Exercise-4(B)

1. **What do you understand by atmospheric pressure?**
   Solution:
   Atmospheric pressure on the earth's surface is the thrust exerted per unit area on the earth surface due to column of air.

2. **Write the numerical value of the atmospheric pressure on the surface of the earth in Pascal.**
   Solution:
   The numerical value of the atmospheric pressure on the surface of the earth in Pascal is 1.013×10^5 Pa.

3. **What physical quantity is measured in torr? How is it related to the S.I unit of the quantity?**
   Solution:
   The physical quantity that is measured in torr is atmospheric pressure. It is related to the S.I unit in the following way:
   1 torr=133.28Pa

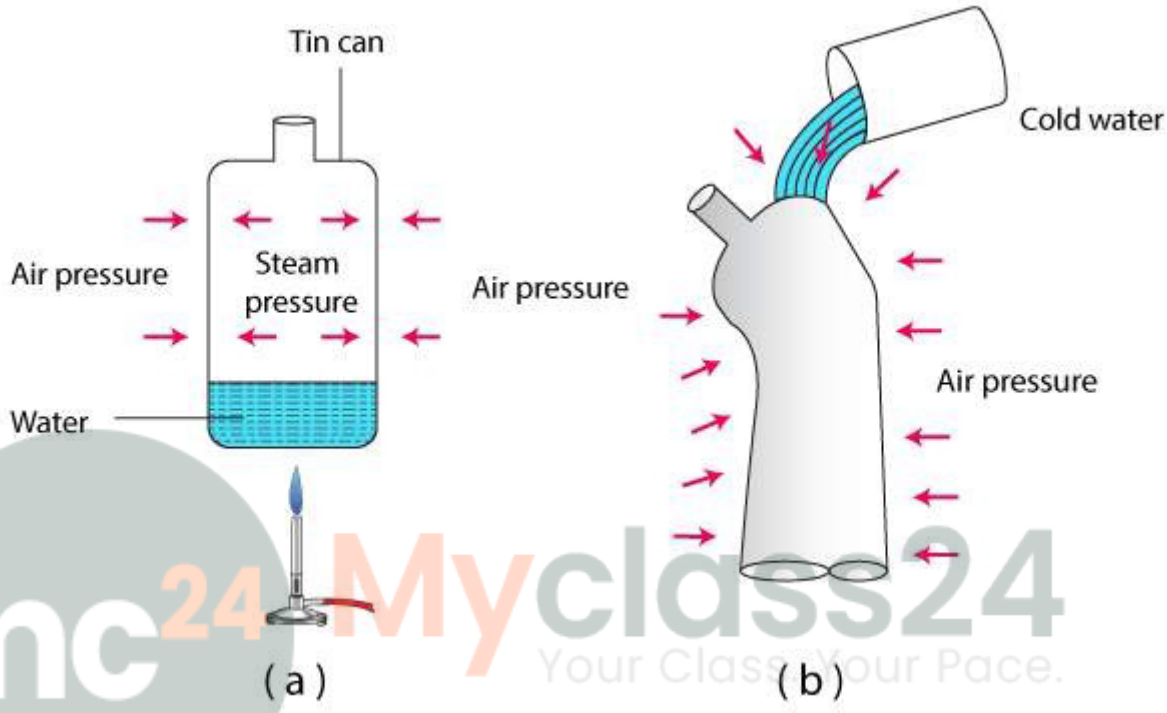
4. **Name the physical quantity which is expressed in the unit 'atm'. State its value in pascal.**
   Solution:
   The physical quantity is pressure that is expressed in the unit 'atm'. Some other units in which pressure can be expressed is bar, pascal etc.
   Value of 1 atm in pascal is 1×10^5

5. **We do not feel uneasy even under the enormous pressure of atmosphere above as well as around us. Give a reason.**
   Solution:
   It is because of our blood pressure which is fairly higher than the pressure in the atmosphere. The imbalance is managed by our blood pressure.

6. **Describe an experiment to demonstrate that air exerts pressure.**
   Solution:
   Aim:
   To demonstrate that air exerts pressure
   Procedure:
   - Use a thin can fitted with an airtight stopper, where the stopper is discarded and some water is boiled in the can.
   - Eventually we observe that steam occupies the space in the can by ousting air as observed in the figure (a).
   - Now the stopper is replaced tightly and parallely the can is removed from the flame.
   - The can is treated with some cold water
   - We observe that the can shrinks as seen in figure (b)
   - It is because the pressure as a result of the steam in the can is the same as the atmospheric

pressure outside the can as observed in the figure a.

