking in a liquid of density 1.2×10^3 kg/m^3. If outer diameter and the density of the bowl are 1 m and 2×10^4 kg/m^3 respectively then the inner diameter of the bowl will be
(a) 0.94m (b) 0.97m
(c) 0.98m (d) 0.99m

106. A uniform rod of density ρ is placed in a wide tank containing a liquid of density $\rho_0 (\rho_0 > \rho)$. The depth of liquid in the tank is half the length of the rod. The rod is in equilibrium, with its lower end resting on the bottom of the tank. In this position the rod makes an angle θ with the horizontal
(a) $\sin\theta = \frac{1}{2}\sqrt{\rho_0/\rho}$ (b) $\sin\theta = \frac{1}{2}.\frac{\rho_0}{\rho}$
(c) $\sin\theta = \sqrt{\rho/\rho_0}$ (d) $\sin\theta = \rho_0/\rho$

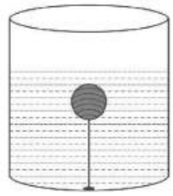
107. Air flows horizontally with a speed v = 106 km/hr. A house has plane roof of area A = 20m^2. The magnitude of aerodynamic lift of the roof is
(a) 1.127×10^4 N (b) 5.0×10^4 N
(c) 1.127×10^5 N (d) 3.127×10^4 N

108. A spherical solid ball of volume V is made 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 applies a viscous force on the ball that is proportional to the square of its speed v, i.e., $F_{viscous} = -kv^2$ $(k > 0)$. The terminal speed of the ball is
(a) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$ (b) $\frac{Vg\rho_1}{k}$
(c) $\sqrt{\frac{Vg\rho_1}{k}}$ (d) $\frac{Vg(\rho_1 - \rho_2)}{k}$

109. When a ball is released from rest in a very long column of viscous liquid, its downward acceleration is 'a' (just after release). Its acceleration when it has acquired two third of the maximum velocity is a/X. Find the value of X.
(a) 2 (b) 3
(c) 4 (d) 5

110. A tiny spherical oil drop carrying a net charge q is balanced in still air will a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5$ Vm^{-1}. When the field is switched off, the drop is observed to fall with terminal velocity 2×10^{-3} ms^{-1}.(Given : g = 9.8 ms^{-2}, viscosity of the air = 1.8×10^{-5} Nsm^{-2} and the density of oil = 900 kgm^{-3}) the magnitude of q is
(a) 1.6×10^{-19} C (b) 3.2×10^{-19} C
(c) 4.8×10^{-19} C (d) 8.0×10^{-19} C

111. A solid sphere of density $\eta (> 1)$ times lighter than water is suspended in a water tank by a string tied to its base as shown in fig. If the mass of the sphere is m, then the tension in the string is given by



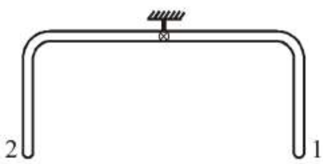
(a) $\left(\frac{\eta - 1}{\eta}\right)mg$ (b) ηmg
(c) $\frac{mg}{\eta - 1}$ (d) $(\eta - 1)mg$

112. An air bubble of radius 1 cm rises with terminal velocity 0.21 cm/s in liquid column. If the density of liquid is 1.47×10^3 kg/m^3. Then the value of coefficient of viscosity of liquid ignoring the density of air, will be
(a) 1.71×10^4 poise (b) 1.82×10^4 poise
(c) 1.78×10^4 poise (d) 1.52×10^4 poise

113. The relative velocity of two parallel layers of water is 8 cm/sec. If the perpendicular distance between the layers is 0.1 cm. Then velocity gradient will be
(a) 80/sec (b) 60 /sec
(c) 50/sec (d) 40/sec

114. If a ball of steel (density $\rho = 7.8$ g cm^{-3}) attains a terminal velocity of 10 cms^{-1} when falling in a tank of water (coefficient of viscosity $\eta_{water} = 8.5 \times 10^{-4}\ Pa - s$) then its terminal velocity in glycerine ($\rho = 12 gcm^{-3}, \eta = 13.2 Pa - s$) would be nearly
(a) 1.6×10^{-5} cms^{-1} (b) 6.25×10^{-4} cms^{-1}
(c) 6.45×10^{-4} cms^{-1} (d) 1.5×10^{-5} cms^{-1}

115. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in figure. Just after opening the valve



(a) air from end 1 flows towards end 2. No change in the volume of the soap bubbles
(b) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases
(c) no change occurs
(d) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases

116. A liquid is filled upto a height of 20 cm in a cylindrical vessel. The speed of liquid coming out of a small hole at the bottom of the vessel is ($g = 10\ ms^{-2}$)

(a) $1.2\ ms^{-1}$ (b) $1\ ms^{-1}$
(c) $2\ ms^{-1}$ (d) $3.2\ ms^{-1}$

117. Two soap bubbles each with radius r_1 and r_2 coalesce in vacuum under isothermal conditions to form a bigger bubble of radius R. Then R is equal to

(a) $\sqrt{r_1^2 + r_2^2}$ (b) $\sqrt{r_1^2 - r_2^2}$
(c) $r_1 - r_2$ (d) $\frac{\sqrt{r_1^2 + r_2^2}}{2}$

118. A boy can reduce the pressure in his lungs to 750 mm of mercury. Using a straw he can drink water from a glass upto the maximum depth of (atmospheric pressure = 760 mm of mercury; density of mercury = $13.6\ gcm^{-3}$)

(a) 13.6 cm (b) 9.8 cm
(c) 10 cm (d) 76 cm

119. An open glass tube is immersed in mercury in such a way that a length of 8 cm extends above the mercury level. The open end of the tube is then closed and sealed and the tube is raised vertically up by additional 46 cm. What will be length of the air column above mercury in the tube now? (Atmospheric pressure = 76 cm of Hg)

(a) 16 cm (b) 22 cm
(c) 38 cm (d) 6 cm

120. A boat carrying a few number of big stones floats in a water tank. If the stones are unloaded into water, the water level

