Unit 07

PROPERTIES OF MATTER

Introduction

In this chapter we will study about kinetic molecular model of matter, density, pressure, atmospheric pressure, pressure in liquids, upthrust principle of floatation, elasticity, stress, strain, and young modulus.

Q1. What are the features of kinetic molecular model of matter?

Ans. Kinetic molecular model of matter

The kinetic molecular model of matter

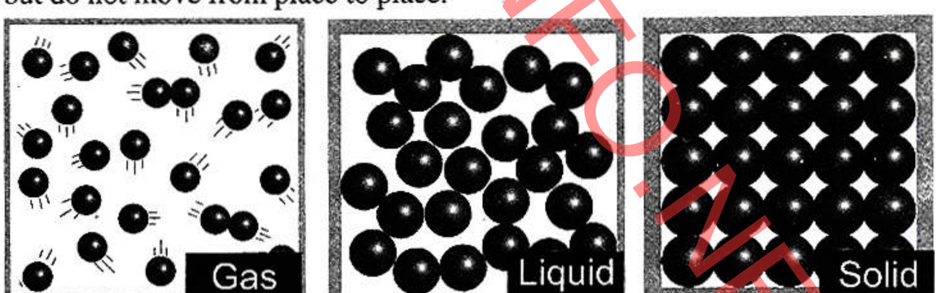
- Matter is made up of many small particles called molecules.
- The molecules remain in continuous motion. Their motion may be translatory, linear or rotatory.
- Molecules of matter attract each other. It helps to explain three states of matter.

Properties of Solids

Substance having specific shape and volume.

Example:

Solids such as a stone, metal spoon, pencil, etc. have fixed shapes and volume. Their molecules are held close together by strong forces of attraction. They vibrate about their mean positions, but do not move from place to place.



Properties of liquids:

(i) The distances between the molecules of a liquid are more than in solids.

(ii) Attractive forces between them are weaker.

(iii) Like solids, molecules of a liquid also vibrate about their mean position but are not rigidly held with each other.

(iv) Due to the weaker attractive forces, they slide over one another. That's why liquids can flow

(v) The volume of a certain amount of liquid remains the same but due to its property of flow, it attains the shape of a container to which it is put.

Properties of gases

(i) Gases such as air have no fixed shape or volume.
(ii) Their molecules have random motion and move with very high velocities.
(iii) In gases, molecules are much farther apart than solids or liquids
(iv) Gases are much lighter than solids and liquids
(v) Gases can be squeezed into smaller volumes.
(vi) The molecules of a gas are constantly striking the walls of a container. Thus, a gas exerts pressure on the walls of the container.

Q.2. Define Plasma Discuss it as fourth state of matter.

Ans. PLASMA – THE FOURTH STATE OF MATTER

The kinetic energy of gas molecules goes on increasing on heating. Which causes the gas molecules to move faster and faster. The collisions between atoms and molecules of the gas become so strong that they escape from the atoms. Atoms lose their electrons and become positive ions. **This ionic state of matter is called plasma. Plasma is also formed in gas discharge tube when electric current passes through these tubes.**

Plasma is called the fourth state of matter in which a gas occurs in its ionic state. Positive ions and electrons get separated in the presence of electric or magnetic fields. Plasma also exists in neon and fluorescent tubes when they glow. Most of the matter that fills the universe is in plasma state. In stars such as our sun, gases exist in their ionic state.

Plasma is highly conducting state of matter. It allows electric current to pass through it.

Q.3. Define density and write down its mathematical form and unit.

Ans. DENSITY

"Density of a substance is defined as its mass per unit volume".

$$\text{Density} = \frac{\text{mass of a substance}}{\text{volume of that substance}}$$

$$\text{Density} = \frac{m}{v}$$

SI unit of density is kilogram per cubic metre (kgm^{-3}).

Density can be calculated if mass and volume are known. e.g.

Suppose the mass of 5 litre of water is 5 kg its density will be

$$\text{density of water} = \frac{5}{5\times10^{-3}} \qquad \therefore 1 \text{ litre} = 10^{-3}m^3$$

$$= 1000\ kgm^{-3}. \qquad \therefore 5 \text{ liter} = 5 \times 10^{-3}m^3.$$

USEFULINFORMATION

1 metre cube ($1\ m^3$) = 1000 litre	
1 litre	$= 10^{-3}\ m^{-3}$
1 cm^3	$= 10^{-6}\ m^3$
1000 kgm^{-3}	$= 1\ gcm^{-3}$

EXAMPLE 7.1

The mass of 200 cm^3 of stone is 500 g. Find its density.

Given data

m = 500g
v = 200 cm^3

Solution

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$= \frac{500g}{200cm^3} = 2.5gcm^{-3}$$

Q4. Define pressure and write its formula.

Ans. Pressure.

The force acting normally per unit area on the surface of a body is called pressure.

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

Or $P = \frac{F}{A}$

Quantity:

Pressure is a scalar quantity.

Unit

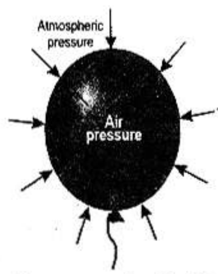
Unit of pressure is Nm^{-2} also called pascal (Pa). Thus

$1\ N\ m^{-2} = 1\ Pa$

Q5. What is atmospheric pressure? Explain it with the help of experiment?

Ans. ATMOSPHERIC PRESSURE

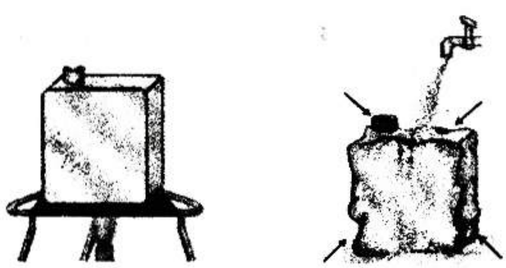
The Earth is surrounded by a cover of air called atmosphere. It extends to few hundred kilometers above sea level. Just as certain sea creatures live at the bottom of ocean, we live at the bottom of a huge ocean of air. Air is a mixture of gases. The density of air in the atmosphere is not uniform. It decreases continuously as we go up. The fact that atmosphere exerts pressure can be explained by experiment.



