

## PRESSURE

Pressure is force acting normally per unit area of the **surface.**

In short pressure = $\frac{Force\ (N)}{Area\ (m^2)}$

The SI unit of pressure is $Nm^{-2}$or Pascal (Pa).

 1Pa =1 $Nm^{-2}$

**A Pascal is the unit of pressure equal to 1$Nm^{-2}$.**

**Larger unit of pressure**

 1kPa = 1k$Nm^{-2}$=1000Pa

**Example 1**

Change 0.7kPa to SI unit.

1kPa = 1000Pa

0.7kPa = 0.7 x 1000 =700Pa.

**Note:**

**(a)**Incase mass is given, then first calculate the weight from:

**Weight = mass (kg) x acceleration due to gravity.**

**Weight = volume ($m^3$) x density (kg $m^{-3}$) x acceleration due to gravity.**

(b) Area of base should be in $m^2$

**-** If the area of contact for the base is circular then Area of base$(A) = \pi r^2$.Where **r** is radius of circle in contact.

-If the area of contact for the base is a square (square) then Area of base$(A)$=**$L^2$.** Where **L** is the length of the side.

-If the area of contact for the base is a rectangular then Area of base$(A)$=**L x W.**Where L is the length and W is the width or breadth.

**Factors which affect pressure exerted by an object resting on another**

From the definition of **pressure** =$\frac{\textbf{Weight}}{\textbf{Area of base}}$, it implies that the factors are:

- **(i)** Weight of the object on top.
- **(ii)** Area of contact between the objects.

**Use of pressure $=\frac{\textbf{Force}}{\textbf{Area of base}}$ in Calculations**

**Example 2.**

Calculate the pressure exerted by a force of 500N acting on the surface of $2m^2$.

Force (F)= 500N   Area of base(A)= $2m^2$

**Pressure** $=\frac{\textbf{Force}}{\textbf{Area of base}} = \frac{\textbf{500}}{\textbf{2}} =$ **$250Nm^{-2}$**

**Example 3.**

Calculate the pressure exerted by a 500kg block of base area $2cm^2$.

**Weight = mass (kg) x acceleration due to gravity.**

=500 x 10 = 5000N

Area of base$(\boldsymbol{A})$= $2cm^2 = \frac{\textbf{2}}{\textbf{100X100}}$ = **$0.0002m^2$**

**Pressure** $=\frac{\textbf{Force}}{\textbf{Area of base}} = \frac{\textbf{5000}}{\textbf{0.0002}}$ = **25000000 = $2.5 \times 10^7 Nm^{-2}$**

**Example 4.**

A block of concrete of 0.9kN and its base is a square of 200cm. Calculate the pressure it exerts.

Force (F) = 0.9kN = 0.9 x 1000 =**900N**

Area of base = 200 x 200 = **$40000cm^2$ = $\frac{\textbf{40000}}{\textbf{100 x 100}}$ $m^2$ = $4m^2$**

**Pressure** $=\frac{\textbf{Force}}{\textbf{Area of base}} = \frac{\textbf{900}}{\textbf{4}}$ = **$225Nm^{-2}$**

**Example 5.**

A pressure of 10Pa acts on an area of $3m^2$. What is the force acting on the area?

Pressure (**P) = 10Pa**   Area of base = $3m^2$   Force = ?

**Pressure** $=\frac{\textbf{Force}}{\textbf{Area of base}}$

$10 = \frac{\textbf{Force}}{\textbf{3}}$

Force = 10 x 3

**= 30N**

**Example 6.**

Calculate the pressure exerted on a level ground by a man whose man is 75kg and the area of both feet is $280cm^2$.

Area of base = $280cm^2 = \frac{\textbf{280}}{\textbf{100x100}}$ = **$0.028m^2$**

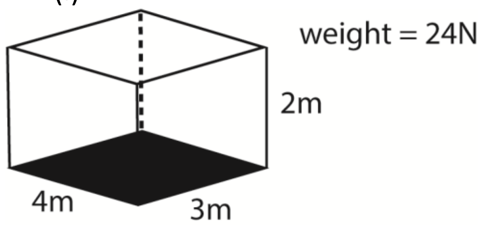
Mass = 75kg   $g=10ms^{-2}$

Weight = mass (kg) x acceleration due to gravity = 75 x 10 **=750N**

**Pressure** $=\frac{\textbf{Force}}{\textbf{Area of base}} = \frac{\textbf{750}}{\textbf{0.028}}$ = **$26,785.7Nm^{-2}$**

The pressure exerted on the floor by the same object

(i)




Area of base = L x W

= 4m x 3m

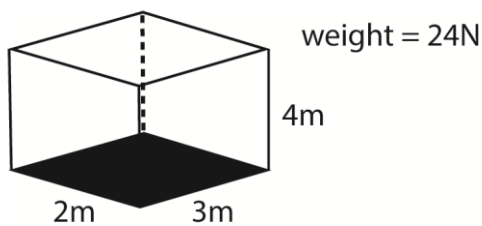
**= 12m²**

Pressure = $\frac{weight}{area}$

= $\frac{24}{12}$

**= 2Nm⁻²**

**(ii)**




Area of base = L x w

= 2m x 3m

**= 6m²**

Pressure = $\frac{weight}{area}$

= $\frac{24}{6}$

= $4Nm^{-2}$

**Note:** When calculating pressure, the unit of area of base should always be in $m^2$. From the above calculations it is noted that: the greater the area over which the force acts normally the less is the pressure exerted.

(i) A tractor with wide wheels can pass over soft ground because the greater area of wide wheel exerts less pressure.

(ii) When the same force is applied on a needle and nail both placed on the hand, one tends to feel more pain from the needle because the small area of needle exerts greater pressure.

(iii) A cushion makes a chair more comfortable to sit on. **Explanation;** The cushion is soft so it curves and increases the area of contact with the body when one sits on it. This leads to larger area of contact which results in less pressure. Thus making the chair more comfortable to sit on.

(iv) A knife sharpened cuts well than before. **Explanation;** Sharpening makes the knife cuts better because the cutting edge of the knife has a smaller area than before sharpening leading to higher pressure when a force acts on it.