(a) rises till half the number of stones are unloaded and then begins to fall
(b) remains unchanged
(c) rises
(d) falls

121. A solid ball of volume V experiences a viscous force F when falling with a speed v in a liquid. If another ball of volume 8 V with the same velocity v is allowed to fall in the same liquid, it experiences a force

(a) F (b) 16 F
(c) 4 F (d) 2 F

122. A beaker of radius 15 cm is filled with a liquid of surface tension 0.075 N/m. Force across an imaginary diameter on the surface of the liquid is

(a) 0.075 N (b) 1.5×10^{-2} N
(c) 0.225 N (d) 2.25×10^{-2} N

123. A water film is formed between two straight parallel wires of 10 cm length 0.5 cm apart. If the distance between wires is increased by 1 mm. What will be the work done ? (surface tension of water = 72 dyne/cm)

(a) 36 erg (b) 288 erg
(c) 144 erg (d) 72 erg

124. The work done in increasing the size of a soap film from 10 cm × 6 cm to 10 cm × 11 cm is 3×10^{-4} J. The surface tension of the film is

(a) 11×10^{-2} N/m (b) 6×10^{-2} N/m
(c) 3×10^{-2} N/m (d) 1.5×10^{-2} N/m

125. A mercury drop of radius 1 cm is sprayed into 10^6 drops of equal size. The energy expressed in joule is (surface tension of Mercury is 460×10^{-3} N/m)

(a) 0.057 (b) 5.7
(c) 5.7×10^{-4} (d) 5.7×10^{-6}

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

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

127. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure 8 N/m^2. The radii of bubbles A and B are 2 cm and 4 cm, respectively.Surface tension of the soap-water used to make bubbles is 0.04 N/m. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity]

(a) 2 (b) 9
(c) 8 (d) 6

128. An isolated and charged spherical soap bubble has a radius r and the pressure inside is atmospheric. If T is the surface tension of soap solution, then charge on drop is $X\ \pi r\sqrt{2rT\varepsilon_0}$ then find the value of X.

(a) 8 (b) 9
(c) 7 (d) 2

129. Two parallel glass plates are dipped partly in the liquid of density 'd' keeping them vertical . If the distance between the plates is 'x', surface tension for liquids is T and angle of contact is θ, then rise of liquid between the plates due to capillary will be

(a) $\frac{T\cos\theta}{xd}$ (b) $\frac{2T\cos\theta}{xdg}$
(c) $\frac{2T}{xdg\cos\theta}$ (d) $\frac{T\cos\theta}{xdg}$

130. A 20 cm long capillary tube is dipped in water. The water rises up to 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) 10 cm (b) 8 cm
(c) 20 cm (d) 4 cm

131. In a capillary tube, water rises to 3 mm. The height of water that will rise in another capillary tube having one-third radius of the first is

(a) 1mm (b) 3mm
(c) 6mm (d) 9mm

132. A wind with speed 40 m/s blows parallel to the roof of a house. The area of the roof is 250 m^2. Assuming that the pressure inside the house is atmospheric pressure, the force exerted by the wind on the roof and the direction of the force will be ($\rho_{air} = 1.2\ kg/m^3$)

(a) 4.8×10^5 N, upwards
(b) 2.4×10^5 N, upwards
(c) 2.4×10^5 N, downwards
(d) 4.8×10^5 N, downwards

133. In a surface tension experiment with a capillary tube water rises upto 0.1 m. If the same experiment is repeated on an artificial satellite, which is revolving around the earth, water will rise in the capillary tube upto a height of

(a) 0.1 m
(b) 0.2 m
(c) 0.98 m
(d) full length of the capillary tube

134. Water rises in a capillary tube to a certain height such that the upward force due to surface tension is balanced by 7.5×10^{-4}N force due to the weight of the liquid. If the surface tension of water is 6×10^{-2}Nm^{-1}, the inner circumference of the capillary tube must be

(a) 1.25×10^{-2}m (b) 0.50×10^{-2}m
(c) 6.5×10^{-2}m (d) 12.5×10^{-2}m

135. Radius of a capillary tube is 2×10^{-3}m. A liquid of weight 6.28×10^{-4} N may remain in the capillary then the surface tension of liquid will be

(a) 5×10^3 N/m (b) 5×10^{-2} N/m
(c) 5 N/m (d) 50 N/m

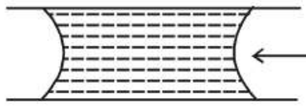
136. If the surface tension of water is 0.06 Nm^{-1}, then the capillary rise in a tube of diameter 1 mm is ($\theta = 0°$)

(a) 1.22 cm (b) 2.44 cm
(c) 3.12 cm (d) 3.68 cm

137. The height upto which liquid rises in a capillary tube is given by $h = \dfrac{2S\cos\theta}{h\rho g}$ this is for which of the following cases, water will be depressed in such a tube?

(a) θ is acute (b) θ is a right angle
(c) θ is zero (d) θ is obtuse

138. If two glass plates have water between them and are separated by very small distance (see figure), it is very difficult to pull them apart. It is because the water in between forms cylindrical surface on the side that gives rise to lower pressure in the water in comparison to atmosphere. If the radius of the cylindrical surface is R and surface tension of water is T then the pressure in water between the plates is lower by



(a) $\dfrac{2T}{R}$ (b) $\dfrac{4T}{R}$
(c) $\dfrac{T}{4R}$ (d) $\dfrac{T}{R}$

139. Water rises to a height 'h' in a capillary tube. If the length of capaillary tube above the surface of water is made less than 'h' then

(a) water rises upto the top of capillary tube and stays there without overflowing
(b) water rises upto a point a little below the top and stays there
(c) water does not rise at all.
(d) Water rises upto the tip of capillary tube and then starts overflowing like fountain.