Air pressure inside the balloon is equal to the atmospheric pressure

EXPERIMENT:-

Take an empty tin can with a lid. Open its cap and put some water in it. Place it over flame. Wait till water begins to boil and the steam expels the air out of the can. Remove it from the flame. Close the can firmly by its cap. Now place the can under tap water.



Crushing of can

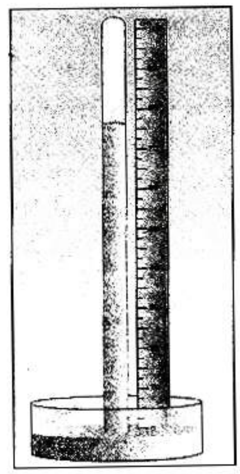
When the can is cooled by tap water, the steam in it condenses. As the steam changes into water, it leaves an empty space behind it. This lowers the pressure inside the can as compared to the atmospheric pressure outside the can. This will cause the can to collapse from all directions. This experiment shows that atmosphere exerts pressure in all directions.

Q. 6 How can we measure the atmospheric pressure?

Ans. "The instruments that is used to measure atmospheric pressure are called barometer.

Construction

One of the simple barometers is a mercury barometer. It consists of a glass tube 1m long closed at one end.


A mercury barometer

Working:- After filling it with mercury, it is inverted in a mercury trough. Mercury in the tube descends and stops at a certain height. The column of mercury held in the tube exerts pressure at its base. At sea level the height of mercury column above the mercury in the trough is found to be about 76 cm. Pressure exerted by 76 cm of mercury column is nearly 101, 300 Nm^{-2} equal to atmospheric pressure. It is common to express atmospheric pressure in terms of the height of mercury column. As the atmospheric pressure at a place does not remains constant, hence, the height of mercury column also varies with atmospheric pressure. Mercury is 13.6 times denser than water. Atmospheric pressure can hold vertical column of water about 13.6 times the height of mercury column at a place. Thus, at sea level, vertical height of water column would be 0.76 mx13.6 = 10.34 m. Thus, a glass tube more than 10 m long is required to make a water barometer. At sea level, the atmospheric pressure is about 101,300 Pa or 101, 300 Nm^{-2}.

Q7. Explain the variation in atmospheric pressure.

Ans. The atmospheric pressure decreases as we go up. The atmospheric pressure on mountains is lower than at sea level. At a height of about 30 km, the atmospheric pressure becomes only 7 mm of mercury which is approximately 1000 pa. It would become zero at an altitude where there is no air. Thus, we can determine the altitude of a place by knowing the atmospheric pressure at that place.

i. Variation of atmospheric pressure in cold and hot regions:

On a hot day, air above the Earth becomes hot and expands, this causes a fall of pressure in that region. On the other hand, during cold chilly nights, air above the earth cools down. This causes an increase in atmospheric pressure.

ii. Variation of weather due to change of atmospheric pressure.

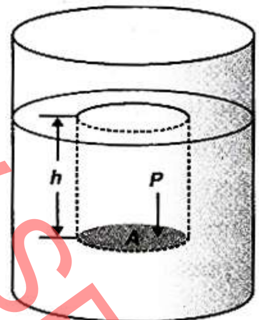
The changes in atmospheric pressure at a certain place indicate the expected changes in the weather conditions of that place. **For example**, a gradual and average drop in atmospheric pressure means a low pressure in a neighbouring locality. Minor but rapid fall in atmospheric pressure indicates a windy and showery condition in the nearby region. A decrease in atmospheric pressure is accompanied by breeze and rain. Whereas a sudden fall in atmospheric pressure often followed by a storm, rain and typhoon to occur in few hours time.

An increasing atmospheric pressure with a decline later on predicts an intense weather conditions. A gradual large increase in the atmospheric pressure indicates a long spell of pleasant weather. A rapid increase in atmospheric pressure means that it will soon be followed by a decrease in the atmospheric pressure indicating poor weather ahead.

Q.8 What do you mean by pressure of liquids? Also prove that P= ρgh.

Ans. PRESSURE IN LIQUIDS

Liquids exert pressure. This acts in all directions. It we take a pressure sensor inside a liquid, and then the pressure of the liquid varies with the depth of sensor.



Pressure of a liquid at a depth h.

Proof

Consider a surface of area **A** in a liquid at a depth h as shown by shaded region in figure. The length of the cylinder of liquid over this surface will be **h**. The force acting on this surface will be the weight **w** of the liquid above this surface. If ρ is the density of the liquid and m is mass of liquid above the surface, then

Mass of the liquid cylinder m = volume × density

$$m = (A\times h) \times \rho \text{ ....(i)}$$

Force acting on area A = $F = w = mg$ ......(ii)

Put (m) in eq.(ii)

$$F = A h \rho g$$

By the definition of pressure.

$$P = \frac{F}{A}$$

$$= \frac{Ah\rho g}{A} \quad \boxed{p = \rho gh}$$

∴ Liquid pressure at depth h = $P = \rho g h$ ... (7.3)

Result gives the pressure at a depth h in a liquid of density ρ. It shows that pressure in a liquid increases with the increase in depth.

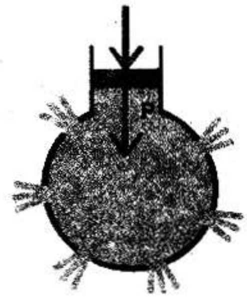
Q9. State the Pascal's law. What are its applications in our daily life?

Ans. PASCAL'S LAW

"Pressure applied at any point of a liquid enclosed in a container, is transmitted without loss to all other parts of the liquid".

Explanation

It can be demonstrated with the help of a glass vessel having holes all over its surface as shown in figure. Fill it with water. Push the piston. The water rushes out of the holes in the vessel with the same pressure. The force applied on the piston exerts pressure on water. This pressure is transmitted equally throughout the liquid in all directions.