(v) Hippopotamus walks on soft ground because it has broad food

**Calculating maximum and minimum pressure of a cuboid:**

**Maximum pressure (greatest pressure)=** $\frac{\text{Weight of cuboid}}{\text{Smallest area of base}}$

**Smallest area of base = smallest length x next smallest length.**

**Example 7**

The dimensions of a cuboid are 5cm x 10cm x 20cm and the weight of the cuboid is 60N. Calculate the maximum pressure and minimum pressure the cuboid exerts.

**Solution.**

Smallest area = smallest length x next smallest length

$= \frac{5m}{100} \times \frac{10m}{100}$

$= 0.005m^2$

Max pressure= $\frac{\text{Weight of cuboid}}{\text{Smallest area of base}}$

$= \frac{60}{0.005} = 12000Nm^{-2}$

Minimum pressure = $\frac{\text{Weight of cuboid}}{\text{Largest area of base}}$

Largest area of base = largest length x next largest length

∴**Largest area =** $\frac{20m}{100} \times \frac{10m}{100}$

**$=0.02m^2$**

∴Minimum pressure = $\frac{60}{0.02}$

= **$3000Nm^{-2}$**

**Example 8**

A rectangular brick of 24kg measures 8cm by 5cm by 4cm calculate the greatest and least pressure.

Mass (m)=24kg g=$10ms^{-2}$

Weight (w) = mg = 24x10 = **240N**

Least pressure = $\frac{\text{Weight of brick}}{\text{Largest area of base}}$

Largest area of base = largest length x next largest length

∴ **Largest area =** $\frac{8m}{100} \times \frac{5m}{100}$

**$=0.004m^2$**

∴ Least pressure = $\frac{240}{0.004}$

**$=60000Nm^{-2}$** = $6.0 \times 10^4$Pa = 60kPa

Greatest pressure = $\frac{\textbf{Weight of brick}}{\textbf{Smallest area of base}}$

Smallest area = smallest length x next smallest length

**∴Smallest area = $\frac{4m}{100}$ x $\frac{5m}{100}$**

**= $0.002m^2$**

∴Greatest pressure = $\frac{240}{0.002}$

**$=120000Nm^{-2}$ = 120kPa = $1.2\text{x } 10^5$Pa**

**Note:** In all these cases the weight of the cuboid is constant

**Atmospheric pressure**

- The air surrounding the earth is called the atmosphere.
- Atmospheric pressure is the pressure exerted by the weight of air on all objects.
- The density of air above the earth decreases as the altitude increases leading to the decrease of atmospheric pressure at high altitude.
- At sea level the atmospheric pressure is $10^5$Pa. Though the value of atmospheric pressure is large we do not normally feel it because:

(i) Blood pressure is slightly greater than atmospheric pressure

(ii) Atmospheric pressure acts equally in all direction

**Daily life experience**

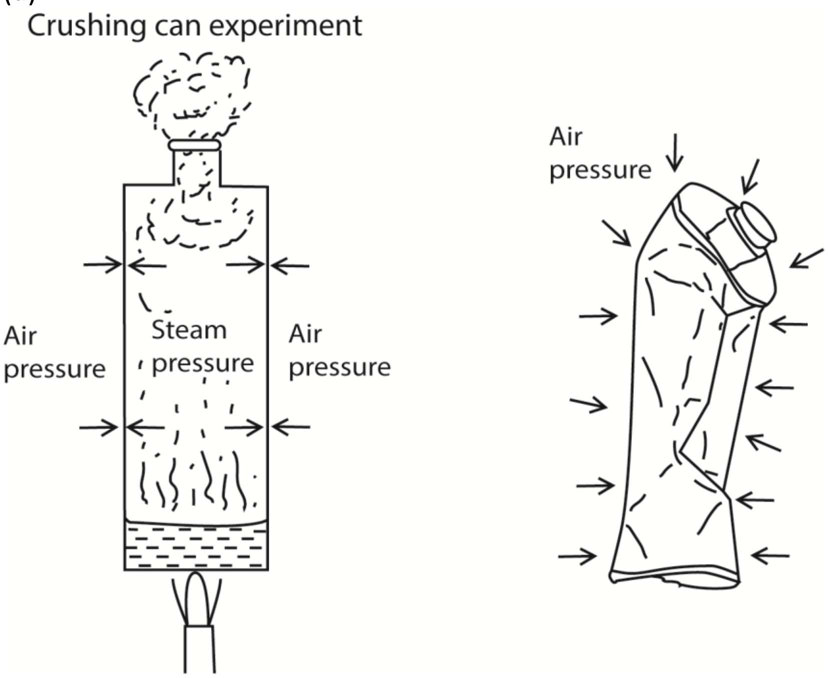
(a) At high altitudes like mountain nose bleeding may occur because of the greater excess pressure of blood as the atmospheric pressure becomes less at high altitude.

(b) When air is sucked out of the bottle it immediately run back in because the excess atmospheric pressure outside bottle forces air to flow into the bottle until the pressure inside the bottle becomes equal to the atmospheric pressure outside.

(c) Pilots operating at high altitude must have protective headgears to prevent bleeding because atmospheric pressure at the greater height is much smaller than blood pressure

**Simple experiment to demonstrate atmospheric pressure**

(a)




**Heating water**

A small amount of water is boiled until steam is driven out.

**Fitting the cork**

The cork is fitted tightly at same time heating is stopped.

**Cooling**

Then cold water is poured over the can.

**Observation**

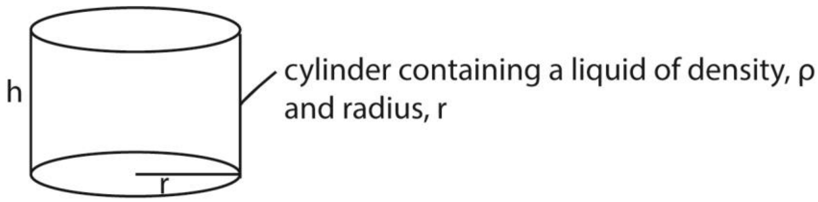
The can collapses inwards.

**Importance of atmospheric pressure**

- Drinking straw
  When sucking, lungs expand and air passes into them from the straw. The atmospheric pressure acting on surface of the liquid in the bottle is greater than air pressure in straw and so it forces the liquid up to the mouth.
- Rubber Sucker
  When the sucker is moistened and pressed on a smooth flat surface, the air inside is pushed out. Atmospheric pressure then holds it firmly against the surface. Suckers are used for attaching car licenses to windscreen and in industry for lifting metal sheets.

