Short Answer Type Questions – I

Q.1. What is atmospheric pressure? Give its different units.

Ans. It is pressure exerted by the atmosphere of our earth.

Units used in medicine, physiology etc.

1 mm of mercury = 1 torr

1 torr = 133 Pa

Nits of meterology etc.

1 bar = 10^5 Pa

1 millibar = 10^2 Pa

Q.2. What are absolute pressure and gauge pressure?

Ans. Pressure at a point is given by the relation

$$P = P_a + h\rho g$$

Where, P_a is the atmospheric pressure and $h\rho g$ is the column pressure. Here, P is the absolute pressure and ($P - P_a$) is the gauge pressure normally measured.

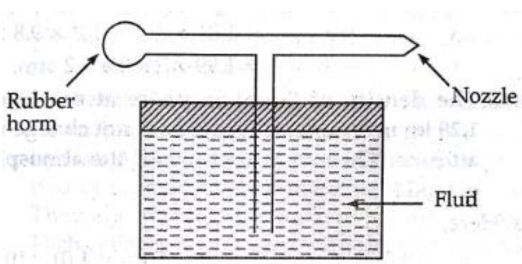
Q.3. What is an ideal fluid?

Ans. An ideal fluid should have the following qualities:

(a) It should be non-viscous, i.e., dragging force or other opposing force should be zero.
(b) It should have steady flow.
(c) It should be incompressible.
(d) The flow of such fluid should be stream line.

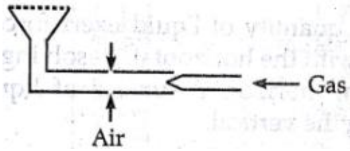
Q.4. How does rubber an atomizer work?

Ans. When rubber horn is repeatedly pressed and released, air inside the tube rushes out with large velocity which in turn decreases the pressure over the tube. The liquid rises in the tube and it is sprayed out with air through the nozzle.



Q.5. How does the burner a gas work?

Ans. The gas comes out of the nozzle with high speed due to which the surrounding pressure decreases. The air from the hole enters the main pipe. So, the gas and air both reached to the top of the burner and starts burning on ignition.



Q.6. A man sitting in a boat which is floating in a pond. If the man drinks some water from the pond, what will happen to the level of water in the pond?

Ans. When a man sitting in a boat drinks m gram of water from the pond, the weight of (boat + man) system will increase by mg and so the system will displace m gram more water for floating. Due to removal of water from pond, the water level in pond will fall. But due to water displaced by the floating system the water level in the pond will rise. Since the water removed from the pond is equal to the water displaced by the system, the level of water in the pond remains unchanged.

Q.7. Explain why it is difficult to make mercury enter a fine thermometer tube?

Ans. Since the cohesive forces between the molecules of mercury are very large as compared to adhesive forces between molecules of mercury and glass containers. Due to which, the mercury does not wet the surface of a glass container. That is why, it is difficult to make mercury enter a fine thermometer tube.

Q.8. The excess pressure inside a soap bubble is thrice the excess pressure inside a second soap bubble. What is the ratio of volume?

Ans. Given,

$$\frac{4S}{r_1} = \frac{3 \times 4S}{r_2}$$

or $$r_2 = 3r_1;$$

$$\frac{V_1}{V_2} = \frac{\left(\frac{4}{3}\right)\pi r_1^3}{\left(\frac{4}{3}\right)\pi r_2^3}$$

$$= \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{1}{3}\right)^3 = \frac{1}{27}$$

Q.9. What is the pressure on a swimmer 10 m below the surface of a lake?

Ans. $P = P_a + \rho g h$

$$= 1.01 \times 10^5 + 10^3 \times 9.8 \times 10$$

$$= 1.99 \times 10^5 \text{ Pa} \approx 2 \text{ atm}$$

Q.10. The density of the atmosphere at sea level is 1.29 kg m^{-3}. Assume that it does not change with altitude. Then how high would the atmosphere extend?

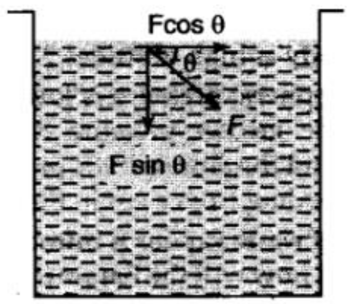
Ans. Here, $1.01 \times 10^5 = \rho g h$

$$h = \frac{1.01\times10^5}{\rho g} = \frac{1.01\times10^5}{1.29\times9.8}$$

$$= 7989 \text{ m.}$$

Q.11. Show that a liquid in a state of equilibrium of rest exerts a force perpendicular to the surface only.

