PROPERTIES OF MATTER

COMPREHENSIVE QUESTIONS

Q.1 Using kinetic molecular model of matter, explain these states of matter.

Ans. Kinetic Molecular Model of Matter:

According to this theory, the matter is made up of molecules which are always in motion. There are three states of matter i.e. solids, liquids and gases. There is a force of attraction between the molecules of solid, liquid and gas that depends upon the intermolecular spaces between the molecules. The motion of molecules depends upon the temperature. By increasing the temperature, the kinetic energy of molecules also increases. So matter and its properties are based on the arrangement and motion of molecules. These three states of matter are explained on the basis of kinetic molecular theory which are as follow:

1. Solids:

i. Solids are made up of molecules which are arranged closely in a fixed pattern (does not change their position).

ii. Solid have definite shape and volume.

iii. Molecules in solids vibrate about their mean positions.

iv. The attractive forces between the molecules are very strong.

v. They have minimum kinetic energy

2. Liquids:

i. In liquids, the molecules are close together but the pattern of molecules are not fixed which means that the molecules in pattern keep changing their position.

ii. The liquids have no definite shape but have volume which means that the molecules are able to move and change its shape.

iii. Liquids can adopt the shape of the container on which it is pour.

iv. The attractive forces between the molecules of liquid are less than the solid.

v. Their kinetic energy of molecules is little higher than that of solids.

3. Gases:

i. A gas is made up of molecules which are in constant random motion.

ii. The distance between molecules is larger as compared to size of molecules.

iii. The gases occupy no definite shape and no definite volume. That's why the molecules collide with each other and with the walls of the container elastically.

iv. The attractive forces between the molecules are negligible except during collisions.

v. Their volume depends upon temperature and pressure.

vi. The molecules of gases are having maximum kinetic energy.

Q.2 Define and explain density and pressure.

Ans. **Density:**

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

Mathematical Form:

$$\textbf{Density} = \frac{mass}{volume}$$

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

Where "ρ" (rho) is the density and "m" is the mass and "V" is the volume of a substance.

Explanation:

Density tells us that how much mass exist in a given volume or how much an object is heavier than other. When the molecules are closed together, then there are more molecules in a unit volume. Therefore, its density will be greater. Solids are denser than liquids and liquids are denser than gases. The density of water is taken as standard. In S.I unit, the density if water is 1000 kg/m^3 or 1000 kgm^{-3}. If density of an object is less than density of water (liquid) then object will float, but if density of an object is more than the density of water (liquid), then it will sink in water.

For Example:

Iron is denser (heavier) than air, because iron has more mass in the same volume as compared to air. We can also say that for some mass of iron and air, volume of iron (same mass) will be less than air. Also an iron nail is denser than water. That's why it will sink in water because in iron more amount of mass present in unit Volume than water.

Unit:

The S.I unit of density is kgm^{-3} or $gm.cm^{-3}$.

Pressure:

Pressure is defined as force per unit area. It is denoted by "P".

Mathematical Form:

If force "F" is applied on area "A" the pressure is

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

$$\mathbf{P} = \frac{F}{A} \;\ldots\ldots(i)$$

Relation between pressure and force:

Eq(i) clearly shows that pressure is directly proportional to the applied force. It means by applying greater force, pressure will be greater.

Relation between pressure and area:

Eq(i) also shows that pressure is inversely proportional to each other. It means that smaller the area for a given force, the greater will be the pressure. Therefore, a force exerted over a small area produces more pressure than the same amount force exerted over a large area.

For Example:

A girl wearing high heel pointed shoes exerts more pressure on the ground than the one wearing flat shoes.

Unit:

The SI unit of pressure is Pascal (Pa) which is equal to Newton per square meter (Nm^{-2}). i.e.

1 Pa = 1. Nm^{-2}

So, one Pascal is the pressure when a force of "1N" acts normally on an area of "$1m^2$".

Q.3 What is atmospheric pressure? How is it measured by using a mercury barometer? Also disable how weather changes with atmospheric pressure?

Atmosphere Pressure:

A Thick layer of air around the earth is called atmosphere. The pressure exerted by this atmosphere on the surface of earth is called atmospheric pressure.

Explanation:

The air around us exerts a force in all directions and is opposed by an equal pressure inside our body, that's why we do not feel atmospheric pressure. But if the internal pressure of our body is increase or decrease from atmospheric pressure then we feel difficulty in breathing. At sea level, the density of air is maximum and the atmospheric pressure is also maximum. But as we go up from sea level (at high altitudes, the density of air decreases and the atmospheric pressure also decreases.

Measurement of Atmospheric Pressure by using mercury barometer:

Introduction

It was first set up Toricelli, a pupil of Galileo in 1643.

Definition

Mercury barometer is an instrument that is used to measure the atmospheric pressure. This is mainly used in meteorology.

Construction

It consists of a long glass tube sealed at one end and the other end of tube is dipped in a mercury dish. The atmospheric pressure process on the mercury in the dish and this keeps the column of mercury up in the glass tube. The greater the pressure, the higher will be the column of mercury.