**Defining pressure in fluids**

Fluids refers to gas or liquids. These take up the shape of the container, so the volume of the liquid filling a cylindrical container is equal to the volume of that cylindrical container.

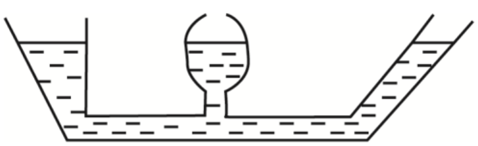



Area of base = $\pi r^2$
Volume of Liquid = $\pi r^2 h$
Mass of liquid = Volume of liquid x density of liquid x g
= $\pi r^2 h\rho$
Weight of liquid = Mass of liquid x g
= $\pi r^2 h\rho g$
Pressure of Liquid = $\frac{\text{Force (weight)}}{\text{Area}}$ = $\frac{\pi r^2 \rho g}{\pi r^2}$
∴ **Pressure in liquids = hρg**

So pressure in liquids is independent of area of base of the vessel. Generally pressure at any point in a liquid is the same in all directions and depends on the following factors:

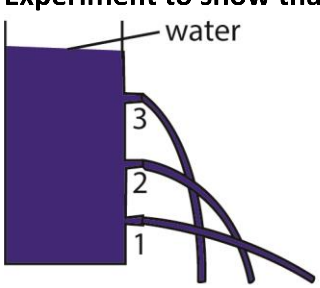
(i) Depth, **h**, below the surface of the liquid.
(ii) Density, **ρ,** of the liquid
(iii) Pressure exerted on the surface of the liquid.

Pressure in liquid does not depend on cross sectional area and shape of vessel containing the liquid. This can be illustrated by an experiment using a communicating tube as shown below.



When the liquid is poured into the communicating tubes, the liquid is found to stand at the same level in each tube showing that pressure at same level is the same.

**Experiment to show that pressure increases with depth**

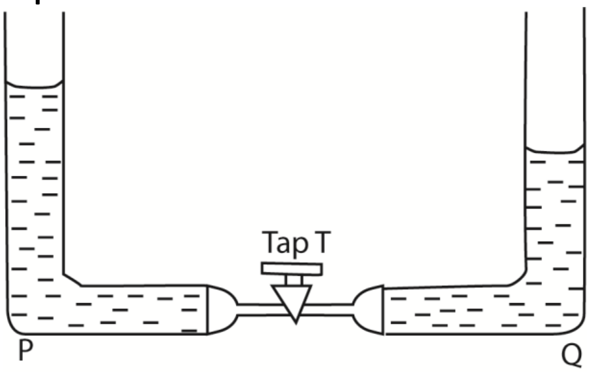



**Holes**
Three holes **1, 2** and **3** of same size at different depth below the surface are made in container. Then water is poured into the container to fill it.
**Water coming out hole**

Water comes out fastest and furthest from the lowest hole **1** followed by **2** and then **3**. This is because the farther down from the surface of water the greater weight of water above. So

Pressure in liquids increases with depth below the surface.

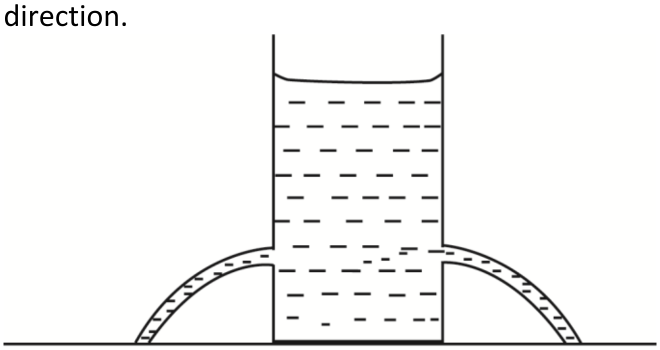
**Pressure at one depth act equally in all directions**
**Experiment: 1**




- The liquid pressure at foot P is greater than at the foot Q because the left hand column is higher than the right hand one.
- When tap T is opened liquid flows from P to Q until the pressure and the levels are the same. Thus the liquid finds its own level.

**Experiment: 2**

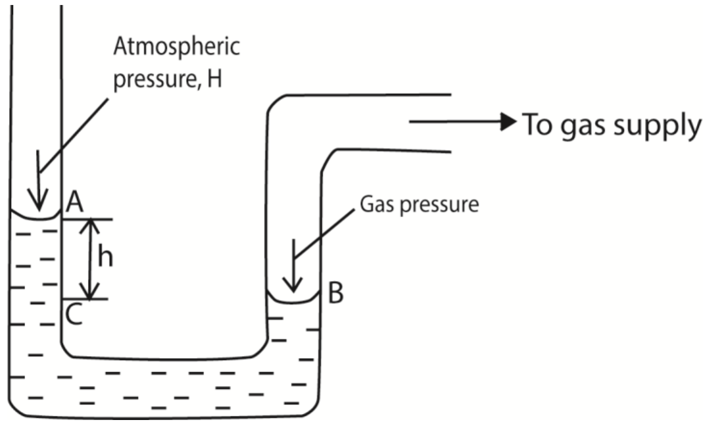
Water comes out of the holes at the same depth of the container with the same pressure in all direction.



**Water supply system**

- Reservoirs for water supply are placed on higher grounds than the places they supply because the lower the place supplied the greater is the water pressure at it.
- Reservoirs for electrical power stations are often made in mountainous regions by building dams at one end of the valley. These dams must be made thicker at the bottom than at the top in order to withstand the large water pressure at the bottom since pressure increases with depth below the surface.

**U-tube Manometer**
A manometer is an instrument for measuring the gas pressure.




- When both sides of the U-tube are open to the atmosphere, the same atmospheric pressure is exerted on the water surface A and B.
- Both A and B are at the same horizontal level.
- For measurement of gas pressure, one side B is connected to the gas supply and the tap is turned on. The gas exerts pressure on the side B which results in level A to raise until the pressure at C the same horizontal level as B becomes equal to the gas pressure.