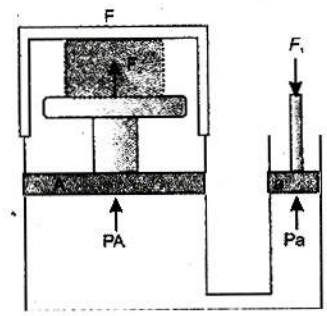


Pascal's law

In general, this law holds good for fluids both for liquids, as well as gases.

APPLICATIONS OF PASCAL'S LAW

Pascal's law is applicable in many ways in our daily life such as automobiles, hydraulic brake system, hydraulic jack, hydraulic press and other hydraulic machine.



A hydraulic press

Q10. Explain the working of Hydraulic press.

Ans. Hydraulic press is a machine which works on Pascal's law

construction.

It consists of two cylinders of different cross- sectional areas. They are fitted with pistons of cross-sectional areas **a** and **A**.

Working

The object to be compressed is placed over the piston of large cross-sectional area **A**. The force F_1 is applied on the piston of small cross- sectional area **a**. The pressure **P** produced by small piston is transmitted equally to the large piston and a force F_2 acts on **A** which is much larger than F_1.

Pressure on piston of small area "a" is given by

$$P = \frac{F_1}{a} \quad \text{............. (1)7}$$

Apply Pascal's law, the pressure on large piston of area A will be the same as on small piston.

$$\therefore \quad P = \frac{F_2}{A} \quad \text{........... (2)}$$

Comparing the equations (1) and (2) we get

$$\frac{F_2}{A} = \frac{F_1}{a}$$

$$\therefore \quad F_2 = A \times \frac{F_1}{a}$$

$$\text{or} \quad F_2 = F_1 \times \frac{A}{a} \quad \text{... ... ... (7.4)}$$

Conclusion

Since the ratio $\frac{A}{a}$ is greater than 1, hence the force F_2 that acts on the larger piston is greater than the force F_1 acting on the smaller piston. Hydraulic systems working in this way are known as force multipliers.

EXAMPLE 7.2

In a hydraulic press, a force of 100 N is applied on the piston of a pump of cross-sectional area $0.01 m^2$. Find the force that compresses a cotton bale placed on larger piston of cross- sectional area $1 m^2$

SOLUTION

Here $F_1 = 100N$

$a = 0.01 m^2$

$A = 1 m^2$

Pressure P on smaller piston $= \frac{F_1}{a}$

$= \frac{100}{0.01}$

$= 10000 Nm^{-2}$

Applying Pascal's law, we get

Force F_2 acting on the bale $= PA$

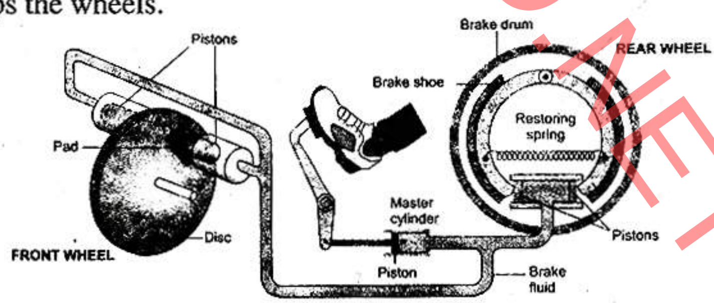
$= 10000 \times 1$

$= 10000 N$

Thus, hydraulic press will compress the bale with a force of 10000 N.

Q11. Explain braking system in vehicles which work on the principle of Pascal's law.

Ans. The braking system of cars, buses, etc. also work on Pascal's law. The hydraulic brakes allow equal pressure to be transmitted throughout the liquid. When brake pedal is pushed, it exerts a force on the master cylinder, which increases the liquid pressure in it. The liquid pressure is transmitted equally through the liquid in the metal pipes to all the pistons of other cylinders. Due to the increase in liquid pressure, the pistons in the cylinders move outward pressing the brake pads with the brake drums. The force of friction between the brake pads and the brake drum stops the wheels.



A hydraulic brake of a car

Q12. State and explain Archimedes principle how can we determine the density of solid using it.

Ans. Statement

"When an object is totally or partially immersed in a liquid, an upthrust acts on it equal to the weight of the liquid it displaces".

Explanation

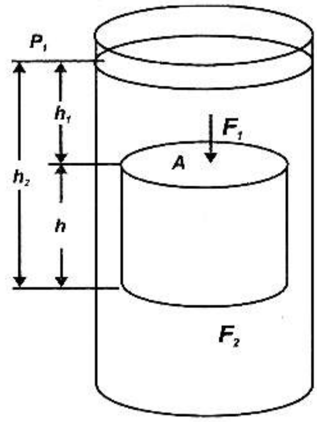
Consider a solid cylinder of cross-sectional area 'A' and height "h" is immersed in a liquid. Let 'h_1' and 'h_2' be the depths of the top and bottom faces of the cylinder respectively. From the surface of the liquid.

Then $h_2 - h_1 = h$

If P_1 and P_2 are the liquid pressures at depths h_1 and h_2 respectively and ρ is its density, then according to equation

$P_1 = \rho g h_1$ .... (1)

$P_2 = \rho g h_2$ .... (2)



Let the force F_1 is exerted at the cylinder top by the liquid due to pressure P_1 and the force F_2 is exerted at the bottom of the cylinder by the liquid due to p_2

By the definition of pressure

Force at top

$P_1 = \frac{F_1}{A}$

$F_1 = P_1 A$

$F_1 = \rho g h A$

Force at bottom

$P_2 = \frac{F_2}{A}$

$F_2 = P_2 A$

$F_2 = \rho g h_2 A$

F_1 and F_2 are acting on the opposite faces of the cylinder. Therefore, the net force F will be $F_2 - F_1$ in the direction of F_2. This net force F on the cylinder **is called the upthrust of the liquid.**

$\therefore \quad F_2 - F_1 = \rho g h_2 A - \rho g h_1 A$

$F_2 - F_1 = \rho g A (h_2 - h_1)$ $\quad$ $\therefore h_2 - h_1 = h$

Or Upthrust force of liquid $= \rho g Ah$

Or $= \rho g V$ $\quad$ $\therefore V = Ah.$

$\therefore \quad m = \rho \times v$

So,

$F_2 - F_1 = m \times g$

Here Ah is the volume V of the cylinder and is equal to the volume of the liquid displaced by the cylinder. Therefore, ρ g V is the weight of the liquid displaced. shows that an upthurst acts on the body immersed in a liquid and is equal to the weight of liquid displaced, which is Archimedes principle.