Ans. Let a given quality of liquid exert force F in a direction θ with the horizontal. Resolving, we get Fcos θ along horizontal surface of liquid and Fsin θ along the vertical.



As there is no flow of liquid so Fcos θ should be zero.

Since, F ≠ 0, cos θ = 0

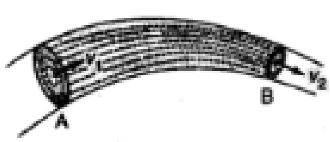
Or θ = 90°

i.e., a liquid at rest exerts normal force to the walls of the container.

Q.12. Derive equation of continuity.

Ans. Equations of continuity. Consider a non-viscous liquid in stream line flow through a tube AB of varying cross-section.

Let a_1, a_2 = area of cross-section of the tube at A and B respectively,



v_1, v_2 = velocity of flow of liquid at A and B respectively.

ρ_1, ρ_2 = densities of liquid at A and B respectively.

∴ Volume of liquid entering, per second at A

$$= a_1 v_1$$

Mass of liquid entering per second at A

$$= a_1 v_1 \rho_1$$

Similarly, mass of liquid leaving per second at B

$$= a_2 v_2 \rho_2$$

If there is no loss of liquid in the tube and the flow is steady, then

Mass of liquid entering per second at A

= Mass of liquid leaving per second at B

Or $a_1 v_1 \rho_1 = a_2 v_2 \rho_2$ …(1)

If the liquid is incompressible,

then $\rho_1 = \rho_2$

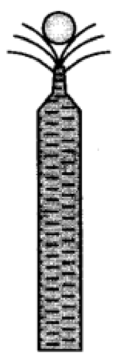
From (1) $a_1 v_1 = a_2 v_2$

or $av = a$ constant …(2)

This is knows as equation of continuity.

Q.13. If a small ping-pong ball is placed in a vertical jet of water or air, it will rise to a certain height above the nozzle and stay at that level. Explain.

Ans. Due to this high velocity of the jet of water, the pressure between the ball and jet decreases. The greater (atmospheric) pressure on the other side of the ball pushes it against the jet and the ball remains suspended. The high velocity of water takes the ball upwards along with it and makes it to spin.



A ping-pong ball supported on a jet of water.

Q.14. A barometer kept in an elevator accelerating downward read 76 cm. what will be the possible air pressure in the elevator?

Ans. When the elevator is going downwards with acceleration a then net acceleration = $(g - a)$,

Therefore pressure = $h\rho(g - a)$ dyne/cm^2.

= $\frac{76 \times 13.6 \times (g-a)}{13.6 \times g}$ cm of Hg column,

Here, (g – a) < g so, the pressure will be less than 76 cm.

Q.15. A barometer kept in an elevator accelerating upwards reads 76 cm. What will be the possible air pressure in the elevator?

Ans. When the elevator is going upwards with acceleration a then net acceleration = $(g + a)$.

Therefore pressure = $h\rho(g + a)$ dyne/cm^2.

$$= \frac{76 \times 13.6 \times (g+a)}{13.6 \times g} \text{ cm of Hg colu}$$

Here, (g + a) > g, so the pressure will be greater than 76 cm.

Q.16. Why does the free surface of a liquid behave like an elastic stretched membrane?

Ans. The liquid molecules on the surface experience a downward force. So, they have greater potential energy.

In order to have minimum energy, the free surface tends to contract to minimum area and hence behaves like an elastic stretched membrane.

Q.17. Why do the hair of a shaving brush ding together when taking out of water?

Ans. When the brush is taken out of water, thin water film is formed at the tips of the hair. It contracts due to surface tension and so the hair ding together.

Q.18. Why the tip of the nib of a pen is split?

Ans. The tip of the nib of a pen is split in order to provide a capillary which helps the ink to rise to the end of the nib and enables it to write continuously.

Q.19. Why does an iron needle float on clean water but sink when some detergent is added to this water?

Ans. Due to surface tension, the free surface of liquid at rest behaves like a stretched membrane. When an iron needle floats on the surface of clean water, its weight is supported by the stretched membrane. When some detergent is added to this water, its surface tension decreases.

As a result of it, the stretched membrane on the surface of water is weakened and is not able to support the weight of needle. Hence, needle sinks in such water.

Q.20. Explain why some oil spreads uniformly on water others float as drops.

Ans. The force of surface tension of some oil is less than surface tension of water. When such oil are dropped on the surface of water, they are pulled in all water and as such they spread uniformly on water.