When each surface of the liquid is acted on equally by atmospheric pressure and the levels are the same i.e.
Atmospheric pressure at A=Atmospheric pressure at B
If side B is connected to the gas supply as shown above.
AC is called a liquid column of height h. It is usually given in cmHg
Or mmHg

Gas pressure = Atmospheric pressure **(H)** + Pressure due to liquid column AC**(h)**
**Gas pressure = H + h**
**Expressing pressure in $Nm^{-2}$ or Pa**

**Gas pressure = (H + h) $\rho$g**
In case when connected to the gas supply the open end level falls below the closed end, then
Gas pressure = Atmospheric pressure **(H)** - Pressure due to liquid column AC **(h)**

**Gas pressure = H - h**
**Expressing pressure in $Nm^{-2}$ or Pa**
**Gas pressure = (H - h) $\rho$g**

**Expressing pressure in $Nm^{-2}$ or Pa**
This is done by applying the formula pressure = hρg.
Where h is the liquid column which should be in metres
ρ is the density of the liquid and it should be in $kgm^{-3}$

**Example 9**

Express a pressure of 75cmHg given that the density of Hg is 13600kgm$^{-3}$

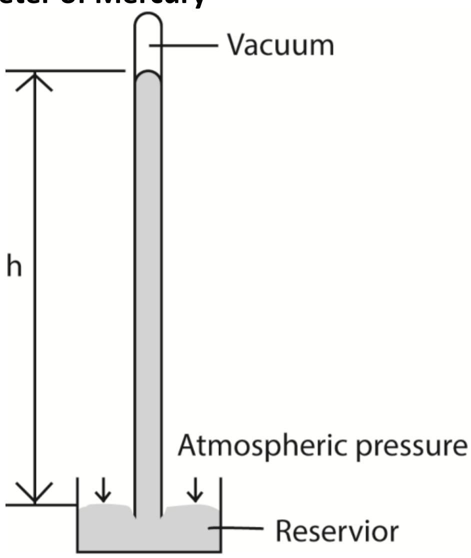
h=75cm =$\frac{75m}{100}$ ρ=13600Kgm$^{-3}$, g= 10ms$^{-3}$

∴Pressure = hρg

=$\frac{75}{100}$x 13600 x 10

= **102000Nm$^{-2}$=1.02xl0$^{5}$Nm$^{-2}$**

**Barometer of Mercury**




- A mercury barometer is an instrument used to measure atmospheric pressure in a certain location and has a vertical glass tube (about 1m) closed at the top sitting in an open mercury-filled basin at the bottom.
- Mercury in the tube adjusts until the weight of it balances the atmospheric force exerted on the reservoir.
- High atmospheric pressure places more force on the reservoir, forcing mercury higher in the column, for instance at sea level mercury column = 760mmHg
- Low pressure allows the mercury to drop to a lower level in the column by lowering the force placed on the reservoir i.e. at higher altitude mercury column is shorter than that at sea level.

**Calculation**

Atmospheric pressure= hρg

Where: ρ = density of mercury, g = acceleration due to gravity

Note that

(i) Deep sea divers return slowly to the surface because the sudden decrease in pressure when they return fast from deep water is very painful.

(ii) Pilots operating at great heights must have protective headgear to prevent nose bleeding because atmospheric pressure at great height is much smaller than blood pressure.

## Hydraulic machines

It is a machine in which force is transmitted by liquids under pressure

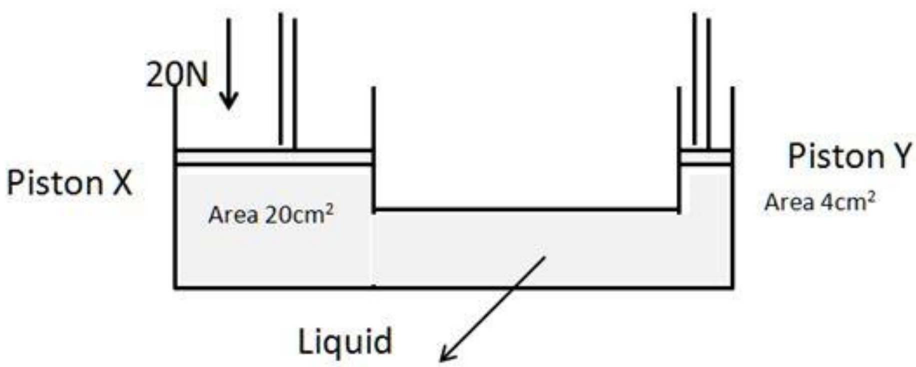
**Pascal's principles states that:** when a force is exerted on a liquid in a closed vessel, pressure is produced which is transmitted equally throughout the liquid.

The above principle is applied in hydraulic press.

- Liquids are incompressible so they can pass on any pressure applied to them. In hydraulic press a small force (called effort) is applied to a small piston in order to raise large force (load placed on large piston).

**Example 10**

In the figure below a downward force of 20 N is applied on the piston X. What will be the upward pressure exerted by the liquid at Y.




Pressure transmitted = $\frac{F}{A} = \frac{20}{20\ x\ 10^{-4}} = \frac{Force\ on\ Y}{4\ x\ 10^{-4}}$