Calculation of Density of an Object

Archimedes principle is also helpful to determine the density of an object. The ratio in the weights of a body with an equal volume of liquid is the same as in their densities.

Let Density of the object = D

Density of the liquid = ρ

Weight of the object = w_1

Weight of equal volume of liquid of the solid in liquid. = w = $w_1 - w_2$. According to Archimedes principle, W_2 is less than its actual weight w_1 by an amount w.

Since $\frac{D}{\rho} = \frac{w_1}{w}$

$\therefore$ $D = \frac{w_1}{w} \times \rho$

Or $$\boxed{D = \frac{w_1}{w_1 - w_2} \times \rho}$$

Hence this formula is used to measure the density of any object.

EXAMPLE 7.3

A wooden cube of sides 10 cm each has been dipped completely in water. Calculate the up thrust of water acting on it

SOLUTION

Length of side L = 10 cm = 0.1m

Volume V = $L^3 = (0.1m)^3$ = $1 \times 10^{-3}\ m^3$

Density of water ρ = $1000\ kgm^{-3}$

Upthrust of water = $\rho\ g\ V$

$= 1000 \times 10 \times 1 \times 10^{-3}$

$= 10\ N$

Thus, upthrust of water acting on the wooden cube is 10 N.

EXAMPLE 7.4

The weight of a metal spoon in air is 0.48 N. Its weight in water is 0.42 N. Find its density.

SOLUTION

Weight of the spoon w_1 = 0.48 N

Weight of spoon in water w_2 = 0.42 N

Density of water ρ = $1000\ kg\ m^{-3}$

Density of spoon D = ?

We Know that

$$D = \frac{w_1}{w_1 - w_2} \times \rho$$

$$= \frac{0.48}{0.48 - 0.42} \times 1000$$

$$D = 8000\,kg\,m^{-3} \text{ Ans}$$

Q13. Under what condition an object sinks and floats on the surface of water?

Ans: "An object sinks if its weight is greater than the upthrust force acting on it. An object floats if its weight is equal or less than the up thrust force. An object floats in a liquid the up thrust acting on it is equal to the weight of the object.

Q14. What is the principle of floatation?

Ans. PRINCIPLE OF FLOATATION

"A floating object displaces a fluid having weight equal to the weight of the object".

Explanation

In case of floating object, the object may be partially immersed. The upthrust is always equal to the weight of the fluid displaced by the object. This is the principle of the fluid displaced by the object.

EXAMPLE 7.5

An empty meteorological balloon weighs 80 N. It is filled with 10^3 Cubic metres of hydrogen. How much maximum contents the balloon can lift besides its own weight? The density of hydrogen is $0.09 kgm^{-3}$ and the density of air is $1.3 kgm^{-3}$

SOLUTION

Weight of the balloon $w = 80\,N$

Volume of hydrogen $V = 10^3\,m^3$

Density of hydrogen $\rho_1 = 0.09\,kg\,m^{-3}$

Weight of hydrogen $w_1 = ?$

Density of air $\rho_2 = 1.3\,kg\,m^{-3}$

Weight of the contents $w_2 = ?$

Up thrust F = Weight of air displaced.

$= \rho_2 V g$

$= 1.3 \times 10 \times 10$

$= 130\,N$

Weight of hydrogen $w_1 = \rho_1 V g$

$= 0.09 \times 10 \times 10$

$= 9\,N$

Total weight lifted $= w + w_1 + w_2$

To lift the contents, the total weight of the balloon should not exceed F.

Thus $w + w_1 + w_2 = F$

Or $80N + 9N + w_2 = 130\,N$

Or $w_2 = 130\text{ N} - 89\text{ N}$

$= 41\text{ N}$

Thus, the maximum weight of 41 N can be lifted by the balloon in addition to its own weight.

Q15. Write the Applications of Archimedes principles.

Ans. SHIPS AND SUBMARINES

Ships:- A wooden block floats on water. It is because the weight of an equal volume of water is greater than the weight of the block. According to the principle of floatation, a body floats if it displaces water equal to the weight of the body when it is partially or completely immersed in water.

Ships and boats are designed on the same principle of floatation. They carry passengers and goods over water. It would sink in water if its weight including the weight of the passengers and goods becomes greater than the upthrust of water.

Submarine:- A Submarine can travel over as well as under water. It also works on the principle of floatation. It floats over water when the weight of water equal to its volume is greater than its weights Under this condition, it is similar to a ship and remains partially above water level. It has a system of tanks which can be filled with and emptied from sea water. When these tanks are filled with seawater, the weight of the submarine increases. As soon as its weight becomes greater than the up thrust, it dives into water and remains under water. To come up on the surface, the tanks are emptied from sea water.

EXAMPLE 7.6

A barge, 40 metre long and 8 metre broad, whose sides are vertical, floats partially, loaded in water. If 125000 N of cargo is added, how many meters will it sink?

Solution

Area of the barge $A = 40 \times 8$

$= 320\text{ m}^2$

Additional load w to carry $W = 125000\text{ N}$

Increased up thrust F of water must be equal to the additional load. Hence

$F = \rho Vg$ .... (1)

Since $F = w$ ....(2)

Comparing (1) & (2)

$w = \rho vg$

$125000 = 1000 \times v \times 10$

$\boxed{v = 12.5\text{m}^3}$

We know

$V = Ah$

$h = \frac{v}{A}$

$$\therefore \quad h = \frac{12.5}{320}$$

Depth "h" to which barge sinks. $= 0.04\ m = \boxed{4\,cm}$

Thus, the barge will sink 4 cm in water on adding 125000 N cargo.