- But when the can that is fitted with a stopper is treated with water, the steam present in the can condenses yielding water and water pressure at a lower pressure.
- As a result, the atmospheric pressure just out of the can tends to become more than the vapor pressure within the can.
- Subsequently, the atmospheric pressure present out of the can causes the can to shrink.



7. Explain the following:

(i) A balloon collapses when air is removed from it.

(ii) Water does not run out of a dropper unless its rubber bulb is pressed.

(iii) Two holes are made in a completely filled sealed tin can to take out oil from it.

Solution:

(i) When air leaves a balloon, the pressure inside is far lesser than the pressure outside the balloon. This is the reason why the balloon collapses.

(ii) It is because the pressure as a result of height column of the liquid in the dropper is lesser than the atmospheric pressure. When the dropper is pressed, the pressure inside the dropper is increased when this pressure becomes more than the atmospheric pressure, the liquid is expelled out of the dropper.

(iii) In a sealed and completely filled can, there is no air. When a hole is forced to expel oil out from the can, some of it comes out and because of the volume of air above the oil increases causing the pressure of air to decrease. However, if two holes are punched on the top cover of the can, the air present outside the can enters through one of the holes applying atmospheric pressure on the oil from within additionally with the pressure because of the oil column and is expelled out from the can through the other hole.

8. Why does the liquid rise in a syringe when its piston is pulled up?

Solution:

When a syringe's piston is drawing liquid, it is pulled up creating pressure inside which becomes lesser than the pressure outside (atmospheric pressure) that acts on the liquid. Hence, the atmospheric pressure compels the liquid to rise up in the syringe.

9. How is water drawn up from a well by a water pump?

Solution:

When the piston is pulled up in a water pump, the pressure inside the siphon declines and the atmospheric pressure acting on the water outside heightens which causes the atmospheric pressure to push the water up in the pump.

10. A partially inflated balloon is placed inside a bell jar connected to a vaccum pump. On creating vaccum inside the bell jar, balloon gets more inflated. How does the pressure change: increase, decrease or remains same, inside the (a) bell jar and (b) balloon?

Solution:

(a) The pressure changes in the bell jar, it decreases.

(b) The pressure changes in the balloon, it decreases.

11. What is the purpose of a barometer?

Solution:

The barometer is used to measure atmospheric pressure.

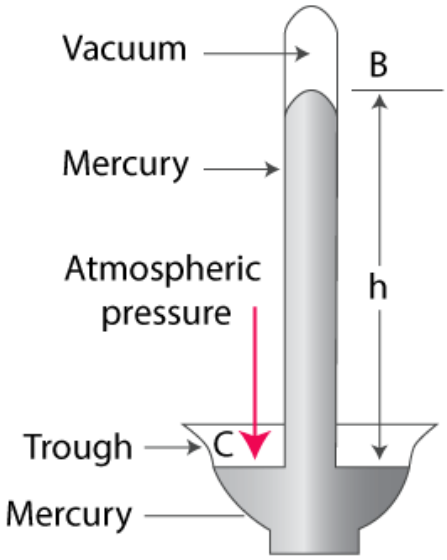
12. What is a barometer? How is a simple barometer constructed?

Solution:

A barometer is an instrument that is used to measure the atmospheric pressure.

A simple barometer can be constructed as follows:

- It uses a hard glass tube of length 1m that is closed at one end.
- Fill the tube completely with pure mercury such that no air bubble is present in the tube
- Seal the open end of the tube with thumb
- Tube is then turned upside down a few times in order to force out any air bubble that may have entered
- The complete set up is then inverted into a trough of mercury in a way that the open end of tube is completely immersed in mercury in the trough and the tube is standing vertically
- Take the thumb off in a way that no air enters the glass tube
- It is observed that the level of mercury in the tube falls till its height above the level of mercury in the trough becomes nearly 76cm

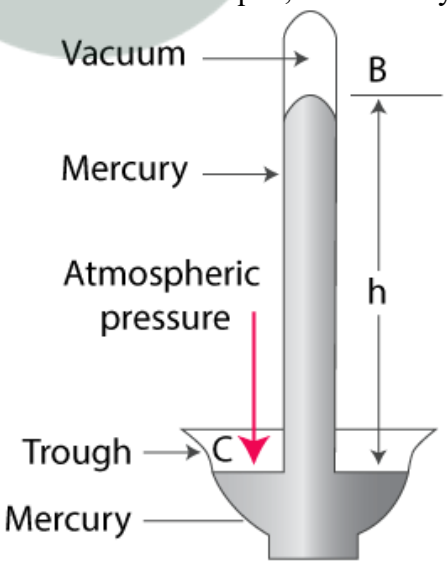


13. Explain how is the height of mercury column in the tube of a simple barometer, a measure of the atmospheric pressure.