Under normal atmospheric pressure, at sea level the column of mercury can rise to 76 cm or 760 mm in the glass tube. At higher altitudes, the atmospheric pressure decreases so column of mercury level also decreases.

Standard Atmospheric Pressure:

The pressure exerted by 760mm (or76cm) of mercury column at sea level is known is standard atmospheric pressure or 1 atmospheric. i.e.

1 atmosphere = 1.013×10^5 Pa

Or **1 atm = 1.013×10^5Pa**

Atmospheric Pressure and weather:

Barometers kept in the same place at the same height above the sea level show some variations in atmospheric pressure from day to day. There pressure variations are shown on weather maps.

Isobars:

The lines in the map joining all those places with the same atmospheric pressure are called isobars.

Unit:

The unit for pressure used in weather maps is called millibar (mbar) or bar. It is exactly equal to 100000 Pa or 100 kPa which is approximately equal to normal atmospheric pressure.

Explanation:

The strength of the wind is determined by the pressure gradient (slope). In weather maps, when the isobars are packed closely together, it indicates high pressure gradient. This means that strong winds may result and rainy weather is detected.

As wind moves from high pressure regions to low pressure regions. So, in the northern hemisphere, the wind moves anticlockwise around areas of low pressure and clock wise around area of high pressure.

Q.4State Pascal's principle and explain with example?

Ans. **Pascal's Principle:**

Statement:

Pascal's Principle of fluid pressure states that whenever an external pressure is applied on a liquid (fluid) in a closed container the pressure is transmitted equally in all directions to every point of the liquid.

Or

All the liquid exerts same pressure in all direction.

Explanation:

Pascal's principle has discovered by a French philosopher named **Blaise Pascal**. This principle is used in different hydraulic machines in our daily life i.e. Hydraulic press, hydraulic brakes, hydraulic jacks and hydraulic lift etc.

Example of Hydraulic lift:

To understand the Pascal's principle, consider an example of hydraulic lift. Hydraulic lift is a device or machine which works on Pascal's principle and is used for lifting heavy loads like heavy vehicles easily.

It consists of two cylinders "A" and "B" one of large cross-sectional area "A_1" and the other of small cross Sectional area "A_2". i.e. $A_2 > A_1$. Each of the cylinder is fitted with a piston which are connected by a tube and they are filled with a suitable fluid usually oil called Hydraulic fluid as shown in fig.

Now, suppose if a force "F" is applied on the piston of cylinder "A" of cross sectional area "A_1", then the pressure "P_1" exerted by this piston is:

$$P_1 = \frac{F_1}{A_1} \text{ .....(i)}$$

In this way, the piston of cylinder "B" of cross sectional area "A_2" moves upward and the vehicle is lifted upward by a force F_2 which is placed at the platform of cylinder "B". So, the pressure on the piston lifting vehicle is P_2, which can be written as,

$$P_2 = \frac{F_2}{A_2} \text{ ....(ii)}$$

Now, According to Pascal's Principle,

$$P_2 = P_1 \text{ ....(iii)}$$

Putting values of P_1 and P_2 in eq......(iii),we get

$$\frac{F_2}{A_2} = \frac{F_1}{A_1}$$

To calculate how much load (F_2) is lifted, the equation can be written as:

$$A_2 \times \frac{F_2}{A_2} = \frac{F_1}{A_1} \times A_2$$

$$F_2 = \frac{F_1 A_2}{A_1}$$

or

$$\mathbf{F_2} = \frac{\boldsymbol{A_2}}{\boldsymbol{A_1}} \boldsymbol{F_1} \text{.........(i)}$$

Equation (iv) shows the amount of force "F_2" exerted on piston of cylinder "B" of Area "A_2". Also, we can find values of A_1, A_2 or F_1 by this equation. Now, depending on the ratio of A_2 / A_1, the force "F_2" can be as large as required. So, to lift more load, we should keep $A_2 > A_1$. Hence a relatively small force can be used to overcome a much larger load.

Q.5: How pressure varies with depth in liquids? Explain

Ans. We know that **$P = \rho gh$**. It is clear from the eq that pressure varies with depth and density of liquid.

Explanation:

Let us take a container full of water, there are three holes A, B and C in the container.

i. From first hole "A" water exert with low speed because of less depth from top of container.
ii. It means on hole "A" due to less depth, pressure "P" is low
iii. From second hole "B" water exert with greatest speed. It means that pressure "P_2" at hole "B" is greater than hole "A".
iv. From third hole "C" water exert with much fast speed than hole "A" and "B" because its depth is greater than hole "A" and "B". It means that at hole "C" the pressure "P_3" is maximum.

Thus, pressure varies directly with depth below the surface of a liquid in any container.

Q.6 What is meant by buoyant force or up thrust in fluids?

Buoyant Force or Upthrust:

The upward force exerted by the fluid on the object which is immersed in it is called upthrust or buoyant force. It is denoted by "F_B"

Explanation:

When an object is immersed in a fluid, the pressure on the lower surface of the object is higher than the pressure on the upper surface. The difference in pressures leads to an upward net force acting on the object due to the fluid pressure called buoyant force and this phenomenon is called buoyancy. So, the buoyant force depends on the density and volume of an object that is immersed in a fluid.