Q16. Define elasticity

Ans. "The property of a body to restore its original size and shape as the deforming force ceases to act is called elasticity."

Q17. Define stress and write its formula and unit.

Ans. "The force acting on unit area at the surface of a body is called stress."

$$\text{Thus} \quad \text{Stress} = \frac{\text{Force}}{\text{Area}}$$

In SI, the unit of stress is Newton per square metre (Nm^{-2})

Q18. Define and Explain Strain.

Ans. Definition:

"The ratio of change in size to the original size is called strain"

Explanation:- When stress acts on a body, it may change its length, volume, or shape. A comparison of such a change caused by the stress with the original length, volume or shape is called as strain. If stress produces a change in the length of an object then the strain is called tensile strain.

$$\text{Tensile strain} = \frac{\text{change in length}}{\text{original length}} = \frac{\Delta L}{L}$$

Strain has no units as it is a ratio between two similar quantities.

Q19. State and explain Hooke's Law.

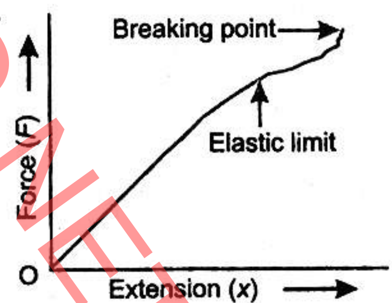
Ans. HOOKE'S LAW

"The strain produced in a body by the stress applied to it is directly proportional to the stress within the elastic limit of the body".

Thus stress $\propto$ strain

Or stress = constant $\times$ strain

$$\text{Or} \quad \frac{\text{stress}}{\text{strain}} = \text{constant} \quad \dots \quad \dots \quad (7.10)$$



Graph between force and extension

Hooke's law is applicable to all kinds of deformation and all types of matter i.e. solids, liquids or gases within certain limit. This limit tells the maximum stress that can be safely applied on a body without causing permanent deformation in its length, volume or shape. In other words, it is a limit with in which a body recovers its original length, volume or shape after the deforming force is removed. When a stress crosses this limit, called the elastic limit, a body is permanently deformed and is unable to restore its original state after the stress is removed.

Q20. What do you mean by Young's modulus? Derive formula to calculate Young modulus.

Ans. YOUNG'S MODULUS

"The ratio of stress to tensile strain is called young's modulus".

Mathematically,

$$\text{Young's modulus } Y = \frac{\text{stress}}{\text{Tensile strain}} \quad \dots \dots \quad (7.11)$$

Let ΔL be the change in length of the rod, then

$$\Delta L = L - L_o$$

Since Stress $= \dfrac{\text{Force}}{\text{Area}} = \dfrac{F}{A}$

And Tensile strain $= \dfrac{L - L_o}{L_o} = \dfrac{\Delta L}{L_o}$

As $Y = \dfrac{\text{stress}}{\text{Tensile strain}}$

$$= \frac{F}{A} \times \frac{L_o}{\Delta L}$$

$$\therefore \quad \boxed{Y = \frac{FL_o}{A\Delta L}}$$

SI unit of young's modulus is newton per square metre (Nm^{-2}).

EXAMPLE 7.7

A steel wire 1 m long and across- sectional area $5\times10^{-5}\ m^2$ is stretched through 1 mm by a force of 10,000 N. Find the Young's modulus of the wire.

SOLUTION

Force $F = 10{,}000\ N$

Length $L_o = 1m$

Extension $\Delta L = 1mm = 0.001m$

Cross sectional Area $A = 5\times10^{-5}\ m^2$

$$\text{Since } Y = \frac{FL_o}{A\Delta L}$$

$$Y = \frac{10000\times1}{5\times10^{-5}\times0.001}$$

$$Y = 2\times10^{11}\ N\ m^{-2}$$

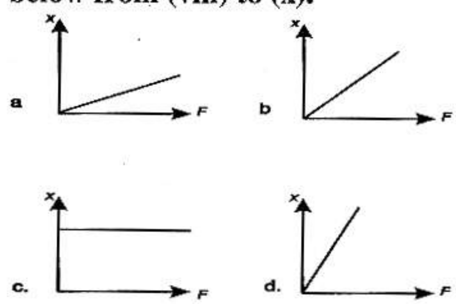
Thus, young's modulus of steel is $2\times10^{11}\ Nm^{-2}$

MULTIPLE CHOICE

7.1 Encircle the correct answer form the given choices:

1. **In which of the following state molecules do not leave their position?**
   (a) Solid (b) liquid
   (c) gas (d) plasma
2. **Which of the substance is the lightest one?**
   (a) copper (b) mercury
   (c) aluminum (d) lead
3. **SI unit of pressure is pascal, which is equal to:**
   (a) 10^4 Nm^{-2} (b) 1 Nm^{-2}
   (c) 10^2 Nm^{-2} (d) 10^3 Nm^{-2}
4. **What should be the approximate length of a glass tube to construct a water barometer**
   (a) 0.5 m (b) 1 m
   (c) 2.5 m (d) 11m
5. **According to Archimedes, up thrust is equal to:**
   (a) weight of displaced liquid
   (b) volume of displaced liquid
   (c) mass of displaced liquid
   (d) none of these
6. **The density of a substance can be found with the help of :**
   (a) Pascal's law (b) Hooke's law
   (c) Archimedes principle
   (d) Principle of floatation
7. **According to Hooke's law**
   (a) Strees × strain = constant
   (b) Strees / strain = constant
   (c) Strain / stress = constant
   (d) Stress = strain

The following force-extension graphs of a spring are drawn or the same scale. Answer the questions given below from (viii) to (x).