Solution:

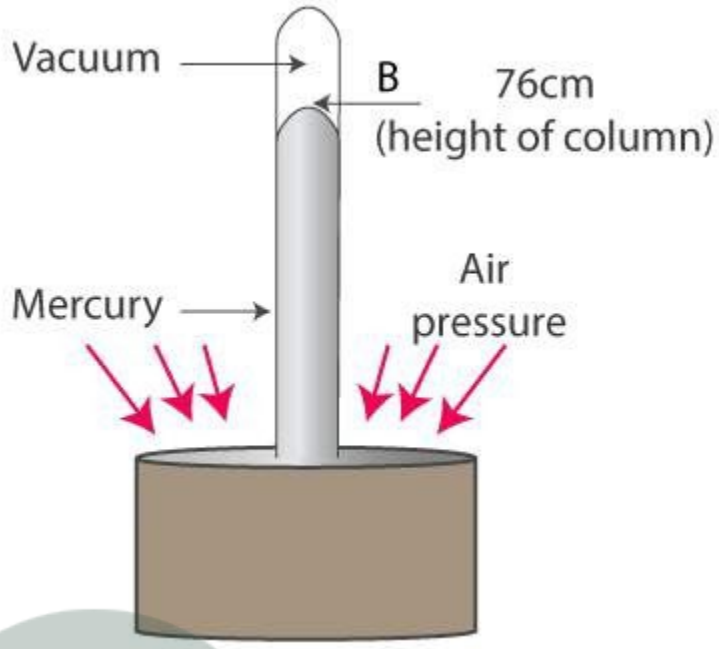
As observed in the figure, on the surface of mercury in the trough, at all points such as C, the only pressure that acts is atmospheric pressure. When the level of mercury in the tube becomes static, the pressure in the tube at point A which is at the same level of point C. The pressure at point A is because of the thrust of mercury column AB above it. Hence, the vertical height of the mercury column from the surface of mercury in the trough to the level in tube which is a measure of the atmospheric pressure.

The vertical of the mercury column in it is called the barometric height. Had the pressure at points A and C be not equal, the mercury level in the tube will not be static.



14. Illustrate with the help of a labelled diagram of a simple barometer that the atmospheric pressure at a place is 76cm of Hg.

Solution:



15. Why is the barometric height used as a unit to express the atmospheric pressure?

Solution:

The atmospheric pressure acts on the mercury surface in the trough which supports the vertical column of mercury. Thus, the barometric height is used as unit to express the atmospheric pressure.

16. What is meant by the statement 'the atmospheric pressure at a place is 76cm of Hg'? State its value in Pa.

Solution:

It means that at normal pressure and temperature, the height of the mercury column supported by the atmospheric pressure is 76cm, where 76cm of Hg=1.013 x 10^5Pa

17. How will you show there is vaccum above the surface of mercury in a barometer? What name is given to this vaccum?

Solution:

The space above mercury is an empty space and is known as 'Torricellian vaccum'. This can be observed by angling the tube so that the mercury completely fills the tube. When the mercury column becomes static again, it vaporizes immediately causing the air to apply pressure on the mercury column because of which the height of the barometer declines.

18. How is the barometric height of a simple barometer affected if

(a) Its tube is pushed down into the trough of mercury?

(b) Its tube is slightly tilted from vertical?

(c) A drop of liquid is inserted inside the tube?

Solution:

(a) If the tube is pushed down into the trough of mercury, the barometric height is unchanged.
(b) If the tube is slightly tilted from vertical, the barometric height is unchanged.
(c) If a drop of liquid is inserted inside the tube, the barometric height decreases.