140. The cylindrical tube of a spray pump has radius, R, one end of which has n fine holes, each of radius r. If the speed of the liquid in the tube is V, the speed of the ejection of the liquid through the holes is

(a) $\dfrac{VR^2}{nr^2}$ (b) $\dfrac{VR^2}{n^3r^2}$
(c) $\dfrac{V^2R}{nr}$ (d) $\dfrac{VR^2}{n^2r^2}$

141. A certain number of spherical drops of a liquid of radius 'r' coalesce to form a single drop of radius 'R' and volume 'V'. If 'T' is the surface tension of the liquid, then :

(a) energy $= 4VT\left(\dfrac{1}{r}-\dfrac{1}{R}\right)$ is released
(b) energy $= 3VT\left(\dfrac{1}{r}+\dfrac{1}{R}\right)$ is absorbed
(c) energy $= 3VT\left(\dfrac{1}{r}-\dfrac{1}{R}\right)$ is released
(d) energy is neither released nor absorbed

142. Two capillary tubes A and B of diameter 1 mm and 2 mm respectively are dipped vertically in a liquid. If the capillary rise in A is 6 cm, then the capillary rise in B is

(a) 2 cm (b) 3 cm
(c) 4 cm (d) 6 cm

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. **(d)** **2.** **(b)**

3. **(d)** 1 atm = 1.01×10^5 Pa; 1 bar = 10^5 Pa
$\therefore$ Pa, atm, Bar, all are the units of pressure.

4. **(b)** Sphygmomanometer is the blood pressure gauge and it measures the gauge pressure.

5. **(c)** Liquid pressure depends upon the height of liquid column and is independent of the shape of liquid surface and the area of liquid surface. The liquid at rest exerts equal pressure in all directions.

6. **(d)** Hydraulic machines & lifts are based on

$$P_1 = P_2 \; ; \; \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

7. **(a)** Archimedes's principle states that when a body is immersed in a liquid, it loses it weight and the loss in weight of body is equal to the weight of the liquid displaced by the immersed part of the body.

8. **(c)** Specific gravity of a body is defined as ratio of weight of body in air to the loss of weight of body in water at 4°C.

$$= \frac{Vsg}{Vswg} = \frac{s}{sw} = \text{Relative density of the body.}$$

9. **(d)** As we go up the density of air decreases and so does the value of g. since $P = h\rho g$
$\therefore$ P also decreases.

10. **(a)** In open-tube manometer, low-density liquid such as oil is used for measuring small pressure differenes.

11. **(c)** Weight of water displaced

(Below the water volum = $\frac{3}{4}$v)

$= V\rho g$

$= \frac{3}{4} V s_w g$

For a floating body weight of body
= weight of water displaced by it

12. **(b)** **13.** **(d)** **14.** **(c)**

15. **(b)** **16.** **(a)**

17. **(d)** Pressure applied to enclosed fluid is transmitted equally in all direction according to Pascal law.

18. **(c)** $P = h\rho g$ i.e. pressure does not depend upon the area of bottom surface.

19. **(b)**

20. **(b)** Beyond the critical speed, the flow of fluids becomes turbulent as the flow loses its steadiness.

21. **(d)** Reynold's number N for turbulent motion is more than 3000 and $N = \frac{v\rho r}{\eta}$ i.e., $N \propto v\rho$

22. **(a)** In stream line flow velocity of flow at any point in the liquid does not vary with time.

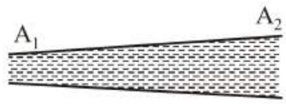
23. **(c)** In Bernoulli's theorem only law of conservation of energy is obeyed.

24. **(c)** Bernoulli's equation is a indespensable tool for the analysis of flow of liquids.

25. **(a)**

26. **(c)** Magnus effect of the ball can be explained easily by Bernoulli's theorem.

27. **(b)** The theorem of continuity is valid.
$\therefore A_1 v_1 \rho = A_2 v_2 \rho$ as the density of the liquid can be taken as uniform.



$\therefore A_1 v_1 = A_2 v_2$

$\Rightarrow$ Smaller the area, greater the velocity.

28. **(a)** **29.** **(c)**

30. **(a)** As the temperature rises the atoms of the liquid become more mobile and the coefficient of viscosity falls.

31. **(b)** When terminal velocity is reached then body moves with constant velocity hence, accelesation is zero.

32. **(a)** Terminal velocities of rain drops are proportional to square of their radii.
Terminal velocity of a body is given by

$$v_T = \frac{2R^2}{9\eta}(d - \sigma)g \text{ or, } V \propto R^2$$

33. **(c)** **34.** **(b)** **35.** **(a)**

36. **(b)** The various forces acting on the plate are,
(i) Weight of the plate acting vertically downward
(ii) Surface tension acting vertically downwards
(iii) Upthrust due to liquid acting vertically upward

37. **(d)** **38.** **(c)**

39. **(c)** Excess pressure inside the soap bubble

$$p = \frac{4s}{r} \quad \therefore \quad p \propto \frac{1}{r}$$

40. **(d)** Surface tension of a liquid is due to force of attraction between like molecules of a liquid i.e., cohesive force between the molecules.

41. **(a)** Surface tension = workdone per unit area in increasing the surface area of a liquid under isothermal condition.

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

43. **(c)** Excess of pressure in a soap bubble, P = 4T/r i.e., $P \propto \frac{1}{r}$ therefore pressure in a smaller bubble is more than that of a bigger bubble. When two bubbles of different radii are in communication, then the air flows from higher pressure to lower pressure i.e. from smaller bubble into larger one.

44. (a) When two drops merge together to form one drop, the surface area of drop will decrease, due to which the energy of bigger drop is less than the sum of the energy of two smaller drops. Due to it, the energy is released.

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

46. (b) When a sparingly soluble salt (like detergent) added to water, the surface tension of water decreases.

47. (b) The surface tension of oil is less than that of water, so the oil spreads as a thin layer.

48. (b) The contact angle between water & glass is acute but that of water & mercury is obtuse.
$\therefore$ the liquid meniscus is common for mercury.

49. (b) Kerosene oil rises up in wick of a lantern because of capillary action. If the surface tension of oil is zero, then it will not rise, so oil rises up in a wick of a lantern due to surface tension.

50. (a) $h = \dfrac{2\,T\cos\theta}{r\rho g}$; The liquid will rise i.e., h is positive if $\cos\theta$ is +ve; It is so if $\theta < 90°$ or θ is acute.