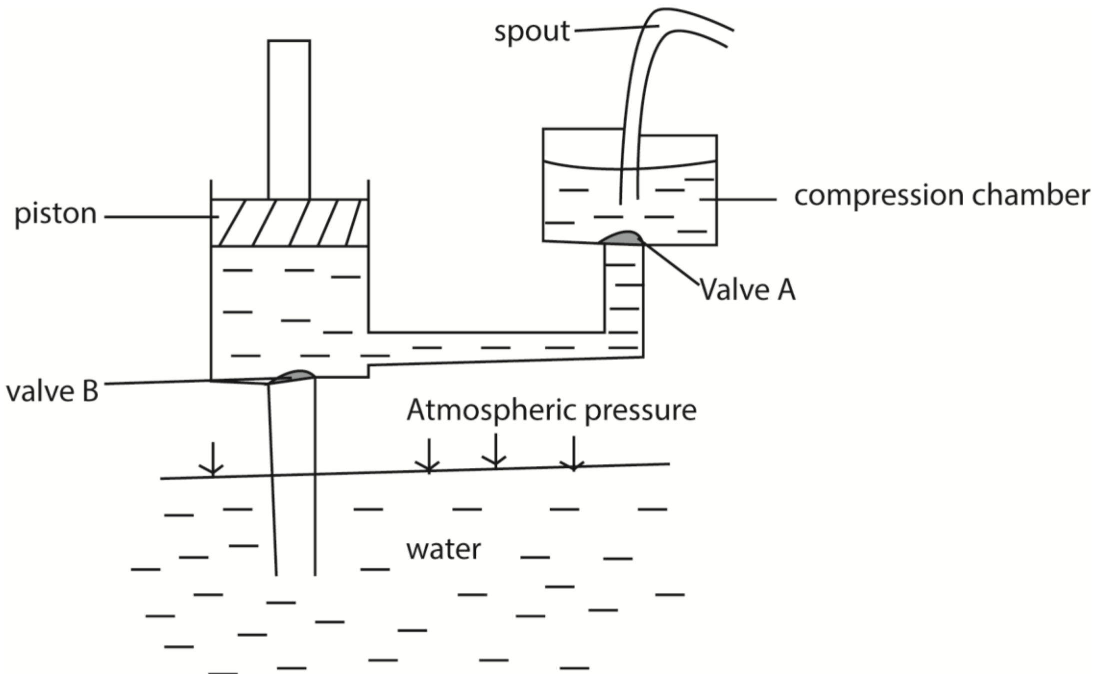
Force on Y = 4N

Pressure on Y = $\frac{F}{A} = \frac{4}{4}$ = 1Ncm$^{-2}$

**Advantage**

A small force called effort s applied on small piston to overcome a large force called load is placed on a large piston.

The force pump




- Upstroke, a vacuum forms under the piston and atmospheric pressure forces water through valve B to fill the space, valve A closes at the same time.
- Down stroke, valve B closes as the plunger comes down. Water is forced into compression chamber through valve A, compressing air in the upper part of the chamber.
- The air acts as a cushion, forcing water out of the spout

## Exercise

1.

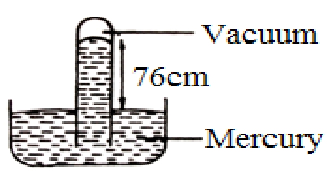
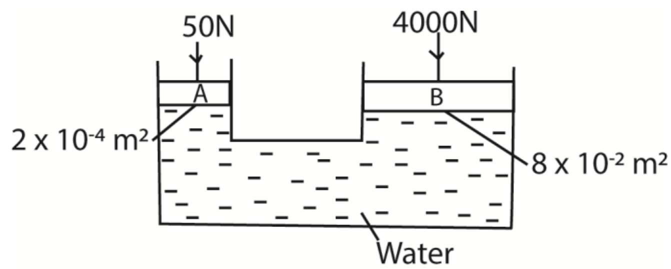



Fig. 3

The figure shows a simple barometer. The height of the mercury column is 76cm. When the tube is slightly tilted, the height of the mercury column will

A. be slightly higher than 76cm
B. be lower than 76cm
C. not change
D. oscillate about 76cm

2. Forces of 50N and 400N are applied to pistons A and B respectively as shown below.




The areas of cross-section of A and B are $2 \times 10^{-4}$ m$^2$ and $8 \times 10^{-2}$m$^2$ respectively. Which of the following is not true?

A. Both pistons A and B remain at the same level

B. The upthrust on piston B is equal to 20000N

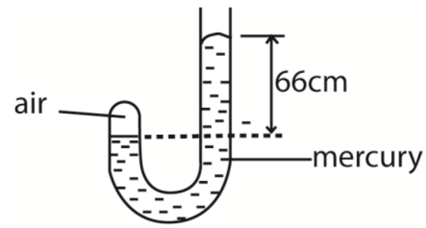
C. The pressure exerted on the water by piston B is $5x10^4$Nm$^{-2}$

D. Piston B is going to move upwards

3. A liquid of density $1.03x10^3$kgm$^{-3}$ fills a vessel of uniform cross-sectional area of $10^{-3}$m$^2$ to a depth of 0.24m. Calculate the force exerted by the liquid on the bottom of the vessel

A. $1.03x10^{-1}$N B. $2.472x10^{-1}$N C. 1.03N D. 2.472N

4.




The diagram above shows air trapped by a column of mercury in a J-tube. The atmospheric pressure is 76cmHg. At what pressure is the enclosed air

A. 10cmHg B. 66cmHg C. 76cmHg D. 142cmHg

5. A hippopotamus can easily walk on mud without sinking while a goat will sink because

A. a hippopotamus has more weight than a goat

B. the centre of gravity of a hippopotamus is lower than that of a goat

C. a hippopotamus exerts more pressure on the ground than a goat

D. a hippopotamus exerts less pressure on the ground than a goat

6. A rectangular block of mass 48kg measures 4mx3mx2m. What is the least pressure it can exert on a given surface?

A. $20Nm^{-2}$ B. $40Nm^{2}$ C. $60Nm^{2}$ D. $80Nm^{-2}$

7. In a hydraulic press, the area of the piston on which the effort is applied is made smaller in order to

A. facilitate the movement of the piston downwards

B. transmit a force as large as possible to the load

C. transmit pressure equally throughout the liquid

D. obtain a pressure as large as possible.

8. An air bubble is introduced at the bottom of a jar containing mercury. Which one of the following explains what will happen to the bubble? It will

A. Be pressed by the mercury column above and will burst.

B. Rise to the surface of the mercury while decreasing in size.

C. Rise to the surface of the mercury while increasing in size.

D. Remain in constant motion within the mercury.

9. Calculate the increase in pressure which a diver experiences when he descends 30m in the sea water of density $1.2x10^{3}kgm^{-3}$

A. $3.0 \times 10^{2}Nm^{-2}$ B. $1.2 \times 10^{4}Nm^{-2}$

C. $3.6 \times 10^4 Nm^{-2}$ D. $3.6 \times 10^5 Nm^{-2}$

10. Which of the following is true about pressure in liquids? It

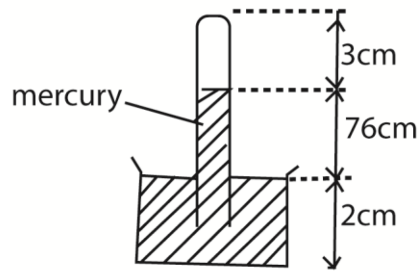
A. increases with the surface area of the liquid

B. is directly proportional to the depth

C. depends on the shape of the container

D. is the same at equal depths in all liquids

11.