For Example:

If we try to push a piece of crock underwater, we feel an up award, force that is pushing the cork back up. So when we release the cork, it will rise to the surface and floats due to upthrust or buoyant force. Here, the buoyant force is greater than the weight of the cork, so it will move upward and float.

Q.7 State and explain Archimedes principle.

Ans. Archimedes Principle:

Archimedes principle states that "The buoyant force acting on an object fully or partially submerged in a fluid (liquid) is equal to the weight of the fluid displaced by the object.

Or

Buoyant force = weight of fluid displaced

$$F_B = W$$

Explanation:

According to Archimedes principle, every object experiences a buoyant force. When a solid object is dipped in a liquid, an upward buoyant force acts on the object. The magnitude of this force "F_B" is given by Archimedes principle. For example, if we dipped a brick in a container of water, the brick sinks and water level rises in it. The total displaced volume of water is equal to the volume of the brick that is underwater. So, the magnitude of the "F_B" acting on the brick is equal to the weight of water displaced by brick. The buoyant force will decrease the weight of the object which is known as apparent loss of weight. That loss in weight of brick is equal to the weight of the liquid displaced.

Principle of Floatation:

A floating object always displaces its own weight of liquid (Fluid) in which it is immersed. The Archimedes principle applies to both floating and submerged bodies and to all fluids i.e. liquids and gases. Whether an object floats or sinks can be explained by using this principle. The floatation or sinking of an object depends on the density of an object relative to the fluids and the buoyant force.

According to law of floatation:

1) When buoyant force "F_B" is greater than objects weight (W) i.e. $F_B > W$, the object will float in liquid or if $\rho_B > \rho_o$, it will float.
2) When buoyant force "F_B" is smaller than object's weight i.e. $F_B < W$ the object will sink. Or we can say if density of liquid (ρ_B) is lesser than density of object (ρ_o) i.e. $\rho_B < \rho_o$, it will sink.
3) When $F_B = W$, the object will float in the liquid in which it is immersed or we can say, if $\rho_B = \rho_o$ then object will fully immersed but not sink.

Derivation:

The criteria for sinking or floating of an object depends on the net force acting on it. This net force can be calculated as follows

$$F_{net} = F_B - W \text{ (object) } \ldots\ldots\ldots\text{(i)}$$

Now we can apply Archimedes principle, F_B is equal to the weight of fluid (liquid) displaced (W_F) i.e. $F_B = W_f$

Now eq .....(i) becomes

$$F_{net} = W_f - W \ldots\ldots\text{(ii)}$$

As we know that, $W = mg$

so $W_f = m_f g$

and $W_o = m_o g$

Where "m_o" represents the mass of submerged object and "m_f" is the mass of fluid displaced and "g" is the acceleration due to gravity. So put values of W_f and W in eq .....(ii)

$$F_{net} = m_f g - m_o g \ldots\ldots\text{(iii)}$$

As we know that, $m = \rho V$,

So, $m_f = \rho_f V_f$ & $m_o = \rho_o V_o$ the eq ....(iii) becomes

$$F_{net} = \rho_f V_f g - \rho_o V_o g$$

Or $$\mathbf{F_{net} = (\rho_f V_f - \rho_o V_o)\, g}$$

Calculation of the relation between weight "W" and F_B:

Now, a relationship between the weight "W" of submerged object of mass "m_0" and density "ρ_0" and the buoyant force "F_B" on the object by fluid displaced of mass 'm_B' and density 'ρ_B' can be found by considering their ration as follows:

$$\frac{W}{F_B} = \frac{m_o g}{m_B g}$$

$$\frac{W}{F_B} = \frac{m_o g}{m_B g} \;\ldots\ldots\text{(i)}$$

As $m_o = \rho_o V_o$ and $m_B = \rho_B V_B$, So

$$\frac{W}{F_B} = \frac{\rho_o V_o}{\rho_B V_B} \ldots\ldots\text{(ii)}$$

As the volume of submerged object is equal to the volume of liquid displaced i.e.

$$V_o = V_B = V$$

So, the eq (ii) becomes,

$$\frac{W}{F_B} = \frac{\rho_o V}{\rho_B V}$$

$$\frac{\boldsymbol{W}}{\boldsymbol{F_B}} = \frac{\boldsymbol{\rho_o}}{\boldsymbol{\rho_B}} \ldots\ldots\ldots \text{(iii)}$$

Hence, above equation … (iii) shows the relation between weight of the object immersed and the buoyant force. Also by using this equation we can find out the density of solid object (ρ_o) and density of liquid displaced (ρ_B) or the buoyant force.

Q.8 What is elasticity? Explain.

Elasticity:

The property of solid materials to return to their original shape and size after removal of deforming force is called elasticity.

Explanation:

A force is required to change the shape of a solid. Rubber band, Spring the bow and tennis ball are examples of elastic bodies. When deforming force is stored in it that enables the body to regain its original shape. For example, if we apply a force to stretch a rubber band, its length increases. When the force is removed, the rubber band will return to its original position.