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

STATEMENT TYPE QUESTIONS

52. (d)

53. (d) According to Bernoulli's theorem, when velocity of liquid flow increases, the pressure decreases. As the two boats moving in parallel directions close to each other, the stream of water between the boats is set into vigorous motion. As a result the presssure exerted by water in between the boats becomes less than the pressure of water outside the boats. Due to this pressure difference the boats are pulled towards each other.

54. (d) For streamline flow, all are correct.

55. (c)

56. (c) Velocity of efflux, $v_e = \sqrt{2gh}$, clearly v_e depends on g and h.

57. (d) For gases, $\eta \propto \sqrt{T}$; for liquids, η increases with increase in pressure, whereas for gases, η is independent of pressure.

58. (c) 59. (d)

60. (b) Surface tension depends on the temperature like viscosity, surface tension decreases with rise in temperature.

61. (c)

MATCHING TYPE QUESTIONS

62. (a) (A)$\to$(3) ; (B)$\to$(2) ; (C)$\to$(1) ; (D)$\to$(4)

63. (a) 64. (c) 65. (a) 66. (d)
67. (c) 68. (b) 69. (b)

DIAGRAM TYPE QUESTIONS

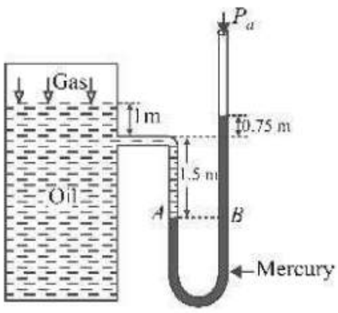
70. (d) Pressure = $h\rho g$ i.e. pressure at the bottom is independent of the area of the bottom of the tank. It depends onthe height of water upto which the tank is filled with water. As is both the tanks, the levels of water are the same, pressure at the bottom is also the same.

71. (d) From the figure it is clear that liquid 1 floats on liquid 2. The lighter liquid floats over heavier liquid. Therefore we can conclude that $\rho_1 < \rho_2$
Also $\rho_3 < \rho_2$ otherwise the ball would have sink to the bottom of the jar.
Also $\rho_3 > \rho_1$ otherwise the ball would have floated in liquid 1. From the above discussion we conclude that
$$\rho_1 < \rho_3 < \rho_2.$$

72. (b) $\rho_{oil} < \rho < \rho_{water}$
Oil is the least dense of them so it should settle at the top with water at the base. Now the ball is denser than oil but less denser than water. So it will sink through oil but will not sink in water. So it will stay at the oil-water interface.

73. (a) Mass of liquid in horizontal portion of U-tube = $Ad\rho$
Pseudo force on this mass = $Ad\rho a$
Force due to pressure difference in the two limbs
$$= (h_1\rho g - h_2\rho g)\,A$$
Equating both the forces
$$(h_1 - h_2)\,\rho g A = Ad\rho a$$
$$\Rightarrow (h_1 - h_2) = \frac{Ad\rho a}{\rho g A} = \frac{ad}{g}$$

74. (a)



Suppose P_{gas} is the pressure of the gas on the oil. As the points A and B are at the same level in the mercury columns, so
$$P_A = P_B$$
or $$P_{gas} + \rho_{oil}\, g h_{oil} = P_a + \rho_{Hg}\, g\, h_{Hg}$$

or $P_{gas} + 820 \times 9.8 \times (1+1.50) =$

$$P_a + 13.6 \times 10^3 \times 9.8 \times (1.5+0.75)$$

or $P_{gas} + 20.09 \times 10^3 = P_a + 299.88 \times 10^3$

$\therefore \quad P_{gas} - Pa = 299.88 \times 10^3 - 20.09 \times 10^3$

or $\quad [P_{gas}]_{gauge} = 279.8 \times 10^3 \ N/m^2$

$= 2.8 \times 10^5 \ N/m^2$

Absolute pressure of gas

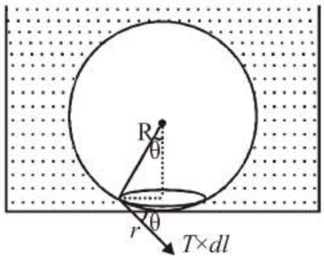
$[P_{gas}]_{absolute} = [P_{gas}]_{gauge} + P_a$

$= 2.8 \times 10^5 + 1.01 \times 10^5$

$= 3.81 \times 10^5 \ N/m^2$

75. (b) The candle floats on the water with half its length above and below water level. Let its length be 10 cm. with 5 cm. below the surface and 5 cm. above it. If its length is reduced to 8 cm, it will have 4 cm. above water surface. So we see tip going down by 1 cm. So rate of fall of tip = 1 cm/hour.

76. (b) None of the given option is correct.
When the bubble gets detached,
Bouyant force = force due to surface tension



Force due to excess pressure = upthrust

Access pressure in air bubble = $\frac{2T}{R}$

$$\frac{2T}{R}(\pi r^2) = \frac{4\pi R^3}{3T}\rho_w g$$

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

77. (d) At equilibrium, weight of the given block is balanced by force due to surface tension, i.e.,
2L. S = W

$$\text{or } S = \frac{W}{2L} = \frac{1.5 \times 10^{-2} N}{2 \times 0.3 \ m} = 0.025 Nm^{-1}$$

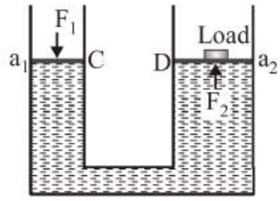
ASSERTION- REASON TYPE QUESTIONS

78. (b) Since mercury is a most dense liquid available therefore by using it, barometric arrangement will be of very convinient size.

79. (c) In case of iron needle, the weight of water displaced by the needle is much less than the weight of the needle, hence it sinks but in case of a large iron ship the weight of water displaced by the ship is higher than the weight of the ship, hence it floats in water.