8. **Which graph does not obey Hooke's law as shown in above _____**
   (a) (b)
   (c) (d)
9. **Which graph gives the smallest value of spring constant?**
   (a) (b)
   (c) (d)
10. **Which graph gives the largest value of spring constant?**
    (a) (b)
    (c) (d)
11. **Substances having specific shape and volume are called.**
    (a) solids (b) liquids
    (c) Gases (d) plasma
12. **Such state of matter which has no specific shape is called.**
    (a) solid (b) liquid, gas
    (c) Gas (d) plasma
13. **Most of the matter that fills the universe is in _____ state.**

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(a) solid (b) plasma
(c) liquid (d) Gas

14. 1litre is equal to _______ m^3.
(a) 10^2 (b) 10^{-3}
(c) 10^3 (d) 10^6

15. The formula of Density is _________
(a) $\frac{m}{v}$ (b) $\frac{v}{m}$
(c) m x v (d) None of these

16. Pressure is ______ quantity.
(a) Scalar (b) Vector
(c) Constant (d) Dependent

17. The formula of pressure is ________.
(a) F x a (b) $\frac{A}{F}$
(c) $\frac{F}{A}$ (d) None of these

18. The density of water is —— kgm^{-3}
(a) 5500 (b) 10000
(c) 1000 (d) 330

19. The Fourth state of matter is
(a) Solid (b) Liquid
(c) Gas (d) Plasma

20. As we go up the value of atmospheric pressure is
(a) Decreased (b) Increased
(c) Remains constant (d) None of these

21. At sea level, the atmospheric pressure is about ________
(a) 101320 pa (b) 101300 pa
(c) 10110 pa (d) 10112 pa

22. Atmospheric pressure is measured by an instrument is called.
(a) Barometer (b) altimeter
(c) Meter rod (d) Hydrometer

23. Density of Mercury is _____ time greater the density of water
(a) 12.5 (b) 13.6
(c) 76 (d) 76.5

24. During the hot summer day the value of atmospheric pressure is ______
(a) Increases (b) Decreases
(c) Constant (d) None of these

Answers

1.	a	**2.**	c	**3.**	b	**4.**	d	**5.**	a
6.	c	**7.**	b	**8.**	c	**9.**	d	**10.**	a
11.	a	**12.**	b	**13.**	b	**14.**	c	**15.**	a
16.	a	**17.**	c	**18.**	c	**19.**	d	**20.**	a
21.	b	**22.**	a	**23.**	b	**24.**	b		

Short Questions

Q.1 How kinetic molecular model of matter is helpful in differentiating various states of matter?

Ans. By finding density, solubility, motion of molecules we can differentiate between solids liquids and gases with the help of kinetic molecular theory.

Q.2 Does there exist a fourth state of matter? What is that?

Ans. Yes! there is fourth state of matter which is called plasma. Plasma consists of ions and electrons which exists on sun and fluorescent tubes.

Q.3 Can we use a hydrometer to measure the density of milk?

Ans. Yes! we can find the density of milk by hydrometer. But for this we use a special hydrometer called lactometer.

Q.4 It is easy to fill air in a balloon but it is very difficult to remove air from a glass bottle. Why?

Ans. To fill air in a balloon is easy because we can enter air inside the balloon until pressure of air inside balloon becomes equal to the atmospheric pressure but to remove air from glass is difficult because pressure in glass is low than atmospheric pressure.

Q.5 What is a barometer?

Ans. It is an instrument which is used to measure atmospheric pressure.

Q.6 Why water is not suitable to be used in a barometer?

Ans. Since the density of water is much less than mercury so we cannot use water in barometer. If we use water in barometer a long glass tube is required.

Q.7 What makes a sucker pressed on a smooth wall sticks to it?

Ans. Sucker sticks to the smooth wall because sucker pump out the air due to which pressure outside sucker is greater than inside.

Q.8 Why does the atmospheric pressure vary with height?

Ans. With the increase of height quantity of air began to decrease due to which atmospheric pressure also becomes low.

Q.9 What does it mean when the atmospheric pressure at a place fall suddenly?

Ans. When the atmospheric pressure fall suddenly at a place it may be storm or rain at that place.

Q.10 What changes are expected in weather if the barometer reading shows a sudden increase?

Ans. When the atmospheric pressure increases suddenly this means that there is poor weather ahead.

Q.11 What is meant by elasticity?

Ans. The property of the body due to which it attain its original shape and size when force ceases to act.

Q.12 What is upthrust? Explain the principle of floatation.

Ans. Upthrust is the force of liquid which acts on the floating object in the upward direction. Which are immersed in liquid and is equal to the weight of displaced water. A floating object displace a fluid having weight equal to the weight of object.

Q.13 Why does a piece of stone sink in water but a ship with a huge weight floats?

Ans. A piece of stone sink in water because up thrust force acts on it is less than its weight but on ship up thrust force is greater than its weight due to which it floats on water.

Q.14 What is effect on atmospheric pressure as we go higher?

Ans. Earth's atmosphere extends upward about a few hundred kilometers with continuously decreasing density. Nearly half of its mass is between sea level and 10 km. Up to 30 km from sea level contains about 99% of the mass of the atmosphere. The air becomes thinner and thinner as we go up.

Q.15 How vacuum cleaner works?

Ans. The fan in a vacuum cleaner lowers air pressure in its bucket. The atmospheric air rushes into it carrying dust and dirt with it through its intake port. The dust and dirt particles are blocked by the filter while air escapes out.

Q.16 How liquid push up in straw?

Ans. When air is sucked through straw with its other end dipped in a liquid, the air pressure in the straw decreases. This causes the atmospheric pressure to push the liquid up the straw.

Q.17 How liquid enter in the syringe?

Ans. The piston of the syringe is pulled out. This lowers the pressure in the cylinder. The liquid from the bottle enters into the piston through the needle.

Q.18 What is hydrometer?

Ans. Hydrometer is a glass tube with a scale marked on its stem and heavy weight in the bottom. It is partially immersed in a fluid, the density of which is to be measured. One type of hydrometer is used to measure the concentration of acid in a battery. It is called acid meter.