In the case of other oils, whose surface tension is equal to or greater than that of water, they float as drops on water.

Q.21. Why surface tension concept is only held for liquids and not for gases which are also fluids?

Ans. We know that the intermolecular distances between the gas molecules is quite 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.

Q.22. If a capillary tube is dipped in water in a state of weightless, how will the rise of water in capillary tube be different to that observed under normal condition?

Ans. In normal conditions, the water rises in the capillary tube due to surface tension upto a height, becomes equal to the weight of water column raised in the tube. In the case of: weightlessness the effective weight of water column raised becomes zero. Hence, the water will rise upto the other end of the capillary tube, howsoever long the capillary is The water meniscus will adjust its curvature at the upper end of capillary tube so that there is no over flowing.

Q.23. (a) Define stream-line.
(b) Write any two properties of streamlines.

Ans. (a) Streamline is the actual path followed by the procession of particles in a steady flow which may be straight or curved such that tangent to it at any point indicated the direction of flow of liquid at that point.

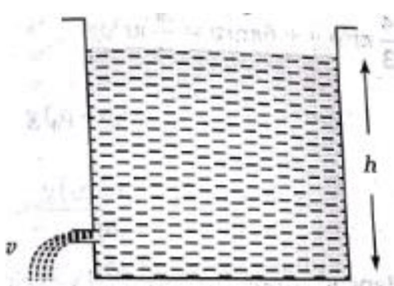
(b) Important properties of stream lines:

(i) In a stream-line flow, no two stream lines can cross each together. If they do so, the particles of the liquid at the point of intersection will have two different direction for their flow, which will destroy the steady nature of the liquid flow.

(ii) The greater is the crowding of stream lines at a place, the greater is the velocity of liquid particles at that place and vice-versa.

Q.24. What is Torricelli's law?

Ans. It states that the speed of a freely falling body is given by $v = \sqrt{2gh}$, where g is acceleration due to gravity and h is the height of fall.



The speed of efflux, i.e., fluid flow through a narrow hole of a container open from top is given by the application of Bernoulli's equation as $v = \sqrt{2gh}$

Q.25. Is Bernoulli's theorem valid for viscous liquid?

Ans. No, it should be modified to take into account the word done against viscous drag.

Q.26. Bernoulli's theorem holds for incompressible, non-viscous fluids. How is this relationship changed when the viscosity of the liquid of the fluid is not negligible?

Ans. If the viscosity of the fluid is not negligible, a part of the mechanical energy of the fluid is spend in doing work against forces of viscosity :

P + ρgh + $\frac{1}{2}pv^2$ of the fluid goes on decreasing along the direction of the flow of the fluid.

Q.27. Why are the cars and aeroplane given stream line shape?

Ans. Cars and aeroplanes are given streamline shape to minimize the backward drag of atmosphere.

Q.28. Why do cloud float in the sky?

Ans. Clouds are composed of tiny water droplets. Since, terminal velocity is proportional to the square of radius, the terminal velocity of tiny droplets is too small. The clouds thus attain terminal velocity much before they reach ground.

Q.29. The sap in trees, which consists mainly of water in summer, rises in a system of capillaries of radius $r = 2.5 \times 10^{-5}$ m. The surface tension of sap is T = 7.28 × 10^{-2} Nm^{-1} and the angle of contact is 0^o. des surface tension alone account for the supply of water to the top of all trees?

Ans. Given:

Surface Tension, T = 7.28 × 10^{-2} N/m

Angle of contact (θ) = 0^o

Radius (r) = 2.5 × 10^{-5} m

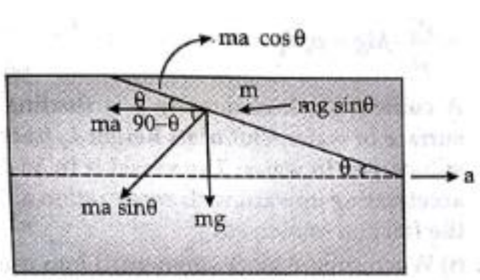
The height to which the sap will rise is

$h = \frac{2T\cos 0^o}{\rho gr} = \frac{2\times 7.28\times 10^{-2}\times 1}{10^{-3}\times 9.8\times 2.5\times 10^{-3}} = 0.6$ m [Here, ρ = density].

This is the maximum height to which the sap can rise due to surface tension. Since many trees have height much more than this, capillary action alone cannot account for the rise of water in all trees.

Q.30. The free surface of oil in a tanker, at rest, is horizontal. if the tanker starts accelerating the free surface will be tilted by a angle θ. If the acceleration is a ms^{-2}, what will be the slope of the free surface?