80. (a)

81. (b) According to Pascal's law, if gravity effect is neglected, the pressure at every point of liquid in equilibrium of rest is same



$$P_1 = P_2 \text{ i.e., } \frac{F_1}{a_1} = \frac{F_2}{a_2} \text{ or } F_2 = \frac{a_2}{a_1}F_1$$

As $a_2 >> a_1 \therefore F_2 >> F_1$
This shows that small force (F_1) applied onthe smaller piston (of area a_1) will be appearing as a very large force onthe larger piston.

82. (a) Since the net buoyant force on the brick completely submerged in water is independent of its depth below the water surface, the man will have to exert same force on both the bricks. Hence statement 1 is true, statement 2 is a correct explanation for statement 1.

83. (a) Height of the blood column in the human body is more at feet than at the brain. As P = hρg. therefore the blood exerts more pressure at the feet than at the brain.

84. (d) Since due to applied force on liquid, the pressure is transmitted equally in all directions inside the liquid. That is why there is no fixed direction for the pressure due to liquid. Hence hydrostatic pressure is a scalar quantity.

85. (a)

86. (a) Since, the fluid move from higher pressure to lower pressure and in a fluid, the pressure increase with increase of depth. Hence, the pressure p_0 will be lesser at the top than that at the bottom ($p_0 + h\rho g$). So, the air bubble moves from the bottom to the top and does not move sideways, since the pressure is same at the same level. Further in coming from bottom to top the pressure decreases. According to Boyle's law pV = constant.

Therefore, if pressure decreases the volume increses, it means radius increases

87. (a) **88. (a)** **89. (a)**

90. (d) Pressure of water reduces when it comes from wide pipe to narrow pipe. According to equation of continuity, av = constant. As the water flows from wider tube to narrow tube, its velocity increases. According to Bernouli prinicple, where velocity is large pressure is less.

91. (a)

92. (d) Surface tension of oils and paints is kept low so that it can spread over larger area.

93. (d) **94. (c)**

95. (c) The two glass plates stick together due to surface tension.

96. (d) The soap solution, has less surface tension as compared to ordinary water and its surface tension decreases further on heating. The hot soap solution can, therefore spread over large surface area and also it has more wetting power. It is on account of this property that hot soap solution can penetrate and clean the clothes better than the ordinary water.

97. (b) We know that the intermolecular distance between the gas molecules is large as compared to that of liquid. Due to it the forces of cohesion in the gas molecules are very small and these are quite large for liquids. Therefore, the concept of surface tension is applicable to liquid but not to gases.

98. (a) $h = \frac{2T}{Rdg} \Rightarrow hR = \frac{2T}{dg} \quad \therefore hR = \text{constant}$

Hence when the tube is of insufficient length, radius of curvature of the liquid meniscus increases, so as to maintain the product hR a finite constant.

i.e., as h decreases, R increases and the liquid meniscus becomes more and more flat, but the liquid does not overflow.

CRITICALTHINKING TYPE QUESTIONS

99. (d) Let V_i be the volume of the iceberg inside sea water and V is the total volume of iceberg.

Total weight of iceberg

= weight of water displaced by iceberg.

$$V.\rho_{ice}\, g = V_i.\rho_{water}.g \Rightarrow \frac{V_i}{V} = \frac{\rho_{ice}}{\rho_{water}} = \frac{0.92}{1.03}$$

Thus the fraction of total volume of iceberg above the sea level

$$= \left(\frac{V - V_i}{V}\right) \times 100\% = \frac{\left[V - \left(\frac{0.92}{1.03}\right)V\right]}{V} \times 100\%$$

$$= \left(1 - \frac{0.92}{1.03}\right) \times 100\% = \frac{0.11}{1.03} \times 100\% \approx 11\%$$

100. (b) The volume of liquid displaced by floating ice

$$V_D = \frac{M}{\sigma_L}$$

Volume of water formed by melting ice, $V_F = \frac{M}{\sigma_w}$

If $\sigma_L > \sigma_w$, then $\frac{M}{\sigma_L} < \frac{M}{\sigma_w}$ i.e., $V_D < V_F$

i.e., volume of liquid displaced by floating ice will be lesser than water formed and so the level if liquid will rise.

101. (d) Weight of submerged part of the block

$$W = \frac{1}{3} v \text{ (Density of water) g} \qquad ...(i)$$

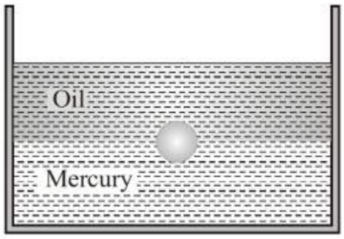
Excess weight, = weight of water having $\frac{2}{3}$ volume of the block.

$$W' = \frac{2}{3} v \text{ (Density of water) g} \qquad ...(ii)$$

Dividing (ii) by (i),

$$\frac{W'}{W} = \frac{2/3}{1/3} \quad \therefore W' = 2W \Rightarrow W' = 2 \times 6 = 12 \text{ kg}$$

102. (c)



As the sphere floats in the liquid. Therefore its weight will be equal to the upthrust force on it

$$\text{Weight of sphere} = \frac{4}{3}\pi R^3 \rho g \qquad ...(i)$$

Upthrust due to oil and mercury

$$= \frac{2}{3}\pi R^3 \times \sigma_{oil} g + \frac{2}{3}\pi R^3 \sigma_{Hg} g \qquad ...(ii)$$

Equating (i) and (ii)

$$\frac{4}{3}\pi R^3 \rho g = \frac{2}{3}\pi R^3 0.8g + \frac{2}{3}\pi R^3 + 13.6g$$

$$\Rightarrow 2\rho = 0.8 + 13.6 = 14.4 \Rightarrow \rho = 7.2$$

103. (c) Since pressure is transmitted undiminished throughout the fluid (Pascal's law)

$$F_1 = \frac{A_1}{A_2} F_2 = \frac{\pi\,(5 \times 5)}{\pi\,(15 \times 15)} (1350 \times 9.81)$$

$$\approx 1.5 \times 10^3 \text{ N}$$

The air pressure that will produce this force is

$$P = \frac{F_1}{A_1} = \frac{1.5 \times 10^3}{\pi\,(5 \times 10^{-2} \text{ m})^2} = 1.9 \times 10^5 \text{ Pa}$$