NUMERICAL PROBLEMS

7.1 A wooden block measuring 40 cm×10cm×5cm has a mass 850 g. Find the density of wood?

Given data

Volume $= 40\text{ cm} \times 10\text{ cm} \times 5\text{cm}$

$= 2000\text{ cm}^3$

$= 2000 \times (10^{-2})^3$

$= 2000 \times 10^{-6}\text{ m}^3$

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

Mass $= m = 850\text{ g} = \frac{850}{1000}$

$= 0.85\text{ kg}$

To find

Density $= \rho = ?$

Solution

We know

$$\rho = \frac{m}{v}$$

$$= \frac{0.85}{2\times10^{-3}}$$

$$= \frac{0.850\times10^3}{2}$$

$$= \frac{0.850\times1000}{2}$$

$$\rho = \frac{850}{100} = \boxed{425\text{ kgm}^{-3}}$$

7.2 How much would be the volume of ice formed by freezing 1 litre of water?

Given Data

Volume of water $= V_w = 1$ Litre $= 1\times10^{-3}\text{m}^3$

Since 1 litre $= 10^{-3}\text{m}^3$

Density of water $= \rho_w = 1000\text{ kg m}^{-3}$

Density of ice $= \rho_{ice} = 920\text{ Kgm}^{-3}$

To find

Volume of ice $= V_{ice} = ?$

Solution

We know that

$$\rho_w = \frac{m_w}{V_w}$$

$m_w = \rho_w \times V_w$

Also

Since $= \rho_{ice} = \frac{m_{ice}}{V_{ice}}$

As mass remains constant so

$m_w = m_{(ice)}$

$\rho_w V_w = \rho_{ice} V_{ice}$

$V_{(ice)} = \frac{\rho_{ice} V_w}{\rho_{ice}}$

$= \frac{1000 \times 10^{-3}}{920}$

$= 1.09 \times 10^{-3} m^3$

$= 1.09 (10^{-3} m^3)$

$=$ 1.09 litre

7.3 Calculate the volume of the following objects:

(i) An iron sphere of mass 5 kg, the density of iron is 8200 kgm^{-3}

(ii) 200 g of lead shot having density 113000 kgm^{-3}

(iii)A gold bar of mass 0.2 kg. the density of gold is 19300 kgm^{-3}

Given Data

(i) Mass $= m = 5$ kg

Density $= \rho = 8200\ kgm^{-3}$

To find

Volume $= V = ?$

Solution

$\rho = \frac{m}{v}$

$V = \frac{m}{\rho}$

$= \frac{5}{8200}$

$= \frac{5}{8.2 \times 10^3}$

$= \frac{5}{8.2} \times 10^{-3}$

$= 0.609 \times 10^{-3}$

$= 6.09 \times 10^{-4} m^3$

$= 6.1 \times 10^{-4} m^3$

$\rho = 6.1 \times 10^{-4} m^3$

(ii)

Given data

mass $= m = 200g = \frac{200}{1000}$ kg

$= 0.2$ kg

Density $= \rho = 11300\ kg\ m^{-3}$

To find

Volume $= V = ?$

Solution

$\rho = \frac{m}{v}$

$V = \frac{m}{\rho}$

$= \frac{0.2}{11300}$

$= \frac{0.2}{1.13 \times 10^4}$

$= \frac{2 \times 10^{-1} \times 10^{-4}}{1.13}$

$= 1.769 \times 10^{-5}\ m^3$

$= 1.77 \times 10^{-5} m^3$

(iii)

Given data

mass $= m = 0.2$ kg

Density $= \rho = 193000\ kgm^{-3}$

To find

Volume $= V = ?$

Solution

$\rho = \frac{m}{v}$

$V = \frac{m}{\rho}$

$= \frac{0.2}{19300}$

$= \frac{2\times10^{-1}}{1.93\times10^{4}}$

$= \frac{2}{1.93}\times10^{-1}\times10^{-4}$

$= 1.036\times10^{-5}\,m^3$

$= \boxed{1.04\times10^{-5}\,m^3}$ Ans.

7.4 The density of air is 1.3 kgm^{-3} Find the mass of air in a room measuring 8 m × 5 m × 4 m.

Given Data

Density = ρ = 1.3 kgm^{-3}

Volume = 8m × 5m × 4m

= 160 m^3

Mass = m = ?

Solution

We know

$\rho = \frac{m}{v}$

$m = \rho V$

$= 1.3 \times 160$

$m = 208$ kg.

7.5 A student presses her palm by her thumb with a force of 75 N. How much would be the pressure under her thumb having contact area 1.5 cm^2?

Given Data

Force = F = 75 N

Area = 1.5 cm^2

$= 1.5\times(10^{-2}m)^2$

$= 1.5\times10^{-4}m^2$

$\boxed{1\text{ cm} = 10^{-2}m}$

To find

Pressure = P = ?

Solution

We know

$P = \frac{F}{A}$

$= \frac{75}{1.5\times10^{-4}}$

$= \frac{75}{1.5}\times10^{4}$

$= 50\times10^4\ Nm^{-2}$

$= 5\times10\times10^4\,Nm^{-2}$

P= $\boxed{5\times10^5\ Nm^{-2}}$

7.6 The head of a pin is a square of side 10 mm. Find the pressure on it due to a force of 20 N.

Given Data

Force = F = 20 N

length = L = 10 mm = 10×10^{-3} m

Area = A = L×L = $10\times10^{-3}\times10\times10^{-3}$

$A=1\times10^{-4}\,m^2$

To find

Pressure = P = ?

Solution

We know

$P = \frac{F}{A}$

$= \frac{20}{1\times10^{-4}}$

$= 20\times10^4\,Nm^{-2}$

$P = 2\times10^5\ Nm^{-2}$

7.7 A uniform rectangular block of wood 20 cm × 7.5 cm × 7.5 cm and of mass 1000 g stands on a horizontal surface with its longest edge vertical. Find (i) the pressure exerted by the block on the surface

(ii) density of the wood.