The diagram in the figure above shows a mercury shows a mercury barometer. What is the value of the atmospheric pressure?

A. 74cm B. 76cm C. 77cm D. 79cm

12. A tank of 2m tall and base of $2.5m^2$ is filled to the brim with a liquid which exerts a force of 40000N at the bottom. Calculate the density of the liquid

A. $\frac{4000}{25} \times 2 \times 10\ kgm^{-3}$ B. $\frac{4000}{2.5} \times 2 \times 10 kgm^{-3}$

C. $\frac{4000}{25} \times 2 \times 10 kgm^{-3}$ D. $\frac{4000}{2.5} \times 2 \times 10 kgm^{-3}$

13. Which one of the following statements is false? The pressure in a liquid

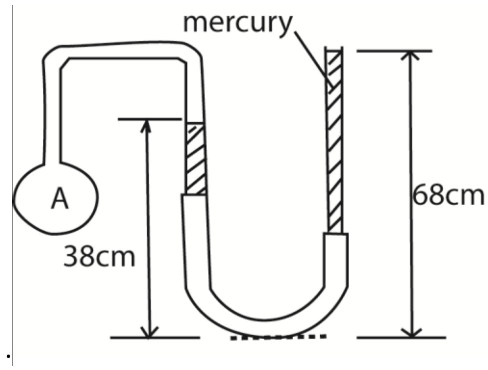
A. at any one point in liquid would not change even when more liquid is added.

B. at any one point depends only on the depth and density.

C. at any one point acts equally in all directions.

D. increases with depth.

14.




In figure 5, a fixed mass of dry air is trapped in bulb A. Calculate the total pressure of the air in A, given that atmospheric pressure is 76 cm of mercury.

A. 106 cm Hg. B. 38 cm Hg.

C. 46 cm Hg. D. 114 cm Hg.

15. What is 730mmHg in $Nm^2$?

A. $\frac{13600 \ x\ 1000x\ 10}{730}$ B. $\frac{13600\ x\ 730\ x\ 10}{1000}$ C. $\frac{13600\ x\ 730}{1000x\ 10}$ D. $\frac{13600\ x\ 10}{1000\ x\ 730}$

16. The mass of a cuboid of dimensions 4m x 2m x 3m is 48kg. The minimum pressure it can exert is

A. 20 $Nm^{-2}$ B. 40$Nm^{-2}$ C. 60$Nm^{-2}$ D. 80$Nm^{-2}$

17. In a hydraulic machine

A. an object displaces its own weight of fluid

B. the pressure transmitted in the fluid is the same in all directions

C. the volume of fluid compressed is proportional to the applied force

D. an object experiences an upthrust equal to the weight of fluid displaced

18. Pressure in a liquid is independent of the

A. density of the liquid

B. depth below the surface of the liquid

C. pressure exerted on the surface of the liquid above

D. cross-sectional area and the shape of the vessel containing the liquid

19. A rectangular block of metal weighs 3N and measures (2x3x4) $cm^3$. What is the greatest pressure it can exert on a horizontal surface?

A. 5.0x103$Nm^{-2}$ B. 3.75x$10^3Nm^{-2}$ C. 2.5x103$Nm^{-2}$ D. 7.5x$10^{-1}Nm^{-2}$

20. In a liquid, pressure is

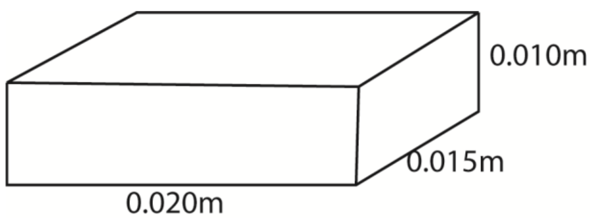
A. Transmitted in a specific direction

B. Transmitted in all direction.

C. Decreased with depth

D. Decreased with density

21.




A box is placed on top of a table as shown above, with dimensions indicated. If its mass is 40kg, find the pressure it exerts on the table.

A. $\frac{40}{0.020\ x\ 0.015}$ B. $\frac{40}{0.015\ x\ 0.010}$ C. $\frac{40\ x\ 10}{0.020\ x\ 0.015}$ D. $\frac{40\ x\ 10}{0.015\ x\ 0.010}$

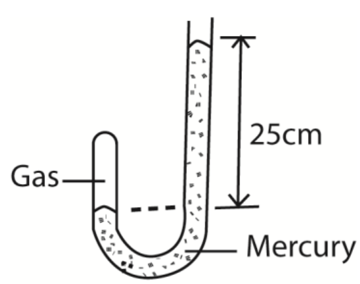
22. A hydraulic brake works on the principle of

A. transmission of pressure in a liquid. B. distribution of force in a liquid.

C. existence of viscosity in a liquid. D. high density of a liquid.

**Structured question**

23.

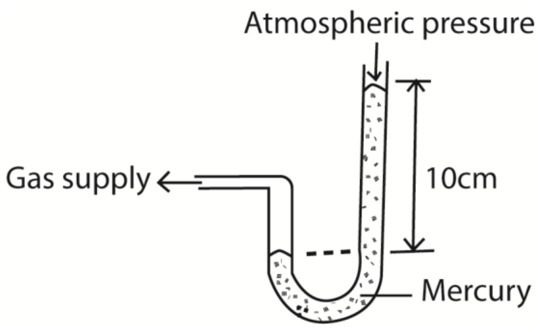



(a) The above figure shows a gas trapped by a mercury column in a J-tube. If the atmospheric pressure is 1.0 x $10^5$ and the density of mercury is 1.36x$10^4$kg $m^{-3}$, find the pressure at which the gas is.

(b) what would happen if the closed end of the J-tube was opened (c) Would it have been better to use water instead of mercury in the J-tube? Give a reason for your answer.

24. (a) State any two factors which affect pressure in liquids.

b) The diagram in figure 8 below shows an instrument used for measuring gas pressure in a laboratory. Find the pressure in $Nm^{-2}$ of the gas if atmospheric pressure is 76cm Hg [density of mercury $=13.6 \times 10^{3} kgm^{-3}$]



## Suggested answers

1.