104. (a) Total cross-sectional area of the thigh bones

$A = 2\,(10 \times 10^{-4}) = 2 \times 10^{-3} \text{ m}^2$

Force acting on the bones = $mg = 40 \times 10$

= 400 N

$$\therefore P_{av} = \frac{F}{A} = \frac{400}{2 \times 10^{-3}} = 2 \times 10^5 \text{ N/m}^2$$

105. (c) Weight of the bowl = mg

$$= V\rho g = \frac{4}{3}\pi\left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right]\rho g$$

Where D = Outer diameter

d = Inner diameter , ρ = Density of bowl

Weight of the liquid diplaced by the bowl

$$= V\sigma g = \frac{4}{3}\pi\left(\frac{D}{2}\right)^3 \sigma g$$

where σ is the density of the liquid

For the floation

$$\frac{4}{3}\pi\left(\frac{D}{2}\right)^3 \sigma g = \frac{4}{3}\pi\left[\left(\frac{D}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] pg$$

$$\Rightarrow \left(\frac{1}{2}\right)^3 \times 1.2\times 10^3 = \left[\left(\frac{1}{2}\right)^3 - \left(\frac{d}{2}\right)^3\right] 2\times 10^4$$

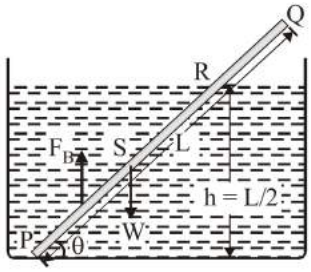
By solving we get d = 0.98 m.

106. (a) Let L = PQ = length of rod

$$\therefore \text{SP} = \text{SQ} = \frac{\text{L}}{2}$$

Weight of rod, W = Alρg. acting

At point S



And force of buoyancy,

$F_B = Al\rho_0 g$. [l = PR]

Which acts at mid-point of PR.

For rotational equilibrium.

$$Al\rho_0 g \times \frac{\ell}{2}\cos\theta = AL\rho g \times \frac{L}{2}\cos\theta$$

$$\Rightarrow \frac{l^2}{L^2} = \frac{\rho}{\rho_0} \Rightarrow \frac{l}{L} = \sqrt{\frac{\rho}{\rho_0}}$$

From figure, $\sin\theta = \frac{h}{l} = \frac{L}{2l} = \frac{1}{2}\sqrt{\frac{\rho_0}{\rho}}$

107. (a) Air flows just above the roof and there is no air flow just below the roof inside the room. Therefore $v_1 = 0$ and $v_2 = v$. Applying Bermaulli's theorem at the points inside and outside the roof, we obtain.

$(1/2)\rho v_1^2 + \rho g h_1 + P_1 = (1/2)\rho v_2^2 + \rho g h_2 + P_2$.

Since $h_1 = h_2 = h$, $v_1 = 0$ and $v_2 = v_1$

$P_1 = P_2 + 1/2\,\rho v^2$

$P_1 - P_2 = \Delta P = 1/2\,\rho v^2$.

Since the area of the roof is A, the aerodynamic lift exerted on it = F = (ΔP) A

⇒ $F = 1/2\,\rho A v^2$

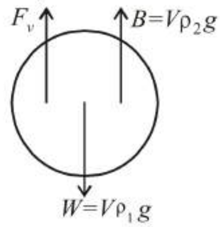
where ρ = density of air = 1.3 kg/m^3

A = 20 m^2, v = 29.44 m/sec.

⇒ $F = \{1/2 \times 1.3 \times 20 \times (29.44)^2\}$ N = 1.127×10^4 N.

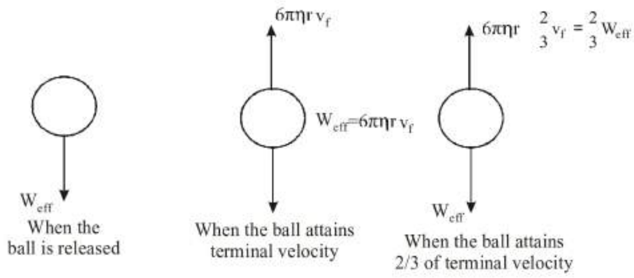
108. (a) The condition for terminal speed (v_t) is

Weight = Buoyant force + Viscous force



$$\therefore V\rho_1 g = V\rho_2 g + kv_t^2 \qquad \therefore v_t = \sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$$

109. (b)



When the ball is just released, the net force on ball is W_{eff} (= mg – buoyant force)

The terminal velocity v_f of the ball is attained when net force on the ball is zero.

∴ Viscous force $6\pi\eta r\, v_f = W_{eff}$

When the ball acquires $\frac{2}{3}$rd of its maximum velocity

v_f the viscous force is = $\frac{2}{3}W_{eff}$

Hence net force is $W_{eff} - \frac{2}{3}W_{eff} = \frac{1}{3}W_{eff}$

∴ required acceleration is a/3

110. (d) **When the electric field is on**

Force due to electric field = weight

$$qE = mg \Rightarrow qE = \frac{4}{3}\pi R^3 \rho g$$

$$\therefore q = \frac{4\pi R^3 \rho g}{3E} \qquad ...(i)$$

When the electric field is switched off

Weight = viscous drag force

$mg = 6\pi\eta R v_t$

$\frac{4}{3}\pi R^3 \rho g = 6\pi\eta R v_t$

$\therefore R = \sqrt{\frac{9\eta v_t}{2\rho g}}$ ...(ii)

From (i) & (ii) $g = \frac{4}{3}\pi\left[\frac{9\eta v_t}{2\rho g}\right]^{\frac{3}{2}} \times \frac{\rho g}{E}$

$= \frac{4}{3}\times\pi\left[\frac{9\times1.8\times10^{-5}\times2\times10^{-3}}{2\times900\times9.8}\right]^{\frac{3}{2}} \times \frac{900\times9.8\times7}{81\pi\times10^5}$

$= 7.8\times10^{-19}$ C

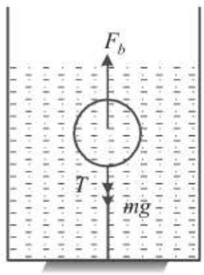
111. (d) $T + mg = F_b$

$\therefore T = F_b - mg$

$= V\rho_w g - mg$

$= \frac{m}{(\rho_w/\eta)}\rho_w g - mg$

$= (\eta-1)mg$.