19. State two uses of a barometer.

Solution:

The two uses of a barometer are:

- It can be used to measure the atmospheric pressure at a place
- It can be used for weather forecasting

20. Give two reasons for the use of mercury as a barometric liquid.

Solution:

Two uses of mercury as a barometric liquid are:

- The vapor pressure of mercury is negligible hence the vapors in the torricellian vaccum does not affect the barometric height
- Density of mercury is greater than any other liquid, hence 0.76m height of the mercury column is required to balance the normal temperature, whereas the usage of other liquids need a longer tube

21. Give two reasons why water is not a suitable barometric liquid.

Solution:

The two reasons why water is not a suitable barometric liquid are:

- The density of water is low hence 10.4m height of water column is required in order to balance the normal atmospheric pressure. However, it is not convenient to take a tube of height 10.4m for a barometer.
- The vapor pressure of water is high, the vapors in the vaccum space will make the reading inaccurate.

22. Mention two demerits of a simple barometer and state how they are removed in a Fortin barometer.

Solution:

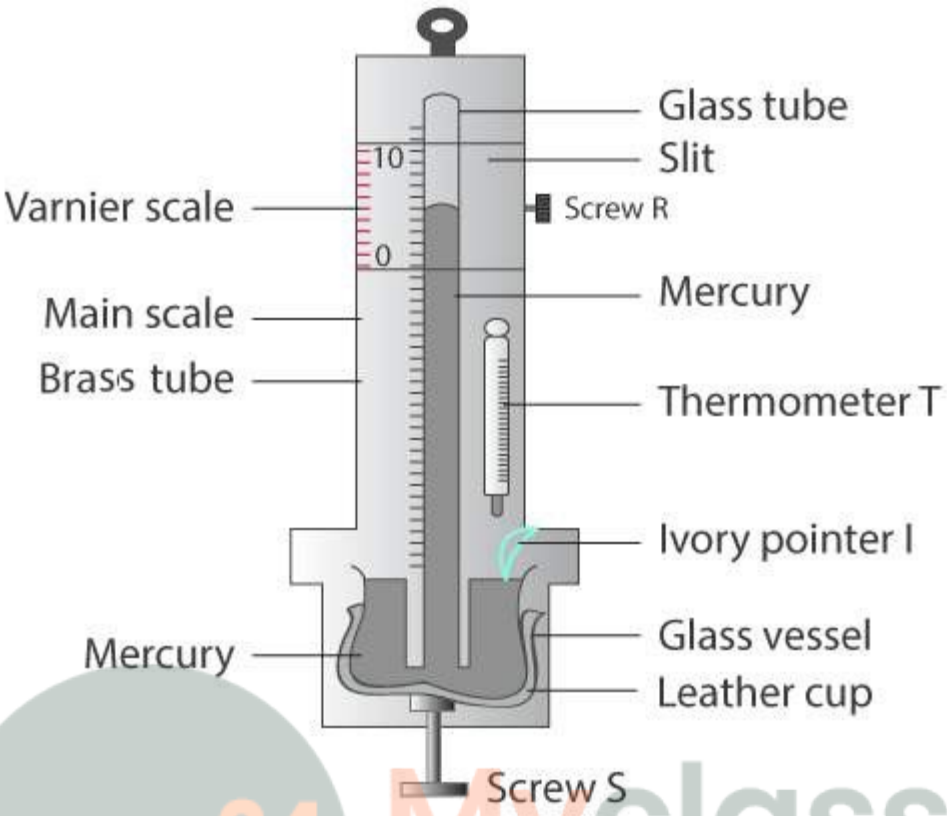
Demerits of a simple barometer are:

- There is no protection for the glass tube
- A scale cannot be fixed with the tube to measure the atmospheric pressure

The demerit of no protection for the glass tube is eliminated by enclosing the glass tube in a brass case and the next defect is rectified in Fortin's barometer as it is provided with a vernier calipers in order to measure accurately.