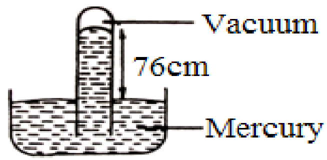
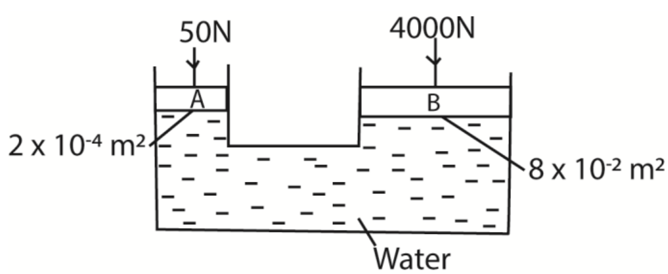


Fig. 3

The figure shows a simple barometer. The height of the mercury column is 76cm. When the tube is slightly tilted, the height of the mercury column will

| | | | |
|---|---|---|---|
| A. | be slightly higher than 76cm | B. | be lower than 76cm |
| **C.** | not change | D. | oscillate about 76cm |

2. Forces of 50N and 400N are applied to pistons A and B respectively as shown below.




The areas of cross-section of A and B are 2 x $10^{-4}$ $m^2$ and 8 x $10^{-2}m^2$ respectively. Which of the following is not true?

A. Both pistons A and B remain at the same level

B. The upthrust on piston B is equal to 20000N

**C.** The pressure exerted on the water by piston B is $5x10^4Nm^{-2}$

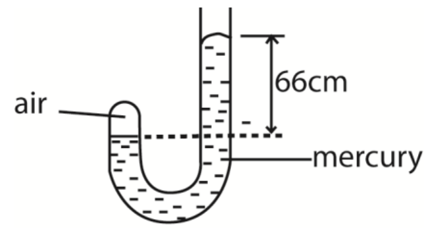
D. Piston B is going to move upwards

3. A liquid of density $1.03x10^3kgm^{-3}$ fills a vessel of uniform cross-sectional area of $10^{-3}m^2$ to a depth of 0.24m. Calculate the force exerted by the liquid on the bottom of the vessel

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A. | $1.03x10^{-1}$N | B. | $2.472x10^{-1}$N | C. | 1.03N | **D.** | 2.472N |

Force = mg= volume x density x gravity = $10^{-3}$ x 0.24 x 1.03 x $10^3$ x 10 = 2.472

4.




The diagram above shows air trapped by a column of mercury in a J-tube. The atmospheric pressure is 76cmHg. At what pressure is the enclosed air

A. 10cmHg B. 66cmHg C. 76cmHg **D.** 142cmHg

Gas pressure = H + h = 76 + 66 = 142cmHg

5. A hippopotamus can easily walk on mud without sinking while a goat will sink because

A. a hippopotamus has more weight than a goat

B. the centre of gravity of a hippopotamus is lower than that of a goat

C. a hippopotamus exerts more pressure on the ground than a goat

**D.** a hippopotamus exerts less pressure on the ground than a goat

Because it has broader feet

6. A rectangular block of mass 48kg measures 4mx3mx2m. What is the least pressure it can exert on a given surface?

A. $20Nm^{-2}$ **B.** $40Nm^{2}$ C. $60Nm^{2}$ D. $80Nm^{-2}$

Least pressure = $\frac{Force}{largest\ crosssection\ area} = \frac{48 \ x\ 10}{4\ x\ 3}$ = $40Nm^{-2}$

7. In a hydraulic press, the area of the piston on which the effort is applied is made smaller in order to

A. facilitate the movement of the piston downwards

B. transmit a force as large as possible to the load

C. transmit pressure equally throughout the liquid

**D.** obtain a pressure as large as possible.

8. An air bubble is introduced at the bottom of a jar containing mercury. Which one of the following explains what will happen to the bubble? It will

A. Be pressed by the mercury column above and will burst.

B. Rise to the surface of the mercury while decreasing in size.

**C.** Rise to the surface of the mercury while increasing in size.

D. Remain in constant motion within the mercury.

NB. Expands due to reduction in pressure as the depth decreases

9. Calculate the increase in pressure which a diver experiences when he descends 30m in the sea water of density $1.2 \times 10^3 kgm^{-3}$

A. $3.0 \times 10^2 Nm^{-2}$

B. $1.2 \times 10^4 Nm^{-2}$

C. $3.6 \times 10^4 Nm^{-2}$

**D.** $3.6 \times 10^5 Nm^{-2}$

Solution

Pressure = $h\rho g = 30 \times 1.2 \times 10^3 \times 10 = 3.6 \times 10^5 Nm^{-2}$

10. Which of the following is true about pressure in liquids? It

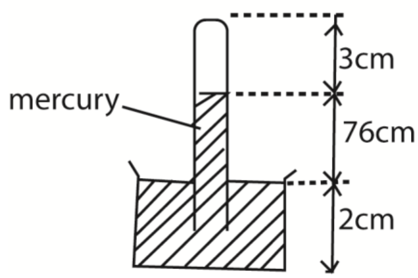
A. increases with the surface area of the liquid

**B.** is directly proportional to the depth

C. depends on the shape of the container

D. is the same at equal depths in all liquids

11.




The diagram in the figure above shows a mercury shows a mercury barometer. What is the value of the atmospheric pressure?

A. 74cm **B.** 76cm C. 77cm D. 79cm

12. A tank of 2m tall and base of $2.5m^2$ is filled to the brim with a liquid which exerts a force of 40000N at the bottom. Calculate the density of the liquid

A. $\frac{4000}{25} \times 2 \times 10\ kgm^{-3}$

**B.** $\frac{4000}{2.5} \times 2 \times 10 kgm^{-3}$

C. $\frac{4000}{25} \times 2 \times 10 kgm^{-3}$

D. $\frac{4000}{2.5} \times 2 \times 10 kgm^{-3}$

Force = mg= volume x density x gravity

4000 = 2.5 x 2 x ρ x 10

ρ = $\frac{4000}{2.5} x\ 2\ x\ 10$

13. Which one of the following statements is false? The pressure in a liquid

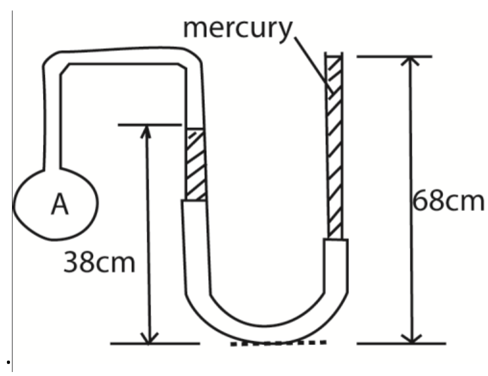
**A.** at any one point in liquid would not change even when more liquid is added.