112. (d) Using the formula of the terminal velocity of a body falling through a viscous medium,

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

Where ρ is the density of material of body and σ is the density of medium.

In case of the air bubble $\rho = 1$ and $\sigma = 1.47\times10^3$ kg/ms and the air bubble rises up.

$\eta = \frac{2r^2\sigma g}{9V}$

$= \frac{2\times(10^{-2})^2\times1.47\times10^3\times9.8}{9\times0.21\times10^{-2}} = \frac{2\times1.47\times9.8\times10}{9\times0.21}$

$= 1.52\times10^3$ decapoise $= 1.52\times10^4$ Poise

113. (a) dv = 8 cm/s and dx = 0.1 cm

Velocity gradient $= \frac{dv}{dx} = \frac{8}{0.1} = 80/s$.

114. (b) $v \propto \frac{\rho-\rho_0}{\eta}$

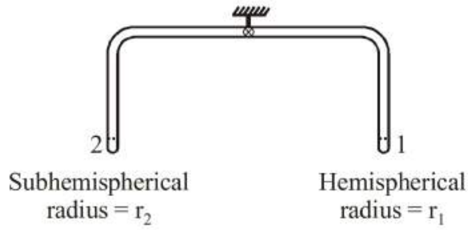
$\therefore \frac{v_2}{v_1} = \frac{\rho-\rho_{02}}{\rho-\rho_{01}}\times\frac{\eta_1}{\eta_2} = \frac{7.8-1.2}{7.8-1}\times\frac{8.5\times10^{-4}\times10}{13.2}$

$= 6.25\times10^{-4}$ cms^{-1}

115. (b) Pressure inside tube $= P = P_0 + \frac{4T}{r}$

$\therefore P_2 < P_1$ (since $r_2 > r_1$)

Hence pressure on side 1 will be greater than side 2. So air from end 1 flows towards end 2



116. (c) Velocity of efflux $v = \sqrt{2gh}$

$= \sqrt{2\times10\times0.2} = 2$ ms^{-1}

117. (a) Volumes of two soap bubbles

$V_1 = \frac{4}{3}\pi r_1^3$ and $V_2 = \frac{4}{3}\pi r_2^3$

where r_1 and r_2 are the radii of soap bubbles.

Let s be the surface tension of the soap solution. The excess pressure inside the two soap bubbles, then

$P_1 = \frac{4S}{r_1}$ and $P_2 = \frac{4S}{r_2}$

When these two bubbles coalesce under isothermal conditions a bigger bubble of radius R is formed. If V and P be the volume and excess pressure inside this bigger bubble, then

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

Here Boyle's law holds as the bigger bubble is formed under isothermal conditions

i.e., $P_1V_1 + P_2V_2 = PV$

$\frac{4S}{r_1}\times\frac{4}{3}\pi r_1^3 + \frac{4S}{r_2}\times\frac{4}{3}\pi r_2^3 = \frac{4S}{R}\times\frac{4}{3}\pi R^3$

$\Rightarrow r_1^2 + r_2^2 = R^2$ or $R = \sqrt{r_1^2 + r_2^2}$

118. (a) Pressure difference between lungs and atmosphere

= (760 – 750) mm of Hg

= 10 mm of Hg = 1 cm of Hg

Let the boy can suck water from depth h. Then

Pressure difference $= h\rho_{water}g = 1$ cm of Hg

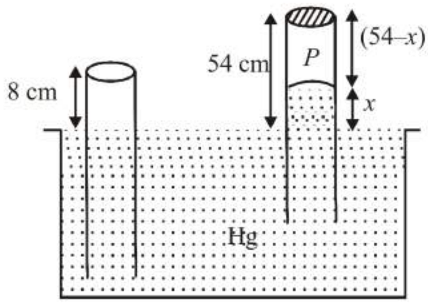
or, $h\times1$g cm$^{-3}\times980$ cm s^{-2}

$= 1$ cm $\times13.6$g cm$^{-3}\times980$ cm s^{-2}

$\therefore h = 13.6$ cm

The boy can suck water from the depth of 13.6 cm

119. (a)



Length of the air column above mercury in the tube is,

$P + x = P_0$

$\Rightarrow \quad P = (76 - x)$

$\Rightarrow \quad 8 \times A \times 76 = (76 - x) \times A \times (54 - x)$

$\therefore \quad x = 38$

Thus, length of air column = 54 – 38 = 16 cm.

120. (d) When stones are inside and float, water displacement = V.p

When inside water displacement is V only.

Then water level falls.

121. (d) From stoke's law, $F = 6\pi\eta R_1 v$, and $V = \frac{4}{3}\pi R^3$

$F' = 6\pi\eta R_2 v, \left(\text{volume } 8\text{ V} = \frac{4}{3}\pi(2R)^3\right)$

$= 6\pi\eta(2R)v$

$= 2F$

122. (d) Surface tension = 0.075 N/m; diameter = 30 cm = 0.30 m

$\therefore$ Force = $0.075 \times 0.30 = 0.0225\text{ N} = 2.25 \times 10^{-2}\text{N}$.

123. (c) Work done = Surface tension × increase in area of the film

$W = S \times \Delta A$

Increase in area = Final area – initial area

$= 10 \times (0.5 + 0.1) - 10 \times 0.5 = 1\text{ cm}^2$

$\therefore \quad W = 72 \times 2 \times 1 = 144\text{ erg}$

[$\because$ There are 2 free surfaces; $\therefore\ \Delta A = 2 \times 1$].