The solids may or may not come to its original state. If a body returns to its original state, the material is said to be elastic. Greater is the opposing force, greater will be the elasticity. But if a body does not return to its original state after applying force the material is said to be inelastic. Examples of inelastic materials are plasticine, clays, dough etc.

Elastic Limit:

Elastic limit is the limit in an elastic body up to which elasticity exists. After crossing this limit means increasing the force the body will break or permanently deforms when the deforming force is removed.

For example, by hanging a weight to a spring it stretches. If we continuously increase the weight, a point comes when it cannot regain its original shape and break; it means that the elastic limit has been crossed. So different materials have different elasticity depending upon the nature of the material.

Q.9 State and explain Hooke's law.

Hooke's Law:

This law states that "Within elastic limit the extension or compression in a body is directly proportional to the restoring force"

Or

"With in elastic limit, stress is directly proportional to strain produced in a body".

Explanation:

When a body (spring) is stretched or compressed this extension (x) or compression is directly proportional to the applied force (F). This relationship is known as Hooke's law.

Mathematically it can be written as

$$F_{res} \propto - x$$

Or

$$\mathbf{F_{res} = - k\, x}$$

Where "k" is known as the force constant or the "modulus of elasticity." Its value depends upon the nature of material and system of units. The negative sign shows that force is directed against displacement. The unit of force constant "k" is **Nm^{-1}**.

Q.10 Define and explain stress strain and young's modulus?

Stress:

The stress is defined as the force applied per unit area of cross section on an elastic body to produce deformation. It is denoted by sigma **"δ".**

Mathematical Form:

Mathematically it can be written as

$$\text{Stress} = \frac{Force}{Area\ of\ cross\ section}$$

$$\boldsymbol{\delta = \frac{F}{A}}$$

Unit:

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

Strain:

The stress is defined as the extension per unit length.

Or

It is the ratio of charge in length to the original length of a body. Strain is denoted by epsilon **(ε).**

Mathematical Form:

Mathematically, it can be written as;

$$\text{Strain} = \frac{Extension}{Original\ Length}$$

Or

$$\boldsymbol{\varepsilon = \frac{x}{l}}$$

As strain is the ratio of two lengths, so, it does not have a unit.

Explanation:

Suppose a wire of length "l" and area "A" is stretched by applying force (stress), then the extension (change in length) is produced in a wire is "x" means its length increases that causes strain. Simply when stress is applied on a wire, strain is produced in it and the length of a wire changes "x" from the original length "l" as shown in figure.

Young's Modulus:

Statement:

"The strain produced in an elastic body is directly proportional to the stress with in the limit of proportionality."

Or

"It is the ratio of stress to the linear strain".

Mathematical Form:

Mathematically,

$$\text{Stress} \propto \text{strain}$$

$$\text{Stress} = \text{Young's Modulus x Strain} \ \ldots\ldots\ldots(i)$$

Where Young's Modulus is constant of proportionality and is denoted by "Y"

Now, rearrange the eq….(i), we get

$$\text{Young's modulus} = \frac{stress}{Strain}$$

Or

$$Y = \frac{Stress}{Strain}$$

Whereas stress = F/A and strain = x/ l,we get

$$Y= \frac{F/A}{x/l} \ \ldots..(ii)$$

Rearrange the eq,

$$Y = \frac{F}{A} \text{ x } \frac{l}{x}$$

Or

$$\mathbf{Y = \frac{Fl}{Ax}}$$

As young's modulus is constant of proportionality, so within elastic limit, the ratio is constant where value depends on the nature of materials.

Unit:

The unit of young's modulus is N/m^2 Or Nm^{-2}

Stress strain curve:

Stress and strain curve show the relationship between them. When stress increases, then strain also increases as shown in figure. When the stress reaches to the elastic limit of the material, then due to further stress rapid changes occur in shape of material. This region is shown between "A" and "B". At point "C" due to maximum stress, material can withstand without breaking. But if the stress is further increased up to point "D" then the material breaks.

IMPORTANT TOPIC WISE QUESTIONS

Q.11 Define Plasma State.

Ans: Plasma State:

Plasma is the fourth state of matter. It consists of free electrons and atoms from which the electrons have been removed. Plasma exists in the sun, where thermonuclear reactions take place at very high temperatures.

Q.12 State the applications of Atmospheric pressure.

Ans: <u>Applications of Atmospheric Pressure:</u>

1. <u>Drinking through Straw:</u>

The action of sucking increases the volume of lungs, so air pressure reduces in the lungs and the mouth. The atmospheric pressure acting on the surface of the liquid will be greater than the pressure in the mouth, thus forcing the liquid to rise up the straw into the mouth.

2. <u>Pulling liquid up the syringe:</u>

To draw a liquid into the syringe the piston of the syringe is drawn back upwards. This decreases the pressure within the cylinder due to increase in volume of cylinder. So, the atmospheric pressure on the surface of liquid increases and rise upto the cylinder of the syringe through the nozzle. Thus atmospheric pressure helps the fluid to lift up the cylinder.