23. Draw a simple labelled diagram of a Fortin barometer and state how it is used to measure the atmospheric pressure.

Solution:

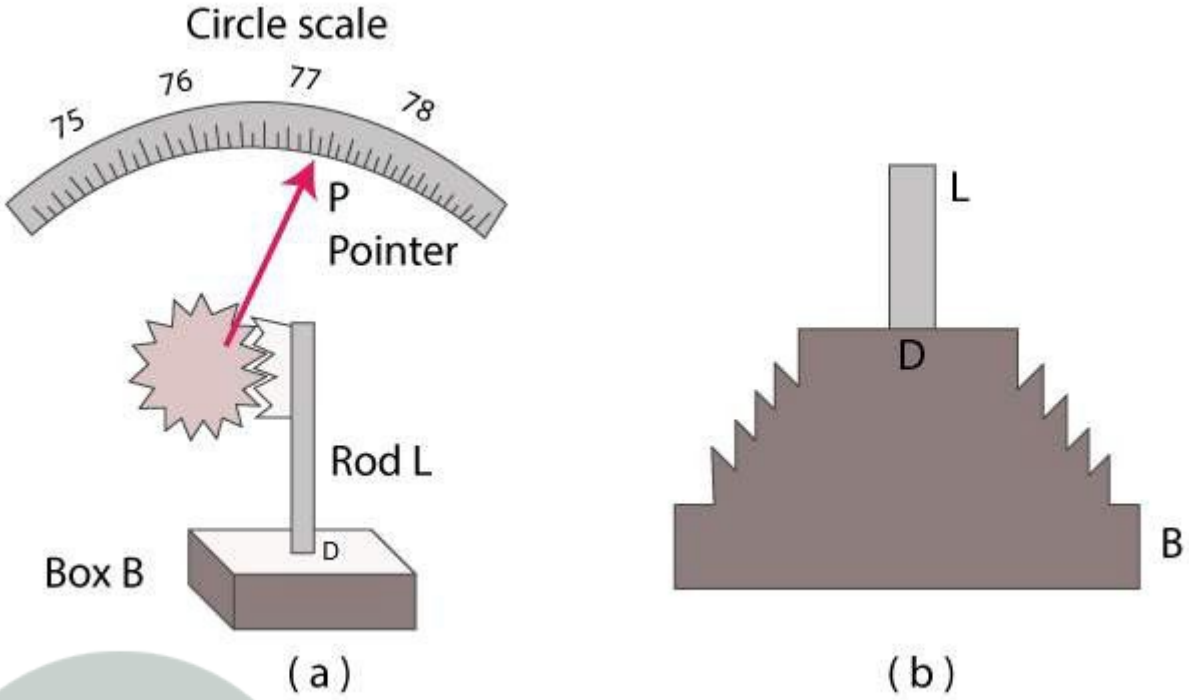


The leather cup is raised up or lowered down first to measure the atmospheric pressure, it is done using a screw S so that the ivory pointer I just touches the level of mercury in the glass vessel. The point of the mercury level in the barometer tube is observed using the main scale and the vernier scale. The addition of the vernier scale reading to the main scale reading yields barometric height.

24. What is an aneroid barometer? Draw a neat and labelled diagram to explain its construction and working.

Solution:

It is a barometer that has no liquid.



Construction:

- The figure shows the main parts which consists of a metabolic box B that is partially evacuated.
- Top D of the box is springy and is corrugated in form of diaphragm as seen in the figure.
- At the middle of the diaphragm, there is a thin rod L toothed to its upper end
- The teeth of rod fit well into the teeth of a wheel S attached with a pointer P that can move over a circular scale which is graduated and is calibrated initially with a standard barometer in order to read the atmospheric pressure directly in terms of the barometric height.

Working:

- When the atmospheric pressure increases, it presses the diaphragm D and the rod L gets depressed
- The wheel S rotates clockwise and pointer P moves to the right on the circular scale
- Simultaneously when the atmospheric pressure decreases, the diaphragm D bulges out as a result of which the rod L moved up and the wheel S rotates anti-clockwise
- Subsequently, the pointer shifts to the left and the pressure is read over the calibrated scale

25. State two advantages of an aneroid barometer over a simple barometer.

Solution:

Two disadvantages of an aneroid barometer over a simple barometer are as follows:

- Aneroid barometer is calibrated to directly read the atmospheric pressure
- It has no liquid and is portable

26. How is the reading of a barometer affected when it is taken to (i) a mine, and (ii) a hill?

Solution:

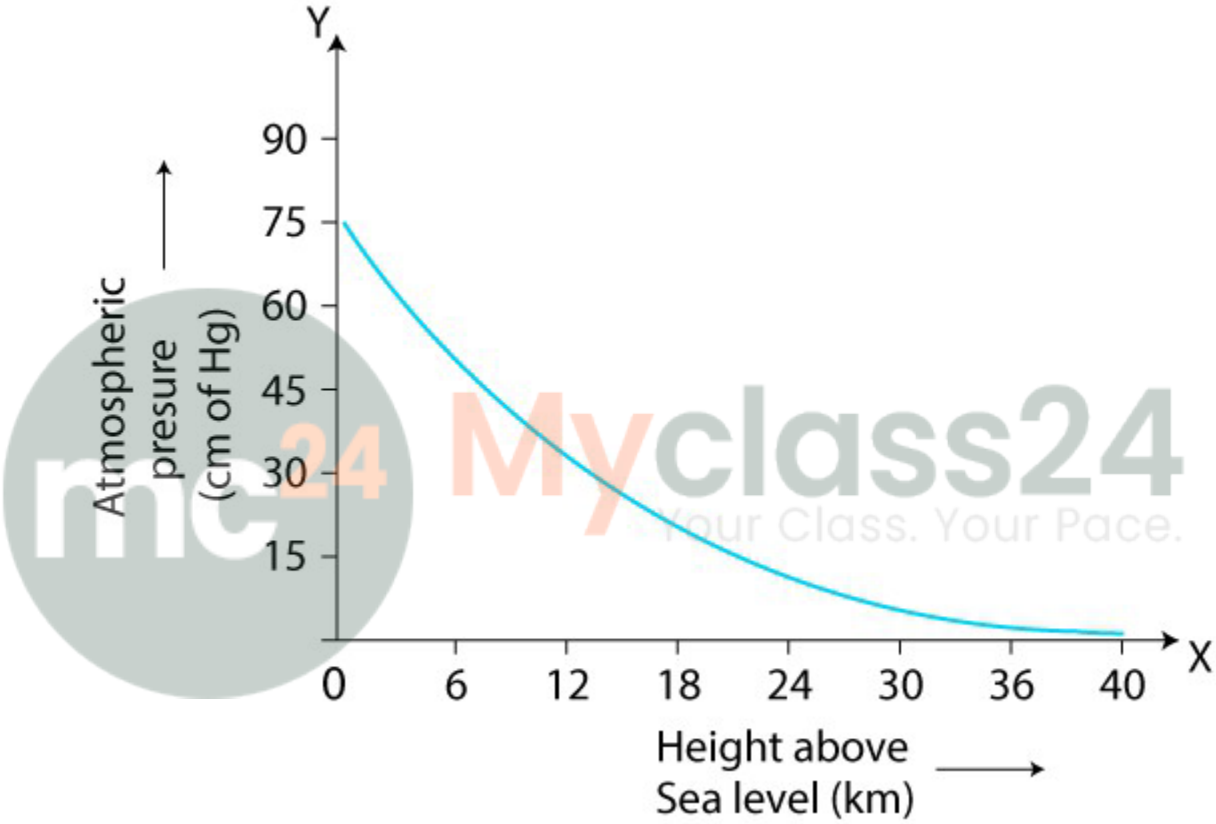
The reading can be affected in the following ways:

- A mine – the reading of a barometer increases in a mine
- A hill – the reading of a barometer decreases on a hill

27. How does atmospheric pressure change with altitude? Draw an approximate graph to show this variation.

Solution:

The atmospheric pressure changes with altitude. As the altitude increases, the pressure decreases.



28. State two factors which affect the atmospheric pressure as we go up.

Solution:

Two factors which affect the atmospheric pressure as we go up:

- Air density
- Height of air column

29. Why does a fountain pen leak at a high altitude?

Solution:

When fountain pen is taken to an altitude, the atmospheric pressure is low hence the excess pressure in the rubber tube forces the ink to leak out.

30. Why does nose start bleeding on high mountains?

Solution:

The atmospheric pressure is reasonably low on mountains. As a result of excess pressure of blood compared to the atmospheric pressure, nose starts bleeding.

31. What is an altimeter? State its principle. How is its scale calibrated?

Solution:

A device utilized in aircrafts to measure its altitude is an altimeter.

Its principle is as follows:

With an increase in the height above the sea level, the atmospheric pressure decreases. Thus, a barometer that measures the atmospheric pressure can be utilized in order to measure the altitude of a place above the sea level.

The scale of the altimeter is calibrated such that is graduates with the height increasing towards the left as the atmospheric pressure decreases with increasing height above the sea level.

32. What do the following indicate in a barometer regarding weather:

(a) Gradual fall in the mercury level

(b) Sudden fall in the mercury level

(c) Gradual rise in the mercury level?