124. (c) Work done, W = S [2 × (Change in area)]

[$\because$ there are two free surface]

Surface tension, $S = \dfrac{W}{2 \times (\text{change in area})}$

$= \dfrac{3 \times 10^{-4}}{2 \times 10(11-6) \times (10^{-2})^2} = 3 \times 10^{-2}\text{ N/m}$

125. (a) $W = T\Delta A = 4\pi R^2 T(n^{1/3} - 1)$

$= 4 \times 3.14 \times (10^{-2})^2 \times 460 \times 10^{-3}[(10^6)^{1/3} - 1] = 0.057$

126. (c) Work done = Change in surface energy

$\Rightarrow W = 2T \times 4\pi\,(R_2^2 - R_1^2)$

$= 2 \times 0.03 \times 4\pi[(5)^2 - (3)^2] \times 10^{-4}\text{J} = 0.4\,\pi\text{ mJ}$

127. (d) Excess pressure inside the soap bubble = $\dfrac{4S}{r}$

So the pressure inside the soap bubble = $P_{atm} + \dfrac{4S}{r}$

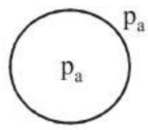
From ideal gas equation $PV = nRT$

$$\frac{P_A V_A}{P_B V_B} = \frac{n_A}{n_B} \Rightarrow \frac{\left(8 + \frac{4S}{r_A}\right)\frac{4}{3}\pi(r_A)^3}{\left(8 + \frac{4S}{r_B}\right)\frac{4}{3}\pi(r_B)^3} = \frac{n_A}{n_B}$$

Substituting S = 0.04 N/m, r_A = 2cm, r_B = 4 cm.

$\dfrac{n_A}{n_B} = \dfrac{1}{6} \qquad \therefore \quad \dfrac{n_B}{n_A} = 6$.

128. (a) Inside pressure must be $\dfrac{4T}{r}$ greater than outside pressure in bubble.

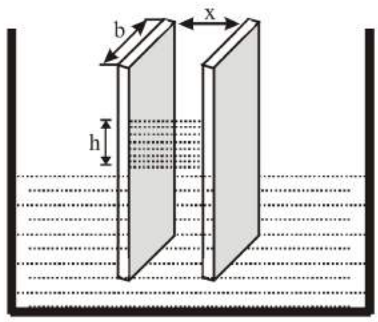


This excess pressure is provided by charge on bubble.

$\dfrac{4T}{r} = \dfrac{\sigma^2}{2\varepsilon_0};\quad \dfrac{4T}{r} = \dfrac{Q^2}{16\pi^2 r^4 \times 2\varepsilon_0}\quad \left[\sigma = \dfrac{Q}{4\pi r^2}\right]$

$Q = 8\pi r\sqrt{2rT\varepsilon_0}$

129. (b)



Let the width of each plate is b and due to surface tension liquid will rise upto height h then upward force due to surface tension.

$= 2Tb\cos\theta$ ...(i)

Weight of the liquid rises in between the plates

= Vdg = (bxh)dg ...(ii)

Equating (i) and (ii) we get, $2T\cos\theta = xhdg$

$\therefore\ h = \dfrac{2T\cos\theta}{xdg}$

130. (c) Water fills the tube entirely in gravity less condition i.e., 20 cm.

131. (d) For rise in capillary, the formula is $h = \dfrac{2T}{r\rho g}$

So, for first capillary tube $h_1 = \dfrac{2T}{r_1\rho g}$

For second, $h_2 = \frac{2T}{r_2\rho g}$

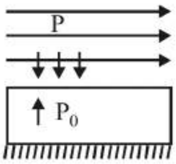
$\frac{h_1}{h_2} = \frac{r_2}{r_1} \Rightarrow \frac{3}{h_2} = \frac{r_1}{3\times r_1}\left[r_2 = \frac{r_1}{3}\right]$

$h_2 = 9mm$

132. (b) According to Bernoulli's theorem,

$P + \frac{1}{2}\rho v^2 = P_0 + 0$

So, $\Delta P = \frac{1}{2}\rho v^2$



$F = \Delta PA = \frac{1}{2}\rho v^2 A$

$= \frac{1}{2} \times 1.2 \times 40 \times 40 \times 250$

$= 2.4 \times 10^5$ N (upwards)

133. (d) In the satellite , the weight of the liquid column is zero. So the liquid will rise up to the top of the tube.

134. (a) Weight of the liquid column = T cosθ × 2πr.
For water θ= 0°. Here weight of liquid column $W = 7.5 \times 10^{-4}$N and $T = 6 \times 10^{-2}$N/m. Then circumference, $2\pi r = W/T = 1.25 \times 10^{-2}$m

135. (b) $T = \frac{F}{2\pi r} = \frac{6.28\times 10^{-4}}{2\times 3.14\times 2\times 10^{-3}} = 5\times 10^{-2}\,N/m$

136. (b) $h = \frac{2T}{rdg} = \frac{2\times 6\times 10^{-2}}{5\times 10^{-4}\times 10^3\times 10} = 2.4\times 10^{-2}\,m = 2.4cm$

137. (d) Since $h = \frac{2s\cos\theta}{h\rho g}$

if θ is obtuse, cos θ is negative. Hence h is negative and water is depressed in the tube.

138. (d) Here excess pressure, $P_{excess} = \frac{T}{r_1} + \frac{T}{r_2}$

$P_{excess} = \frac{T}{R}$ $\quad \because \begin{pmatrix} r_1 = R \\ r_2 = O \end{pmatrix}$

139. (a) Water rises upto the top of capillary tube and stays there without overflowing.

140. (a) Inflow rate of volume of the liquid = Outflow rate of volume of the liquid

$\pi R^2 V = n\pi r^2(v) \Rightarrow v = \frac{\pi R^2 V}{n\pi r^2} = \frac{VR^2}{nr^2}$

141. (c) As surface area decreases so energy is released.
Energy released $= 4\pi R^2 T[n^{1/3} - 1]$
where $R = n^{1/3}r$

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

142. (b) For capillary rise, according, to zurin's law
$h_1 r_1 = h_2 r_2$
$6 \times 1 = h_2 \times 2 \Rightarrow h_2 = 3$ cm