Given Data

Mass = m = 1000g = 1 kg

Weight = W = F = mg = 1×10 = 10N

Area = 7.5 cm × 7.5 cm

$A= 7.5\times7.5\times(10^{-2}\,m)^2$

$A = 56.25\times10^{-4} m^2$

$A = 5.625\times10^{-3} m^2$

Volume = V = 7.5 cm × 7.5 cm × 20cm

$= 1125 \times (10^{-2} m)^3$

$= 1125 \times 10^{-6} m^3$

$= 1.125 \times 10^{-3} m^3$

To find

Pressure = P = ?

Density = ρ = ?

Solution

We know

$P = \frac{F}{A}$

$= \frac{10}{5.625\times10^{-3}}$

$= \frac{10\times1000}{5.625}$

$= \frac{10000}{5.625}$

$P = \boxed{1778 \ Nm^{-2}}$

$\rho = \frac{m}{v}$

$= \frac{1}{1.125\times10^{-3}}$

$= \frac{1000}{1.125}$

$= 888.9 \ kgm^{-3}$

$\rho = \boxed{889 \ kgm^{-3}}$

7.8 A cube of glass of 5 cm side and mass 306 g, has a cavity inside it. If the density of glass 2.55 gcm^{-3}. Find the volume of the cavity.

Given Data

We know

Length = L = 5 cm

Volume = $V_1' = 5 \times 5 \times 5 \Rightarrow 125 \ cm^3$

Mass = m = 306 g

$\rho = 2.55 \ g \ cm^{-3}$

V = ?

Solution

$\rho = \frac{m}{v}$

$V = \frac{306}{2.55}$

$V = 120 cm^3$

Volume of cavity $= V_1' - V$

$= 125 - 120$

$= \boxed{5 cm^3}$

7.9 An object has weight 18 N in air. Its weight is found to be 11.4 N when immersed in water. Calculate its density. Can you guess the material of the object?

Given Data

Weight in air = w_1 = 18N

Weight in water = w_2 = 11.6N

Loss in weight = W = $W_1 - W_2$

= 18 - 11.6 = 6.6 N

Density of water = ρ_w = 1000 kgm^{-3}

To find

D = ?

Solution

We know

$D = \frac{w_1}{w_1 - w_2} \times 1000$

$= \frac{18}{6.6} \times 1000$

$= 2727 \ kgm^{-3}$

Material is Aluminum

7.10 A solid block of wood of density 0.6 gcm^{-3} weighs 3.06 N in air. Determine (a) volume of the block (b) the volume of the block immersed when placed freely in a liquid of density 0.9gcm^{-3}?

Given Data

Density of wood = ρ = 0.6 g cm^{-3}

$= \frac{6}{1000 \times 10} \times (10^{-2})^3$

$= 600 \text{ kg m}^{-3}$

Weight = W = 3.06 N

Mass = m = $\frac{w}{g} = \frac{3.06}{10} = 0.306\text{kg}$

Density of liquid = ρ_1 = 0.9gcm^{-3}

$= \frac{9\times}{1000}(10^{-3})^2$

$= 900 \text{ kgm}^{-3}$

To find

Volume of block = V = ?

Volume of immersed block = V_1 = ?

Solution

We Know

$\rho = \frac{m}{v}$

$V = \frac{m}{\rho} = \frac{.306}{600}$

$= 5.10 \times 10^{-4} \text{ m}^3$

$= 5.10 \times \frac{10^2}{10^2} \times 10^{-4} \text{ m}^3 = 510 \times 10^{-6} \text{m}^3$

$510 \times (10^{-2}\text{m})^3 = 510 \text{ cm}^3$

$V_1 = \frac{m}{\rho^1}$

$m = V_1 \rho_1$

$mg = \rho_1 V_1 g$

$w = \rho_1 V_1 g$

So $V_1 = \frac{w}{\rho g}$

$= \frac{3.06}{900 \times 10}$

$= \frac{3.06}{9000}$

$= 3.4 \times 10^{-4} \text{ m}^3$

$V_1 = 340 \text{ cm}^3$

7.11 The diameter of the piston of a hydraulic press is 30 cm. How much force is required to lift a car weighing 20000 N on its piston if the diameter of the piston of the pump is 3 cm?

Given data

Diameter of piston of Hydraulic press

D = 30 cm = .3m

Radius of piston of Hydraulic press

$R = \frac{.3}{2}\text{m} = .15\text{m}$

Area of piston of Hydraulic press

$A = \pi r^2 = (0.15)^2 \pi$

Diameter of Piston of pump

d = 3cm = 0.03 m

Radius of Piston of pump

$r = \frac{d}{2}$

$= \frac{.03}{2} = .015\text{m}$

Area = $A = \pi r^2$

$= (0.015)^2 \pi$

Weight on larger Piston = F_2 = 20000 N

To find

Force on Smaller piston = F_1 = ?

Solution

We know

$\frac{F_2}{F_1} = \frac{A}{a}$

$F_1 = \frac{F_2 \times a}{A}$

$$= \frac{20000\times(0.015)^2}{(0.15)^2}$$

$$= \frac{20000\times.000225}{.0225} = \frac{4.5}{0.0225} = 200N$$

7.12 A steel wire of cross-sectional area 2×10^{-5} m^2 is stretched through 2 mm by a force of 4000 N. Find the Young's modulus of the wire. The length of the wire is 2 m.

Given Data

Area = $A = 2\times10^{-5}\ m^2$

Increase in length = ΔL = 2mm = 2×10^{-3} m

Force = 4000 N

Length = L_o = 2m

To find

Young Modulus = Y = ?

Solution

$$Y = \frac{F/A}{\Delta L/L_o}$$

$$= \frac{F\times L_o}{A\times\Delta L}$$

$$= \frac{4000\times2}{2\times10^{-5}\times2\times10^{-3}}$$

$$= \frac{4\times10^3\times2\times10^5\times10^3}{2\times2}$$

$$= 2\times10^{11}\ Nm^{-2}$$