Solution:

(a) The eventual fall in the level of mercury indicates that the moisture is increasing indicating the possibility of rain

(b) The sudden fall in the level of mercury indicates arrival of a storm or a cyclone

(c) The eventual rise in the mercury level indicates that the moisture level is decreasing representing dry weather.

Multiple choice type:

1. The unit torr is related to the barometric height as:

(a) 1 torr = 1cm of Hg

(b) 1 torr = 0.76cm of Hg

(c) 1 torr=1mm of Hg

(d) 1 torr=1m of Hg

Solution:

(c)1 torr=1mm of Hg

2. The normal atmospheric pressure is:

(a) 76m of Hg

(b) 76cm of Hg

(c) 76 Pa

(d) 76 Nm^{-2}

Solution:

(b) 76cm of Hg

3. The atmospheric pressure at earth surface is P_1 and inside mine is P_2. They are related as:

(a) $P_1 = P_2$

(b) $P_1 > P_2$
(c) $P_1 < P_2$
(d) $P_2 = 0$
Solution:
(c) $P_1 < P_2$

Numericals:

1. **Convert 1mm of Hg into pascal. Take density of Hg=13.6 x 10^3 kg m^{-3} and g=9.8 m/s^2**
Solution:
Given: density of Hg=13.6 x 10^3 kg m^{-3}, acceleration due to gravity =9.8 m/s^2, height of mercury column = 1mm or 0.001m
We know that pressure = h ρ g
= 0.001 x 13.6 x 10^3 x 9.8
= 133.28 Pa

2. **At a given place, a mercury barometer records a pressure of 0.70m of Hg. What would be the height of water column if mercury in barometer is replaced by water? Take density of mercury to be 13.6 x 10^3 kg m^{-3}**
Solution:
Given: density of Hg=13.6 x 10^3 kg m^{-3}, acceleration due to gravity =9.8 m/s^2, height of mercury column = 0.70m
We know that pressure = h ρ g
P = (0.7)(13.6 x 10^3)(9.8)
= 93.3 x 10^3 Pa
Consider 'h' to the height of the water column
P = h (density of water) g
93.3 x 10^3 = h x 1 x 10^3 x 9.8
h = 93.3/9.8
= 9.52m

3. **At sea level, the atmospheric pressure is 76cm of Hg. If air pressure falls by 10mm of Hg per 120m of ascent, what is the height of a hill where the barometer reads 70cm of Hg. State the assumption made by you.**
Solution:
Given: atmospheric pressure = 76cm of Hg
Pressure falls by 10mm of Hg per 120m of ascent => 1cm of Hg per 120m of ascent
Consider 'h' to be the height of the hill, given=> pressure at the hill = 70cm of Hg
∴ total fall in pressure = atmospheric pressure – pressure at the hill
= 76 – 70 = 6cm of Hg
Given the rate of fall in pressure is 1cm Hg for every 120m advancement in height
Hence for 6cm Hg, advancement in height is 6 x 120m = 720m
Thus, the height of the hill is 720m
The assumption made is that the atmospheric pressure falls linearly with ascent.

4. At sea level, the atmospheric pressure is 1.04 x 10^5 Pa. Assuming g=10m/s^2 and density of air to be uniform and equal to 1.3kg m^{-3}, fint the height of the atmosphere.

Solution:

Given: P = 1.04 x 10^5 Pa, g = 10m/s^2, density of air = ρ = 1.3 kg m^{-3}

Consider 'h' to be the height of the atmosphere,

We know that pressure = h ρ g

$$h = P / \rho g$$

$$= \frac{1.04 \times 10^5}{1.3 \times 10} = 8000m$$

∴ Height of the atmosphere is 8000m

5. Assuming the density of air to be 1.295 kg m^{-3}, find the fall in barometric height in mm of Hg at a height of 107m above the sea level. Take density of mercury = 13.6 x 10^3 kg m^{-3}

Solution:

Density of air=1.295 kg m^{-3}

Consider 'h' to be the height above the level of sea

Pressure at height 'h' – pressure above the sea level = h ρ_{air} g

⇨ h ρ_{air} g = ρ_m g h_f - ρ_m g h_i

⇨ Change in the height = $\frac{\rho air\, h}{\rho_m}$ = 1.295 x 10^7/13.6 x 10^3

⇨ 10mm of Hg