Ans. Let us consider the following diagram.



If the tanker accelerates in the positive direction with acceleration a. consider a parcel, the fluid of mass 8m. Forces which are acting on particle w.r.t. the tanker. Now, balancing forces (in equilibrium) along inclined direction component of weight = component of pseudo force [ma = pseudo force] mg sin θ = ma cos θ

or g sin θ = a cos θ

or $\frac{\sin\theta}{\cos\theta} = \frac{a}{g}$

∴ tan θ = $\frac{a}{g}$

This is required slope.

Q.31. Two mercury droplets of radii 0.1 cm and 0.2 cm collapse into one single drop. What amount of energy is released? The surface tension of mercury T = 435.5 × 10^{-3} Nm^{-1}

Ans. Radii of mercury droplets, $r_1 = 0.1$ cm = 1 × 10^{-3} m

r_2 = 0.2 cm = 2 × 10^{-3} m

Surface Tension, T = 435.5 × 10^{-3} N/m

Let V_1 and V_2 be the volume of the droplets and V of the resulting drop, and R be the radius of big drop formed by collapsing.

Then V = $V_1 + V_2$ or $\frac{4}{3}\pi R^3$ = $\frac{4}{3}\pi r_1^3 + \frac{4}{3}\pi r_2^3$

Or $R^3 = r_1^3 + r_2^3 = (0.001 + 0.008)$ cm^3 = 0.009 cm^3

∴ R = 0.21 cm

Change in surface area, $\Delta A = 4\pi[R^2 - (r_1^2 + r_2^2)]$

∴ Energy released, $\Delta U = T\Delta A = 4\pi T[R^2 - (r_1^2 + r_2^2)]$

= 4 × 3.14 × 435.5 × 10^{-3} [$(0.21)^2$ × 10^{-4} – (1 × 10^{-6} + 4 × 10^{-6})]

= 435.5 × 4 × 3.14 [4.41 – 5] × 10^{-6} × 10^{-3}

= –32.23 × 10^{-7} J

∴ = 3.22 × 10^{-6} J energy will be absorbed.

Q.32. If a drop a liquid breaks into smaller droplets, it results in lowering of temperature of the droplets. Let a drop radius. Let a drop of radius R, break into N small droplets each of radius r. Estimate the drop in temperature.

Ans. When a big drop having radius R breaks into N droplets each of radius r, the volume remains constant.

∴ Volume of big drop = N × volume of each small drop

$\frac{4}{3}\pi R^3$ = N × $\frac{4}{3}\pi r_3$

Or R^3 = Nr^3 or N = $\frac{R^3}{r^3}$

Change in surface area = $4\pi R^3$– N$4\pi r^2$

$= 4\pi(R^2 - Nr^2)$

Energy released = T × ∆A

$= T \times 4\pi(R^2 - Nr^2)$

Released energy lowers the temperature by ∆θ, then

Energy released = $ms\Delta\theta$

$T \times 4\pi(R^2 - Nr^2) = \left(\frac{4}{3} \times R^3 \times \rho\right) s\Delta\theta$ $\begin{bmatrix} s = \text{specific heat of liquid} \\ \rho = \text{density} \end{bmatrix}$

or $\Delta\theta = \frac{T \times 4\pi(R^2 - Nr^2)}{\frac{4}{3}\pi R^3 \rho \times s} = \frac{3T}{\rho s}\left[\frac{R^2}{R^3} - \frac{Nr^2}{R^3}\right]$

$\Delta\theta = \frac{3T}{\rho s}\left[\frac{1}{R} - \frac{1}{r}\right]$ $\because \left(N = \frac{R^3}{r^3}\right)$

Q.33. The surface tension and vapour pressure of water at 20°C is 7.28 × 10^{-2} Nm^{-1} and 2.33 × 10^3 Pa, respectively. What is the radius of the smallest spherical water droplet which can form without evaporating at 20°C?

Ans. Surface Tension of water, T = 7.28 × 10^{-2} N/m.

Vapour pressure, P = 2.33 × 10^3Pa.

The drop will evaporate if the water pressure is more than the vapour pressure. Let a water droplet of radius R can be formed.

Vapour pressure = Excess pressure in drop

$\therefore p = \frac{2T}{r} = 2.33 \times 10^3\ Pa$

$\therefore r = \frac{2T}{p} = \frac{2(7.28 \times 10^{-2})}{2.33 \times 10^3}$

$= 6.25 \times 10^{-5}$m