3. <u>Working of vacuum cleaner:</u>

When the electric motor of vacuum cleaner is switched on its fan rotates in such a way that it sucks the air inside container and sends it out through exhaust, creating a partial vacuum inside the container. By doing so, low pressure region is created inside the container. Here surrounding air moves from outside the container through the tube to inside the container with greater force. So it gathers all the dirt and dust that comes across its way thus pulling them inside the container. These dust particles are filtered and stored in the filter bag which will be disposed later.

Q.13 Describe the properties or characteristics of pressure in liquids.

Ans: 1. Pressure in a liquid increases with depth because the further down you go, the greater the weight of the liquid above. Thus, pressure varies directly with depth below the surface of a liquid.

2. Pressure at one depth acts equally in all directions means pressure is same in horizontal surface of every level. For example, the can of water has similar holes all round it at the same level. Water comes out equally from each hole. Hence pressure exerted by water at this depth is same in all directions.

3. A liquid finds its own level means the pressure in a liquid is not affected by the surface area. So, the tube of different shapes and diameters shows the same pressure at the same depth since the water level is same in each tube. It does not depend on the shape or width of a tube. It only depends on the vertical depth of the liquid.

Q.14 What Is Hydraulic Brake and how does it works?

Ans: Hydraulic Brakes:

The brakes of vehicles work on the principle of Pascal. In such type of brakes, when the driver pushes down the pedal, the piston in the master cylinder exerts a force on the brake fluid(oil) and the resulting pressure is transmitted equally to the brake of the wheels (other pistons). These force the brake shoes or pads against the wheels and stop the car. But when pressure is released from the pedal, the springs pull back the brake shoes and wheel again turn freely.

Q.15 What is hydrometer and discuss it uses?

Ans: Hydrometer:

A hydrometer is an instrument that measures the ratio of density of the liquid to the density of water i.e. 1000 kgm^{-3}. This is a glass tube with a scale on the side weighted at the bottom with lead shot. The hydrometer floats in the liquid and if the liquid is dense the hydrometer does not need to sink very low to displace its own weight of liquid. If the liquid has a lower density, it will sink much deeper.

By using hydrometers, we can measure the density of milk, density of sugar in a liquid, or to find the density of alcohol in spirits etc.

Q.16: Derive the equation for pressure in liquids.

Ans: Pressure in liquids:

As we know that pressure is defined as "the force exerted on unit area" i.e.

$$P = \frac{F}{A} \text{.......(i)}$$

Now, suppose a disc is placed at the bottom of water tank. The force "F" acting on the disc is the weight "W" of the cylindrical column of liquid of mass "m"

$$F = W = mg$$

$$P = \frac{mg}{A} \text{.....(ii)}$$

We find the mass "m" at the liquid above the disc through the density "ρ" of the liquid (water), which is given as:

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

$$\text{or } m = \rho V \text{ .... (iii)}$$

Since "V" is the cylindrical volume of liquid which has height "h" and area of cross section "A" therefore,

V = Ah

Put the value of "V" in eq ....(iii), we get

$$m = \rho Ah$$

Now, by putting the value of "m" in eq… (ii)

$$P = \frac{\rho A h g}{A}$$

$$\mathbf{P = \rho hg} \ \ldots\ldots \text{(iv)}$$

Above eq (iv) clearly shows that pressure in liquid depends on the density "ρ" of liquid and the height "h" of liquid. Greater the density of liquid, greater will be the pressure in liquids. Also the pressure with depth increases directly below the surface of the liquid.

CONCEPTUAL QUESTIONS:

Q1: If you climbed a mountain carrying a mercury barometer, would the level of the mercury column in the glass tube of the barometer increase or decrease as you climb the mountain? Explain.

Ans: The level of mercury in the column depends upon the atmospheric pressure. Greater the atmospheric pressure, high will be the level of mercury in the column and vice versa.

As the elevation of the mountain increases, the pressure reads by barometer decreases and hence column of mercury decreases or fall down and vice versa.

Q2: Walnuts can be broken in the hand by squeezing two together but not one. Why?

Ans: When two walnuts are placed in hand, the area of the palm of hand is greater than the area of surfaces of walnuts in contact. When pressure is provided to squeeze these walnuts together, the pressure between the surfaces in contact increases which causes the walnuts to break.

Q3: Why is the cutting edge of the knife made very thin?

Ans: As we know that

$$\mathbf{P} = \frac{F}{A} \ \_\_\_\_\_\_\_\_\_\_ \text{(i)}$$

Eq (i) shows that pressure is inversely proportional to the area. That is greater the area, smaller will be the pressure and vice versa. So in this way cutting edge of the knife is made thin to apply more pressure and things can be cut easily.

Q4: Why water tanks are constructed at the highest level in our houses?

Ans: Water has the ability to maintain its level. The pressure of water increases with height. Thus for the easy flow of water in a pipe system, the water tanks are constructed at highest level in our houses.

Q5: Why a small needle sinks in water and huge ships travel easily in water without sinking?

Ans: The water displace by a small needle is less than its weight. So, the upthrust acting on the needle is less than the weight of the needle. While, in case of huge ship, the weight of water displaced is greater than weight of ship. So, the up thrust acting on the ship is greater than the weight of the ship. Therefore, a small needle sinks in water but a huge ship floats.