B. at any one point depends only on the depth and density.

C. at any one point acts equally in all directions.

D. increases with depth.

14.




In figure 5, a fixed mass of dry air is trapped in bulb A. Calculate the total pressure of the air in A, given that atmospheric pressure is 76 cm of mercury.

**A.** 106 cm Hg. B. 38 cm Hg.

C. 46 cm Hg. D. 114 cm Hg.

Pressure of air = H + h = 76 + (68 – 38) = 106

15. What is 730mmHg in $Nm^2$?

A. $\frac{13600\ x\ 1000x\ 10}{730}$ **B.** $\frac{13600\ x\ 730\ x\ 10}{1000}$ C. $\frac{13600\ x\ 730}{1000x\ 10}$ D. $\frac{13600\ x\ 10}{1000\ x\ 730}$

Pressure = hρg = $\frac{730}{1000}\ x\ 13600\ x\ 10$

16. The mass of a cuboid of dimensions 4mx2mx3m is 48kg. The minimum pressure it can exert is

A. 20 $Nm^{-2}$ **B.** 40$Nm^{-2}$ C. 60$Nm^{-2}$ D. 80$Nm^{-2}$

Minimum pressure = $\frac{Force}{maximum\ cross\ section\ area} = \frac{48 x 10}{4 x 3}$

17. In a hydraulic machine

A. an object displaces its own weight of fluid

**B.** the pressure transmitted in the fluid is the same in all directions

C. the volume of fluid compressed is proportional to the applied force

D. an object experiences an upthrust equal to the weight of fluid displaced

18. Pressure in a liquid is independent of the

A. density of the liquid

B. depth below the surface of the liquid

C. pressure exerted on the surface of the liquid above

**D.** cross-sectional area and the shape of the vessel containing the liquid

19. A rectangular block of metal weighs 3N and measures (2x3x4) $cm^3$. What is the greatest pressure it can exert on a horizontal surface?

A. $5.0x10^3Nm^{-2}$ B. $3.75x10^3Nm^{-2}$ C. $2.5x10^3Nm^{-2}$ D. $7.5x10^{-1}Nm^{-2}$

Greatest pressure = $\frac{Force}{least\ area} = \frac{3}{(2 x 3)x 10^{-4}} = 5.0x10^3Nm^{-2}$

20. In a liquid, pressure is

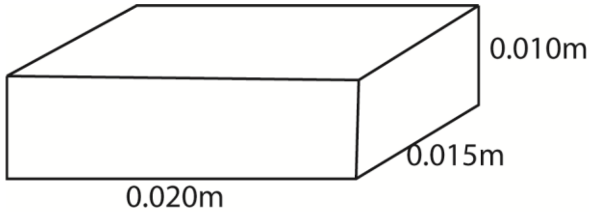
A. Transmitted in a specific direction

**B.** Transmitted in all direction.

C. Decreased with depth

D. Decreased with density

21.



A box is placed on top of a table as shown above, with dimensions indicated. If its mass is 40kg, find the pressure it exerts on the table.

A. $\frac{40}{0.020\ x\ 0.015}$ B. $\frac{40}{0.015\ x\ 0.010}$ **C.** $\frac{40\ x\ 10}{0.020\ x\ 0.015}$ D. $\frac{40\ x\ 10}{0.015\ x\ 0.010}$

Pressure = $\frac{Force}{Area}$

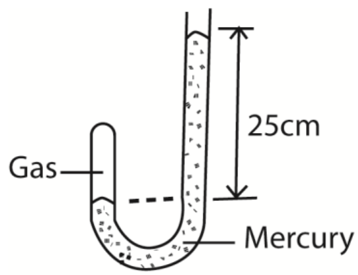
22. A hydraulic brake works on the principle of

**A.** transmission of pressure in a liquid. B. distribution of force in a liquid.

C. existence of viscosity in a liquid. D. high density of a liquid.

**Structured question**

23.




(a) The above figure shows a gas trapped by a mercury column in a J-tube. If the atmospheric pressure is 1.0 x $10^5$ and the density of mercury is 1.36x$10^4$kg $m^{-3}$, find the pressure at which the gas is.

Solution

Pressure = H + hρg

1.0 x 105 + $\frac{25}{100}\ x\ 1.36\ x\ 10^4\ x\ 10$ = 134,000Pa

(b) What would happen if the closed end of the J-tube was opened

The level of mercury would be the same

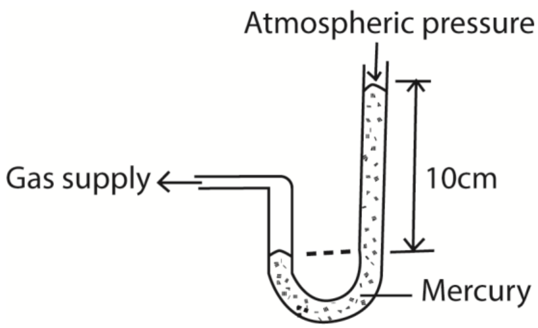
(c) Would it have been better to use water instead of mercury in the J-tube? Give a reason for your answer.

It is better to use mercury that does not wet the glass and has high density that the column is not very tall

24. (a) State any two factors which affect pressure in liquids.

- Density
- depth

b) The diagram in figure 8 below shows an instrument used for measuring gas pressure in a laboratory. Find the pressure in $Nm^{-2}$ of the gas if atmospheric pressure is 76cm Hg [density of mercury $=1.36x10^3kgm^{-3}$]




Pressure of the gas =H + h

= 76 + 10 = 86cm

= hρg

$= \frac{86}{100}\ x\ 1.36\ x\ 10^3\ x\ 10$

= 11,696$Nm^{-2}$

Thank you so much