Q6: Explain how and why camels have adapted to allow them to walk more easily in desert conditions?

Ans: The camels have feet with large surface area, therefore the camel's feet exert less pressure on sand and properly distributed its weight on sand. As a result of less pressure they can walk in desert easily.

Q7: You would have probably experienced your ears 'popping' while driving in the mountains. Why ears 'pop'?

Ans: In plane area, the pressure of air inside the ears and outside remains the same, so we feel comfortable.

When we drive a car in mountains as height increases the atmospheric pressure decreases. At this stage the pressure of air inside the ear is higher than outside pressure. So the ear drum is stressed outwards due to higher inner pressure of the ear. This high pressure air pushes out through a tube into our throat with bubble – popping sound. So the reason of our ears pop while driving in mountain is due to the escape of high pressure air from the inner ear region.

Q8: If you filled an airtight balloon at the top of a mountain, would the balloon expand or contract as you descend the mountain? Explain.

Ans: At the top of mountains, the air pressure is lower as compared to plane area. So low pressure air will be filled in a balloon at the top of mountain.

When we descend the mountain, the air pressure increases. Thus the outside air pressure becomes higher than air pressure inside the balloon. The higher atmospheric pressure force the walls of the balloon inwards, due to which the balloon contracts.

Q9: A rowboat is floating in a swimming pool when the anchor is dropped over the side. When the anchor is dropped, will the water level in the swimming pool increase, decrease, or remain the same? Explain.

Ans: When the anchor is in the boat, the water is displaced more due to combine weight of boat and anchor. When anchor is dropped in water, it will displace an amount of water equal to its volume. The water displaced by weight is more than water displaced by volume. So when the anchor is dropped in water, the level of water in pool decreases.

Q10: Which material is more elastic, steel or rubber and why?

Ans: Steel is more elastic than rubber because steel produce more resistance against the deforming force than rubber. So, more deforming force is required to deform steel while rubber can be easily deformed. As we know that the young's modulus of rubber is 1.40×10^{6} N/m^2 and steel is 20×10^{20} N/m^2. Therefore, steel is more elastic than rubber.

ASSIGNMENTS

7.1: A diamond has a volume of 0.00002m³, its mass is measured as 0.72 kg. Calculate its density.

Data:

Volume of diamond = V = 0.00002 m^3

Mass of diamond = m = 0.072 kg

Find:

Density = ρ = ?

Solution:

By definition of density

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

Putting Values

$$\rho = \frac{0.072}{0.00002}$$

= 3600 kgm^{-3}

7.2: A block of concrete weights 900 N and its base is a square of side 3m. What pressure does the block exert on the ground?

Data:

Weight = W =F = 900 N

Side = 3m

Area of base = A = $Side^2 = (3m)^2 = 9m^2$

Find:

Pressure = P = ?

Solution:

We know that

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

Putting values

$$= \frac{900}{9}$$

P = 100 Pa or $N/_{m^2}$

7.3: What is the pressure at a depth of 100m below the surface of water?

Data:

Depth = h = 100m

Density of water = ρ = 1000 $kg/_{m^3}$

Acceleration due to gravity = 10 $m/_{s^2}$

Find:

Pressure = P = ?

Solution:

We know that

$$P = \rho gh$$

putting value

$$= (1000)\,(10)\,(100)$$

$$= 1000000 \text{ Pa}$$

or $\mathbf{P = 10^6\ Pa}$

7.4: A geologist finds that a moon rock whose weight is 90.9N has an apparent weight of 60.6N when submerged in water. What is the density of the rock?

Data:

Weight in air = W_A = 90.9N

Weight in water = W_B = 60.6N

Density of water = ρ_B = 1000 kg/m^3

Find:

Density of rock = ρ_o = ?

Solution:

As we know that

$$\frac{W}{F_B} = \frac{\rho o}{\rho B}$$

$$\frac{W}{F_B} \times \rho_B = \rho_o$$

Or $\rho_o = \frac{W_A}{F_B} \times \rho_B$ .... (i)

As $F_B = W_A - W_B$

$$= 90.9 - 60.6$$

$\mathbf{F_B = 30.3\ N}$

Putting value of $\mathbf{F_B}$ in Eq (i)

$$\rho_o = \frac{W}{F_B} \times \rho_B$$

Putting value

$$\rho_o = \frac{90.9}{30.3} \times 1000$$

$$= 3 \times 1000\ kg/m^3$$

$$= 3000\ kg/m^3$$

$$\boldsymbol{\rho_o = 3 \times 10^3\ kg/m^3}$$

7.5: An elastic wire of length 2m and cross sectional area 0.02m² is stretched 0.10m by a 300N weight. Calculate the young modulus of the material.

Data:

Length of wire = ι = 2m

Cross sectional area = A = 0.02m^2

Extension = x = 0.10m
Weight = W = F = 300N

Find:

Young's modulus = Y = ?

Solution:

As we know that

Young's Modulus = Y = $\frac{Stress}{Strain}$ ....(i)

First we find stress and strain:

By definition of stress

$$\text{Stress} = \frac{F}{A}$$

Putting values

$$\text{Stress} = \frac{300}{0.02}$$

$= 15000\ Nm^{-2}$

Stress $= 15 \times 10^3\ Nm^{-2}$

By definition of strain

$$\text{Strain} = \frac{x}{l}$$

$= \frac{0.10}{2}$

Strain = 0.05

Now put the values of stress and strain in Eg ....(i)

Young's Modulus = Y = $\frac{Stress}{Strain}$

$= \frac{15 \times 10^3}{0.05}$

$= 300 \times 10^3\ Nm^{-2}$

$= 3 \times 10^2 \times 10^3\ Nm^{-2}$

$= 3 \times 10^{2+3}\ Nm^{-2}$

$Y = 3 \times 10^5\ Nm^{-2}$

NUMERICALS

1.0 A rectangular glass block of dimensions 30 cm by 5cm by 10 cm weights 37.5 N. Calculate the least and greatest pressure it can exert when resting on a horizontal table?

Data:

Length of one side = ι_1 = 30 cm

$= \frac{30}{100}$ m

= 0.3 m

Length of second side = ι_2 = 5cm

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

` = 0.05 m

Length of third side = ι_3 = 10 cm

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

$= 0.1$ m

Force = F = W = 37.5 N

Find:

Greatest Pressure = P_1 = ?

Least Pressure = P_2 = ?

Solution:

By using formula

$$\mathbf{P_1 = \frac{F}{A}} \ldots\ldots(i)$$

To find value of smaller area A

Smaller Area = $A_1 = \iota_2 \times \iota_3$

$= 0.05 \times 0.1$

$= 0.005\ m^2$

Put value of A_1 in Eg (i)

$$P_1 = \frac{37.5}{0.005}$$

$$\mathbf{P_1 = 7500\ Pa}$$

So, P_1 = 7500 Pa

Greater Area = $A_2 = \iota_1 \times \iota_3$

$=0.3 \times 0.1$

$= 0.03\ m^2$

Put value of A_2 in eq (i)

$$P_2 = \frac{F}{A2}$$

$$P_2 = \frac{37.5}{0.03}$$

$$\mathbf{P_2 = 1250\ Pa}$$

2.0 What is the height of a water barometer at atmospheric pressure?

Data:

Normal atmospheric pressure = P = 100 kPa

or

1 atm = 10^5 Pa

Gravitational acceleration = g = 10 m/s^2

Density of water = ρ = 1000kgm^{-3}

Find:

Height of water = h =?

Solution:

By using Formula

$$P = \rho gh$$

Or $$\mathbf{h = \frac{P}{\rho g}}$$

Putting values

$= \frac{10^5}{1000 \; x \; 10}$

$= \frac{10^5}{10000}$ m

$= \frac{10^5}{10^4}$ m

$h = 10^{5-4}$ m

h = 10 m

3.0 The small piston of a hydraulic lift has an area of 0.20 m². A car weighting 1.20 x 10⁴ N sits on a rack mounted on the large piston. The large piston has on area of 0.90 m². How large a force must be applied to the small piston to support the car?

Data:

Area of small piston = $A_1 = 0.02 \; m^2$

Area of large piston = $A_2 = 0.09 \; m^2$

Force on large piston = $F_2 = 1.20 \times 10^4$ N

Find:

Force applied to the small piston = F_1 = ?

Solution:

According to Pascal's Principle $P_1 = P_2$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Multiplying A_1 on both sides

$$\frac{F_1}{A_1} \text{ x } A_1 = \frac{F_2}{A_2} \text{ X } A_1$$

$$\mathbf{F_1 = \frac{F_2}{A_2} \text{ x } A_1}$$

Putting values

$$F_1 = \frac{1.20 \; x \; 10^4}{0.90} \text{ x } 0.20$$

$$F_! = \frac{1.20}{0.90} \text{ x } 10^4 \text{ x } 0.20$$

$= 1.33 \text{ x } 0.20 \text{ x } 10^4$

$= 0.266 \text{ x } 10^4$ N

$= 0.27 \text{ x } 10^4$ N

$= 2.7 \text{ x } 10^{-1} \text{ x } 10^4$ N

$=2.7 \text{ x } 10^{4-1}$ N

$\mathbf{F_1 = 2.7 \text{ x } 10^3}$ **N**

4.0 The deepest point in the ocean is 11 km below sea level, deeper than Mt. Everest is tall. What is the pressure in atmospheres at this depth?

Data:

Depth = h = 11 km

$= 11 \text{ x } 10^3$m

Gravitational acceleration = g = 10 m/s^2

Density of water = ρ = 1000 kg/m^3

Find:

Pressure = ?

Solution:

As we know that

$$P = \rho gh$$

Putting values

$$= 1000 \times 10 \times 11 \times 10^3$$
$$P = 10000 \times 11 \times 10^3$$
$$= 110000 \times 10^3$$
$$= 1.1 \times 10^5 \times 10^3$$
$$= 1.1 \times 10^{5+3} \text{ Pa}$$
$$\mathbf{P = 1.1 \times 10^8 \text{ Pa}}$$

5.0 A block is fully immersed in water. Before the immersion the block weighed 30N and while immersed, its apparent weight was found to be 25 N. Calculate (a) the up thrust in the block.

(a) The up thrust on the block.
(b) The weight of the water.
(c) The volume of water displace.
(d) The volume of the block.
(e) The Density of the block.

Data:

Weight of block in air = W_A = 30 N

Weight of block in water = W_B = 25 N

(a) Upthrust or buoyant force = F_B = ?

Solution:

By Archimedes principle

$$W_A = W_B + F_B$$

or

$$F_B = W_A - W_B$$

Putting values

$$= 30 - 25$$
$$\mathbf{F_B = 5 \text{ N}}$$

(b) Weight of water displace = W= ?

As weight of water displace = buoyant force

$$W = F_B$$

Put F_B = 5N

$$\mathbf{W = 5N}$$

(c) Volume of water displace = V_w = ?

As we know that

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

or $V_w = \frac{m}{\rho_w}$ .... (i)

Weight of water displace = W = 5N .. W=mg

$$mg = 5N$$

$$m = \frac{W}{g}\ kg$$

As $g = 10 m/s^2$ and W= 5

$$m = \frac{5}{10}\ kg$$

$$m = 0.5\ kg$$

Density of water = $\rho_w = 1000\ kg/m^3$

Now put values of 'm' and 'ρ_w' in eq ....(i)

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

$$= \frac{0.5}{1000}$$

$$\mathbf{V_w = 5 \times 10^{-4}\ m^3}$$

(d) Volume of block = V_B = ?

As Volume of block = Volume of water displaced

$V_B = V_w$ ....(ii)

Putting value of V_W in eq (ii)

$$\mathbf{V_B = 5 \times 10^{-4}\ m^3}$$

(e) Density of block = ρ_B = ?

As we know that $\rho = \frac{m}{V}$

$\Rightarrow$ $\rho_B = \frac{m}{V_B}$ ....(iii)

Weight of block in air = W_A = 30N

$$W_A = mg$$

$\Rightarrow$ $m = \frac{W_A}{g}$

$$= \frac{30}{10}\ kg$$

$$m = 3\ kg$$

Now put value of 'm' and 'V_B' in eq ...(iii)

$$\rho_B = \frac{m}{V_B}$$

$$= \frac{3}{5 \times 10^{-4}}$$

$$= \frac{3}{5} \times 10^4\ kg/m^3$$

$$= 0.6 \times 10^4\ kg/m^3$$

$$= 6 \times 10^{-1} \times 10^4\ kg/m^3$$

$$\rho_B = 6 \times 10^{4-1}\ kg/m^3$$

$$\mathbf{\rho_B = 6 \times 10^3\ kg/m^3}$$

6.0 When a weight of 30 N is hung from a wire of original length 2.0 m, its new length becomes 2. 20m.Calculate the force constant for the wire, if the elastic limit is not exceeded?

Data:

Force = F = 30 N

Initial length of wire = l_1 = 2.0 m

Final length of wire = l_2 = 2.20 m

Extension = $x = l_2 - l_1$

$x = 2.20 - 2.0$

$x = 0.20$ m

Find:

Force constant = k = ?

Solution:

As we know that

$$F = kx$$

Or $$k = \frac{F}{X}$$

Putting values $$k = \frac{30}{0.20}$$

$$\mathbf{k = 150\ N/m}$$

7.0 An 80cm long, 1.0mm diameter steel guitar string must be tightened to a tension of 2000 N by turning the tuning screws. By how much is the string stretched?

Data:

Length = l = 80cm

$= \frac{80}{100}$

= 0.8 m

Diameter = D = 1mm

Radius = $\frac{D}{2} = \frac{1}{2}$ mm

= 0.5 mm

= 0.5×10^{-3} m

Force = F = 2000 N

Young modulus = Y = 20×10^{10} Pa

Find:

Stretchiness in string = x = ?

Solution:

As we know that

$$Y = \frac{F \times l}{A \times x}$$

$$A \times x = \frac{F \times l}{Y}$$

$$\mathbf{x = \frac{F \times l}{Y \times A}} \quad \ldots\ldots(i)$$

Now First find cross sectional Area

$$\text{Area} = A = \pi r^2$$

Putting values

$$= 3.14 \times (0.5 \times 10^{-3})^2$$

$$= 3.14 \times 0.25 \times 10^{-6}\ m^2$$

$$A = 0.785 \times 10^{-6}\ m^2$$

Eq….(i) becomes

$$x = \frac{F \times l}{Y \times A}$$

Putting values

$$= \frac{2000\ x\ 0.8}{20\ x\ 10^{10} \times 0.785\ x\ 10^{-6}}$$

$$= \frac{1600}{20\ x\ 0.785 \times 10^{10-6}}$$

$$= \frac{1600}{15.7 \times 10^{4}}$$

$$x = \frac{1600}{15.7} \times 10^{-4}$$

$$= 101.9 \times 10^{-4}$$

$$= 1.01 \times 10^{2} \times 10^{-4}$$

$$= 1.01 \times 10^{2-4}\ m$$

$$= 1.01 \times 10^{-2} m \qquad (10^{-2}\ m = 1cm)$$

x = 1 cm